ANOCI-ASSOCIATION

BY

GEORGE W. CRILE, M.D.

PROFESSOR OF SURGERY, SCHOOL OF MEDICINE, WESTERN RESERVE UNIVERSITY
VISITING SURGEON TO THE LAKESIDE HOSPITAL, CLEVELAND

AND

WILLIAM E. LOWER, M.D.

ASSOCIATE PROFESSOR OF GENITO-URINARY SURGERY, SCHOOL OF MEDICINE,
WESTERN RESERVE UNIVERSITY; ASSOCIATE SURGEON TO THE
LAKESIDE HOSPITAL, CLEVELAND

EDITED BY

AMY F. ROWLAND

ORIGINAL ILLUSTRATIONS

PHILADELPHIA AND LONDON

W. B. SAUNDERS COMPANY

1914

PRINTED IN AMERICA

PREFACE

THIS volume contains in Part I a statement of the Kinetic Theory of Shock and the principle of *Anoci-association* and a summary of a long series of experiments in part published by one of us (G. W. C.) in the following monographs: *Surgical Shock*, *Surgery of the Respiratory System*, *Problems Relating to Surgical Operations*, *The Blood-Pressure in Surgery*, and *Hemorrhage and Transfusion:* and in part to be published later in other monographs. In Part II the application of the Kinetic Theory to the technique of surgical operations is described.

Our purpose is the most practical presentation possible of the technique of *anoci-association*, although it is recognized that each operator who accepts the fundamental principles will work out their practical applications according to his own personal equation and to the surgical environment in which he works.

Grateful acknowledgment is made of the valuable services rendered by Dr. J. B. Austin, who undertook the histologic studies; by Dr. F. W. Hitchings and Dr. H. G. Sloan, for the physiologic experiments undertaken by them; and by Dr. M. L. Menten, for her physico-chemical researches.

GEORGE W. CRILE.
WILLIAM E. LOWER.

CUSHING LABORATORY OF EXPERIMENTAL MEDICINE,
WESTERN RESERVE UNIVERSITY, *July*, 1914.

CONTENTS

Introduction

By George W. Crile, M. D.

Part I

The Kinetic Theory of Shock and Anoci-association

By George W. Crile, M. D.

Part II

The Treatment of Shock and its Prevention through Anoci-association

By George W. Crile M. D., and William E. Lower, M. D.

APPENDIX

The Technique of Administering Nitrous-Oxid-Oxygen Anesthesia

BY AGATHA HODGINS

LIST OF ILLUSTRATIONS

INTRODUCTION

By GEORGE W. CRILE, M.D.

THE EVOLUTION OF THE KINETIC THEORY OF SHOCK AND THE SHOCKLESS OPERATION

The desire to discover the cause of surgical shock led us in 1893 to the experimental investigation of the comparative effects on the blood-pressure and respiration of traumatism of different kinds and of varying degrees of intensity inflicted upon various parts and organs of the body. These researches were published in detail in 1897 in a monograph.* As a result of these investigations we concluded that shock was *the result of exhaustion* and since, from the surgeon's point of view, the most vital phenomenon accompanying shock was a low blood-pressure, we concluded at that time that the most important effect of traumatism was the impairment of the vasomotor mechanism.

Later we investigated various methods by which shock might be prevented and found that the shock phenomena did not follow injuries in territories the nerve supply of which was blocked; that is, blocking the spinal cord prevented shock from traumatization in the blocked area.

After investigating many drugs and following many different lines of research, we concluded that shock was most conspicuously diminished by morphin administered hypodermically and by local and regional anesthesia. We found, however, that careful handling, sharp dissection, and minimum trauma also were effective in preventing shock.

These later investigations, published in 1901,† laid the

* G. W. Crile: An Experimental Research into Surgical Shock.

† G. W. Crile: An Experimental and Clinical Research into Certain Problems Relating to Surgical Operations.

foundation for the development of the preventive technique which we later designated *anoci-association*.

In our belief that the most vital effect of shock was the impairment of the vasomotor mechanism, we next directed our attention to the maintenance of the blood-pressure. We found that as long as an animal's blood-pressure was maintained within certain limits, we could sustain life; logically then if we could devise some means by which the blood-pressure could be maintained, we could overcome the disastrous effects of shock.

A research was made upon the effect of strychnin, and it was discovered that this stimulating drug not only did not improve the condition of the animal after shock, but actually made it worse. At the end of that research, therefore, we concluded that shock could be produced by strychnin alone, and that *it was as logical to treat traumatic shock with strychnin as it would be to treat strychnin shock with trauma.*

As the field of stimulants offered no valuable remedy, we then endeavored to maintain the blood-pressure by applying pressure to different parts of the body, and we found that we could raise the blood-pressure by local bandaging. As a result of these experiments, we finally devised the pneumatic suit, by means of which the general blood-pressure could be raised at will within a range of from 15 to 45 mm. of mercury. This was used at Lakeside Hospital for a time, but it was not an easy working method, for the suit was cumbersome and uncomfortable and valuable time was lost in putting it on.

We also made an extensive research in the hope that by increasing the atmospheric pressure of a room in which the patient could be placed the blood could be pressed to the inner organs and to the brain. In these experiments we used a metallic cylinder and tried the effect of variations in the atmospheric pressure. We found that the air pressure was transmitted through the body equally and that, therefore, by this means we could not increase the general blood-pressure.

We then tried the effect of increased air pressure upon all of the body excepting the intrapulmonary tract, hoping thereby to overcome low blood-pressure by forcing an adequate volume of blood back to the heart. By placing an animal in an air-tight metal cylinder and tying into the trachea a tube which passed out to the external air, we were able to increase the air pressure upon the entire body while the air within the pulmonary tract remained constantly at the atmospheric pressure of the room. By this means the blood could be driven rapidly from the periphery into the thorax. We encountered, however, a difficulty which we had not anticipated: the heart was so rapidly filled and its work so suddenly increased that dilation readily occurred; for, when the amount of blood driven to the auricles is doubled, the work of the heart is increased fourfold.

We were unable to find any mechanism by means of which we could with sufficient delicacy control the air pressure in all parts of the body but the thorax, so that the heart could take care of its added work without danger of immediate paralysis. We even went so far as to have an air-tight chamber built in the hospital, but on account of the difficulties of compression and decompression this was found impracticable.

Having failed to establish any valuable therapeutic action in drugs, in direct mechanical pressure on the body, or in increased air pressure, we turned to the treatment of shock by means of infusions. It was obvious that in shock the blood becomes massed in the larger venous trunks, especially in those in the abdomen and the chest. We argued that if we could fill the collapsed circulatory system, we could raise the blood-pressure, and so prevent the damaging anemia of the brain.

We experimented with various artificial methods, with Locke's and Ringer's solutions and with saline solution, but in every case we found that it was impossible to do more than raise the blood-pressure temporarily. We found that, whatever the rate of infusion, the hemoglobin estimation and the red blood cell counts showed that the blood was not diluted. We then tested the effect of rapid intravenous infusion with indefinite quantities of these solutions. The animals died in from five to eight minutes after sufficiently large infusions. The solutions passed through the vessel walls as fast as they entered. The abdomen distended rapidly and became hard and tense. Autopsies showed that the fluid had accumulated in the walls and lumina of the stomach and the intestines, in the liver and the spleen, thus mechanically fixing the diaphragm and the floating ribs so that death was caused by asphyxia.

All of these results made it increasingly obvious that an agent must be found which could increase the peripheral resistance so that for a time it would take the place of the impaired vasomotor mechanism. Adrenalin accomplished this result immediately. By employing a continuous intravenous infusion of a 1 : 50,000 solution of P. D. & Co.'s adrenalin at the rate of 3 c.c. per minute it was possible to maintain the blood-pressure for many hours.

By the use of adrenalin alone the circulation in a decapitated dog was maintained for eleven hours. Adrenalin infusions were found effective in human cases but the obvious difficulties and dangers in its use led us to continue the search for a better therapeutic agent by means of which the blood-pressure could be maintained.

From all of these observations we concluded that the ideal treatment would be to fill the blood-vessels with some fluid which would not pass through the vessel walls, would cause no chemical injury, would carry oxygen, and would always be immediately available. *Human blood is the only fluid which possesses all of these qualifications.*

After a long research we devised a method by which the circulation of one animal could be connected with that of another so that blood could be transmitted at will from one to the other and we found that as long as the heart could do its work, the blood-pressure could be raised and maintained indefinitely through the transfusion of blood. An overtransfused animal could be decapitated even without resultant change in its blood-pressure. If artificial respiration were maintained then the blood-pressure did not fall for half a day or longer. If an animal were overtransfused one day and decapitated the next, its blood-pressure did not fall. These experiments showed that the elasticity of the over-distended blood-vessels supplied the peripheral resistance normally maintained by the vasomotor mechanism.

This experimental research yielded the ideal treatment for surgical shock—*the direct transfusion of blood.*

Having established an efficient *treatment* for shock, we turned our attention once more to an investigation of the cause and the pathology of shock. We had long ere this observed in our experiments that the use of cocain as a local anesthetic in some measure diminished shock, and in 1900, Dr. Lower made use of spinal analgesia for the purpose of preventing shock. These clinical observations and our laboratory researches convinced me that in shock the brain-cells must show morphologic changes analogous to the changes seen by Hodge in the nerve-cells of bees and birds. To this end I asked Dr. D. H. Dolley, who was then associated with me, to make a histologic study of the brains of dogs after traumatic shock and of rabbits after emotional shock. Since Dr. Dolley's departure for a distant post these nerve-cell investigations have been continued by Dr. J. B. Austin to the present time. As will be seen in the following chapters, the brain-cell changes give an excellent index to the degree of shock, not only of shock from trauma and from emotion, but of drug shock, toxic shock, anaphylactic and foreign proteid shock.

Believing that the changes in the brain-cells were work changes, we then studied other organs whose functions seemed to indicate that they were closely related to the brain in its activities. And finally, we threw out our net of inquiry so as to include every tissue and organ of the body and found that exhaustion from insomnia, from muscular exertion, from emotional excitation, from physical injury, from anaphylaxis, *all cause histologic changes in the brain, the suprarenals, and the liver, and that these stimuli do not cause histologic changes in any other organ.*

Our researches have shown also that in shock the H-ion concentration of the blood is increased. This significant fact will be elaborated in later monographs.

Thus, after many years of investigation and experimentation we have come at last not only to an expanded conception of the causation of surgical shock, but also to a generalization regarding exhaustion from the most varied causes, and an unexpected insight into the origin of certain diseases.

In the following pages we confine ourselves for the most part to the brain-cell changes produced by the trauma and environment attending surgical operations, but it should be borne in mind that these brain-cell changes are an index to the changes which the same causes are producing in the suprarenals and the liver.

It should be stated also that our *kinetic theory of shock* and exhaustion does not rest entirely upon laboratory researches. The results of laboratory experimentation can become of practical value only when tried in the crucible of the clinic. In the formulation and the application of the kinetic theory of shock we have drawn upon the knowledge gained by the practical experience of our colleagues and ourselves in the operating room and at the bedside of our patients.

PART I

THE KINETIC THEORY OF SHOCK AND ANOCI-ASSOCIATION

By GEORGE W. CRILE, M.D.

CHAPTER I

THE KINETIC THEORY OF SHOCK

THE KINETIC THEORY OF SHOCK—GENERAL STATEMENT

When a barefoot boy steps on a sharp stone there is an immediate discharge of nervous energy in his effort to escape from injury. This is not a voluntary act. It is not due to his own personal experience (his ontogeny) but is the result of the experience of his progenitors during the vast periods of time required for the evolution of his species (his phylogeny). The wounding stone made an impression upon the nerve receptors in the foot similar to the innumerable injuries which gave origin to this nerve mechanism itself during the boy's vast phylogenetic or ancestral experience. The stone supplied the phylogenetic association and the appropriate discharge of nervous energy automatically followed.

In like manner all actions are performed. Every adequate stimulus awakens an ontogenetic or phylogenetic memory—or *association*, and the nerve mechanism evolved by countless similar experiences in the life of the individual or of his race makes the appropriate response. These *associations*, like that awakened by the sharp stone in our illustration, may be injurious to the individual—*noci-associations;* or they may be of benefit to the individual—hence *bene-associations*. The sight of appetizing food is a *bene-association*—it awakens both the phylogenetic and the ontogenetic memory of similar experiences. The nerve centers are stimulated as if the food were actually being eaten—and the "mouth waters."

All of life, therefore, is made up of *bene-* and *noci-associations* and the constant effort of the race and of the individual is to increase the former and decrease the latter, to develop an environment which shall as far as possible be free from *noci-associations*—to reach a state of *anoci-association.*

The environmental influences that threaten annihilation, such as the assaults of beasts or of man against man; the impacts of sharp, rough, and moving objects; the irritations of dust and débris are among the coarser, *nocuous* elements, to meet which there have been evolved in man adaptive mechanisms which are excited to activity by the *nociceptors*, which are richly implanted in the skin. The nocuous effects of cold, rain, and storm are met by other adaptations—shelter, clothing, fire; while against those unseen nocuous elements which cannot be perceived by the senses—pathogenic bacteria—the body has evolved chemical defenses—antibodies, immunity, febrile reaction, phagocytosis.

Thus man is constantly beset by *noci-associations* and as constantly is striving to reach a state of *anoci-association.* An umbrella in a rain-storm; a glowing fireside in a blizzard; bolts and bars against attack; antitoxin in an infection—all are attempts to produce *anoci* conditions. In the beginning of human history, however, man in common with most animals had two principal methods of self-defense against the dangers which surrounded him—he fought or he ran away. It is, therefore, the motor mechanism in particular which through its phylogenetic association with injury to the individual is responsible for the discharges of energy which are occasioned by the presence or even the thought of danger. These discharges of energy, when intense enough or protracted enough, produce the extreme conditions called "exhaustion" and "shock." In other words, shock is the result of the *excessive conversion of potential into kinetic energy in response to adequate stimuli.*

According to this conception—*the kinetic theory of shock*—the essential lesions of shock are in the cells of the brain, the suprarenals, and the liver, and are caused by the conversion of potential energy into kinetic energy at the expense of certain chemical compounds stored in the cells of the brain, the suprarenals, and the liver. There is strong evidence also that animals capable of being shocked are animals whose self-preservation originally depended upon some form of motor activity. In man and other animals this motor activity expresses itself in running and fighting; hence the motor mechanism comprises the muscles and the organs that contribute to their activity.

Motor activity then is excited by the adequate stimulation of the nerve ceptors, both of the *contact* ceptors in the skin and of the *distance* ceptors or special senses. We assume that stimulation of the distance ceptors (special senses) is as potent as stimulation of the contact ceptors in producing a discharge of energy. As has already been indicated, we assume also that the environment of the past (phylogeny) through the experiences of adaptation to environment, predetermines the environmental reactions of the present. In each individual at a given time there is a limited amount of potential energy stored in the brain, the suprarenals, and the liver. Motor activity, expressed as action or emotion, following upon each stimulus, whether traumatic or psychic, diminishes by so much this store of potential energy. Stimuli of sufficient number or intensity inevitably cause exhaustion or death even. If this motor activity, resulting from responses to stimuli, takes the form of obvious work performed, such as running, the phenomena expressing the depletion of the vital force are termed *physical exhaustion*. If the expenditure of vital force is due to traumatic or to psychic stimuli which lead to no obvious work performed, especially if the stimuli are strong and the expenditure of energy is rapid—the condition is designated "*shock*."

Shock or exhaustion, therefore, may be produced by diverse causes, such as fear and worry, physical injury, infection, hemorrhage, excessive muscular exertion, starvation, insomnia. We shall present evidence that all of these conditions cause physical alterations in the cells of the brain, the suprarenals, and the liver, that these physical changes are identical, whatever their cause; and that those cells which reach a certain degree of alteration cannot be restored, but go on to annihilation. The histologic changes in the brain, the suprarenals, and the liver may be caused by emotion alone, by physical injury alone, by hemorrhage alone, by starvation alone, by insomnia alone; or these changes may be started by emotion, carried a step further by muscular exertion, another step by physical injury, another by hemorrhage, and so on until they are destroyed; or all of these factors acting simultaneously may produce the same disastrous result. There is no microscopical evidence of specificity in the effects of these various factors; that is, no one could look at an altered brain-cell, suprarenal cell or liver cell under the microscope and be able to state the cause of its structural change. *These changes in shock and exhaustion from any cause whatsoever seem to be identical.*

If the cytoplasm be regarded as the index of the potential energy stored in the cell, it is easy to comprehend the identical changes ultimately wrought by factors that diminish the stores of energy. The physical state of the arsenal is identical, however the ammunition has been exhausted, whether it has been stolen or fired. For our thesis we may consider the brain, the suprarenals, and the liver as the magazine, the cytoplasm as the powder, and adequate stimuli, however produced, as the means by which rounds of ammunition are withdrawn.

Although, as already stated, all of life is filled with *noci-associations*, as a result of which the stored energies of the body are being constantly drained, in this monograph we shall consider first the pathology of traumatic shock; of emotional shock; of toxin and foreign proteid shock; and of drug shock, and then the practical application of the kinetic theory of shock in the development of the shockless operation through *anoci-association*.

CHAPTER II

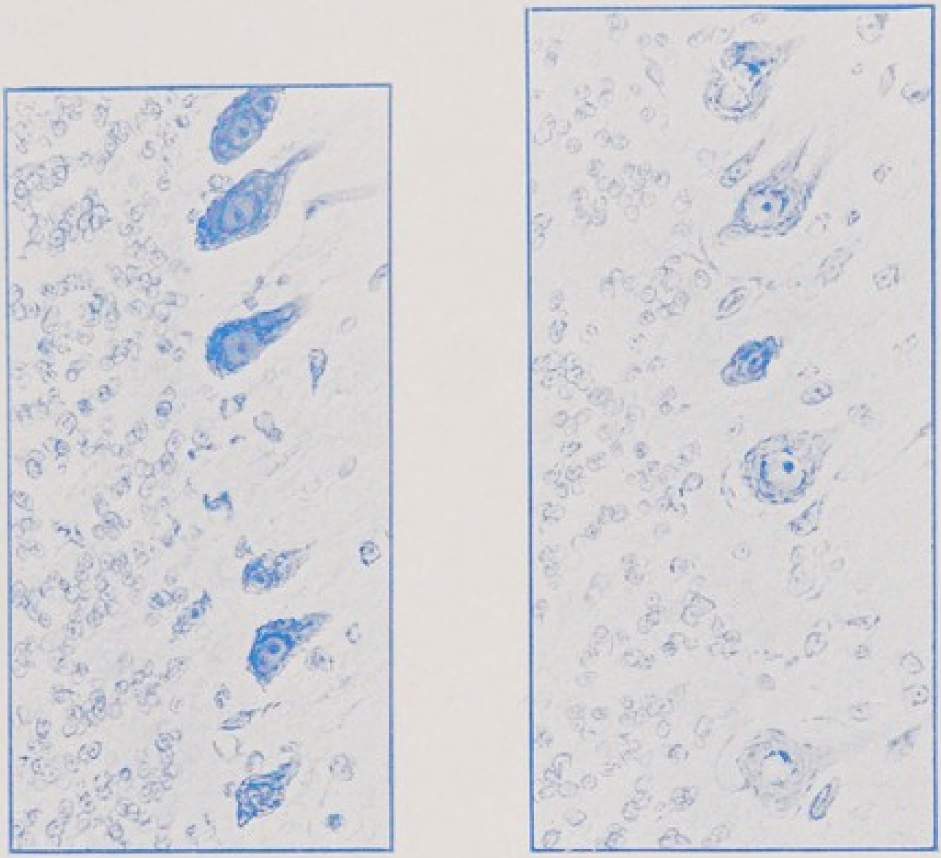
THE HISTOLOGIC PATHOLOGY OF SHOCK

Traumatic Shock. Emotional Shock. Toxic, Foreign Proteid, and Anaphylactic Shock. Drugs—Anesthetics, Narcotics, and Stimulants. Anemia. Are the Cell Changes Seen in Shock due to the Products of Pathologic Metabolism, or to Altered Gases in the Blood? The Influence of the Inhalation Anesthetics upon Shock-Production.

The kinetic theory of shock, as has already been indicated, postulates that all forms of shock are caused by over-stimulation and consequent exhaustion; that the cells of the brain, the suprarenals, and the liver show physical changes corresponding to each change in the clinical cycle of shock; that each shock-producing agency causes in the cells of the brain a *hyperchromatic* stage followed by a *hypochromatic* stage (Fig. 1).

The organs of the body especially involved in shock are certain organs whose function is that of converting latent energy into kinetic energy in response to adaptive stimulation. These organs, among which are the brain, the thyroid, the suprarenals, the liver, and the muscles, have been designated *the kinetic system* because of this peculiarly kinetic function. In response to environmental stimuli of any sort these organs convert latent energy into motion or into heat. Here, however, we shall consider only the conversion of latent energy into motion as a response to the need for self-preservation against physical injury.

As evidence, we shall present clinical and experimental observations of the energy-producing results of insomnia;

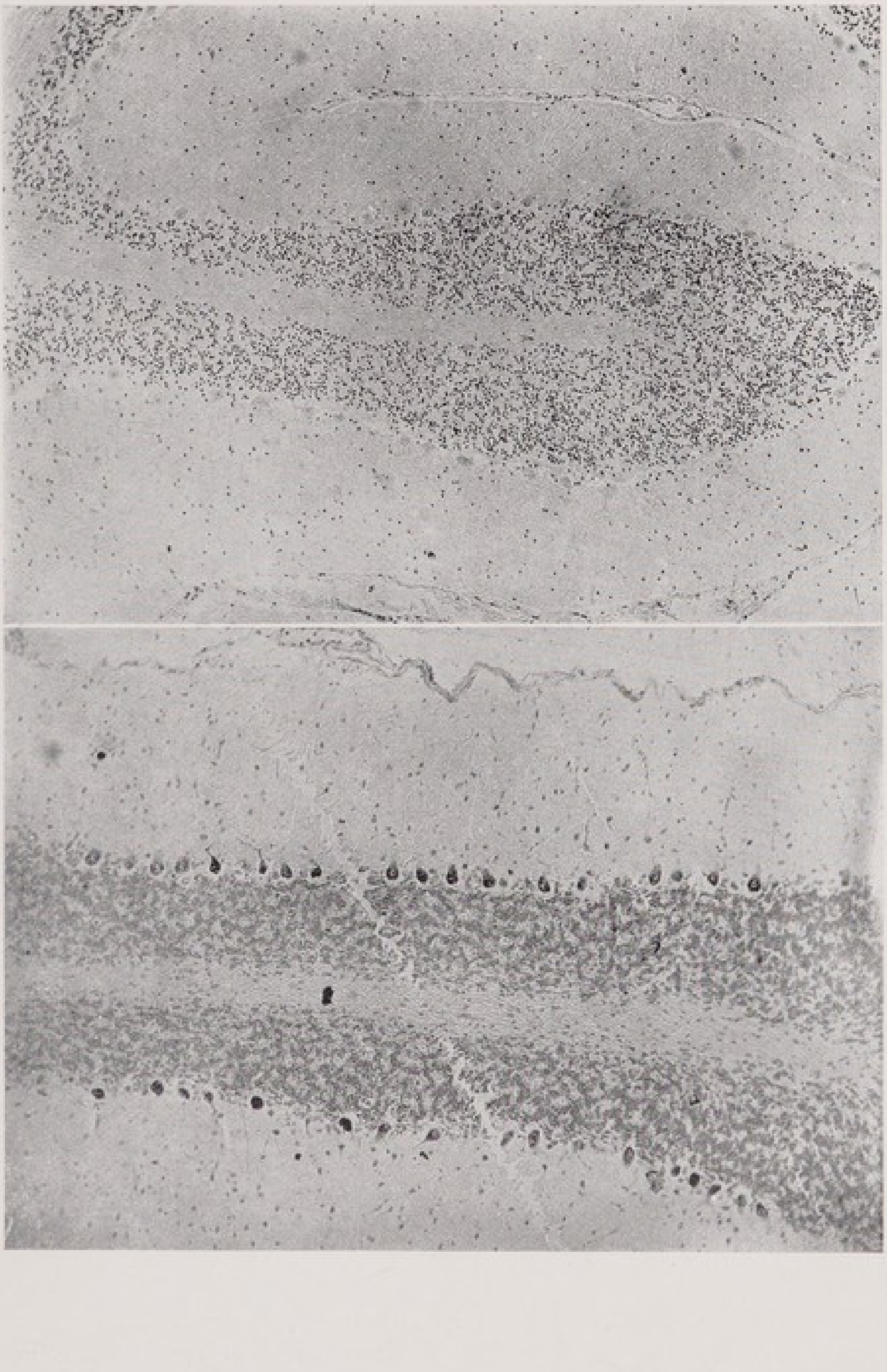


Area from cerebellum after single dose of strychnin.

Area from cerebellum after repeated doses of strychnin.

FIG. 1.—BRAIN-CELLS SHOWING STAGE OF HYPERCHROMATISM FOLLOWED BY CHROMATOLYSIS RESULTING FROM THE CONTINUATION OF THE STIMULUS.*

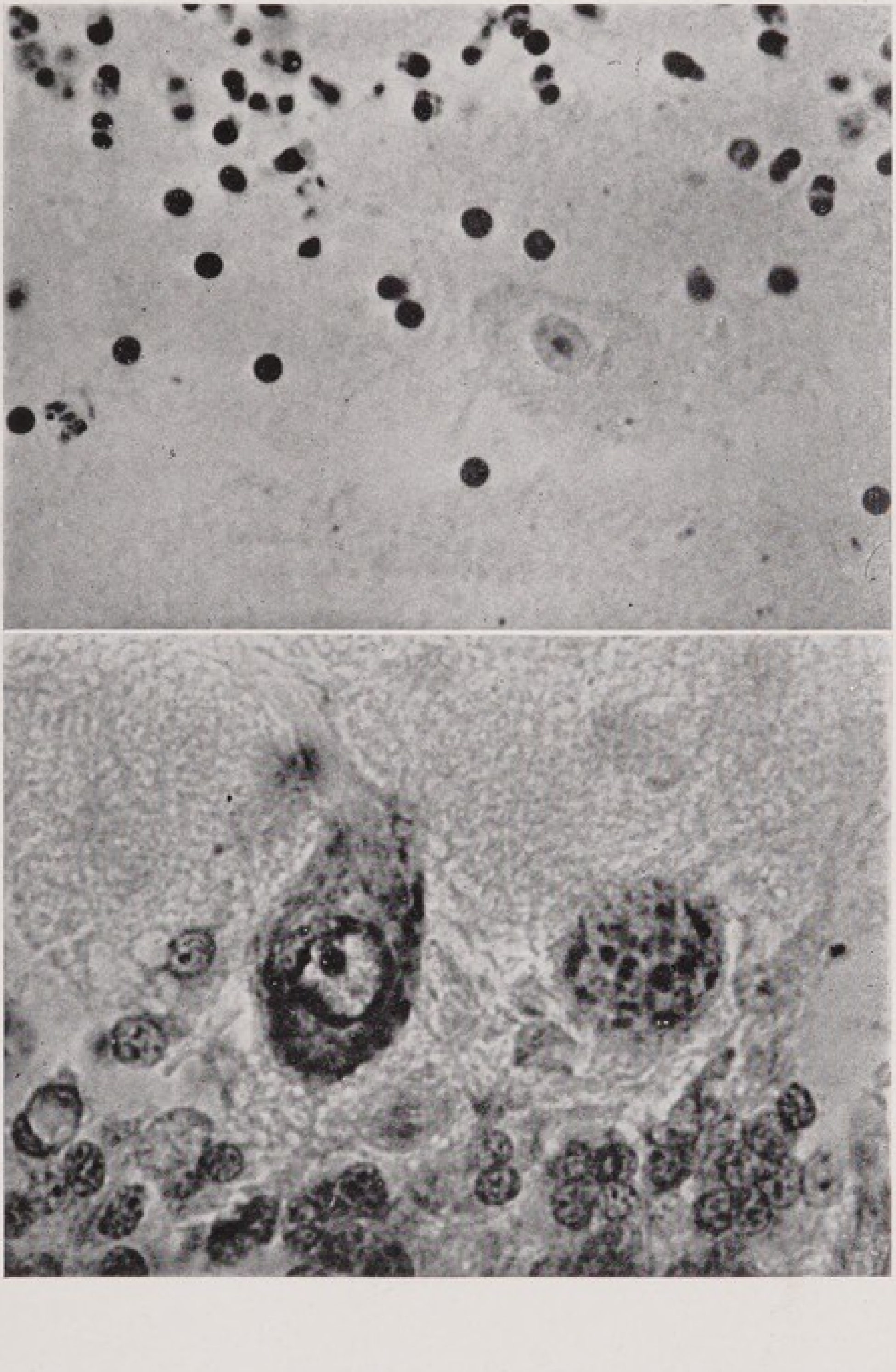
* With the exception of the microphotographs on pp. 37 and 39, the illustrations of the brain-cells are from camera lucida drawings.



A
Section of normal cerebellum of rabbit
(×100).

B
Section of cerebellum of rabbit after insomnia—109 hours
(×100).

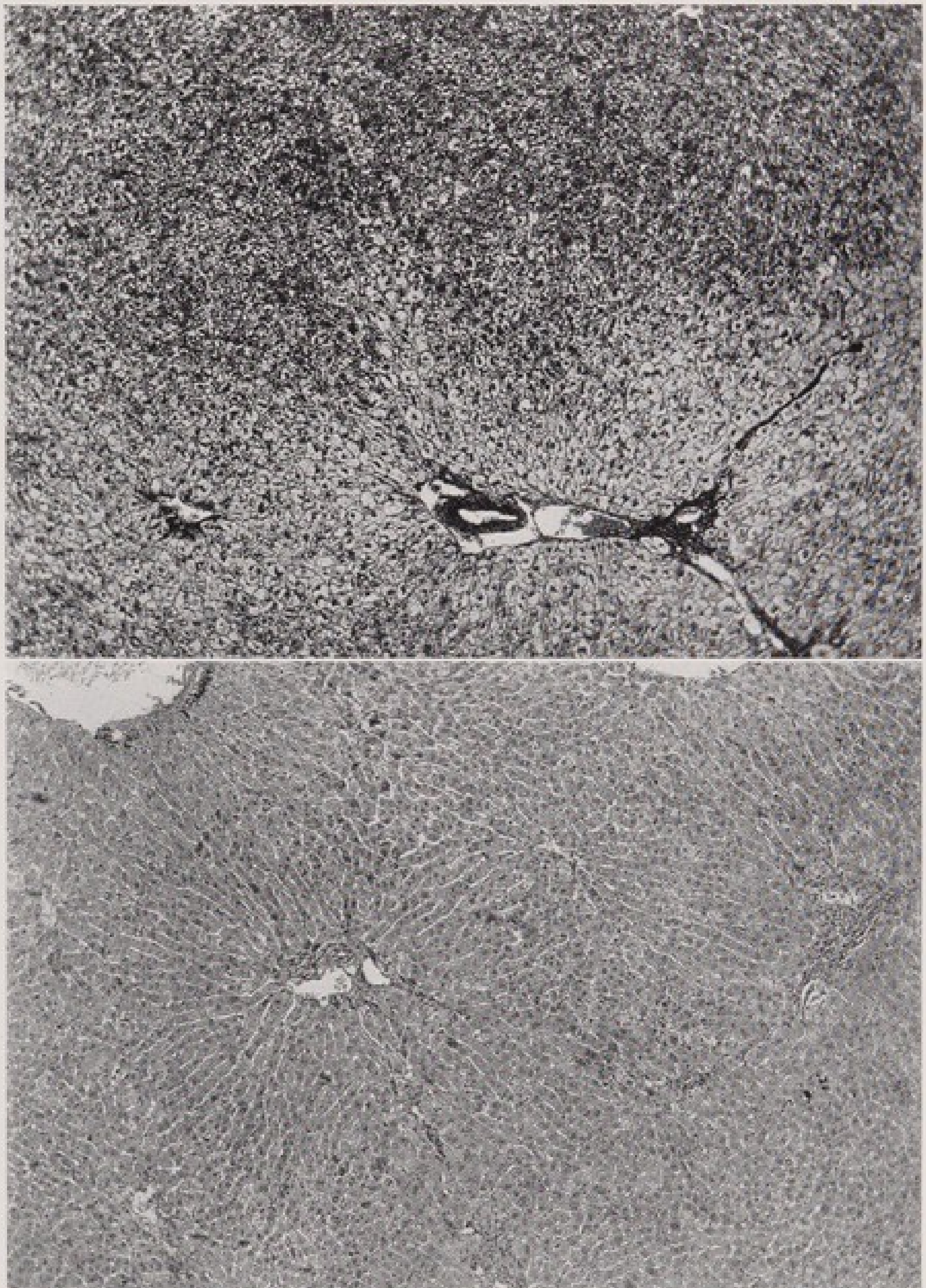
Fig. 2.—Compare the Well-stained, Clearly Defined Purkinje Cells in A with the Faint Traces of the Purkinje Cells which are Barely Visible in B.



A
Section of normal cerebellum of rabbit (×1600)

B
Section of cerebellum of rabbit after insomnia—109 hours (×1600).

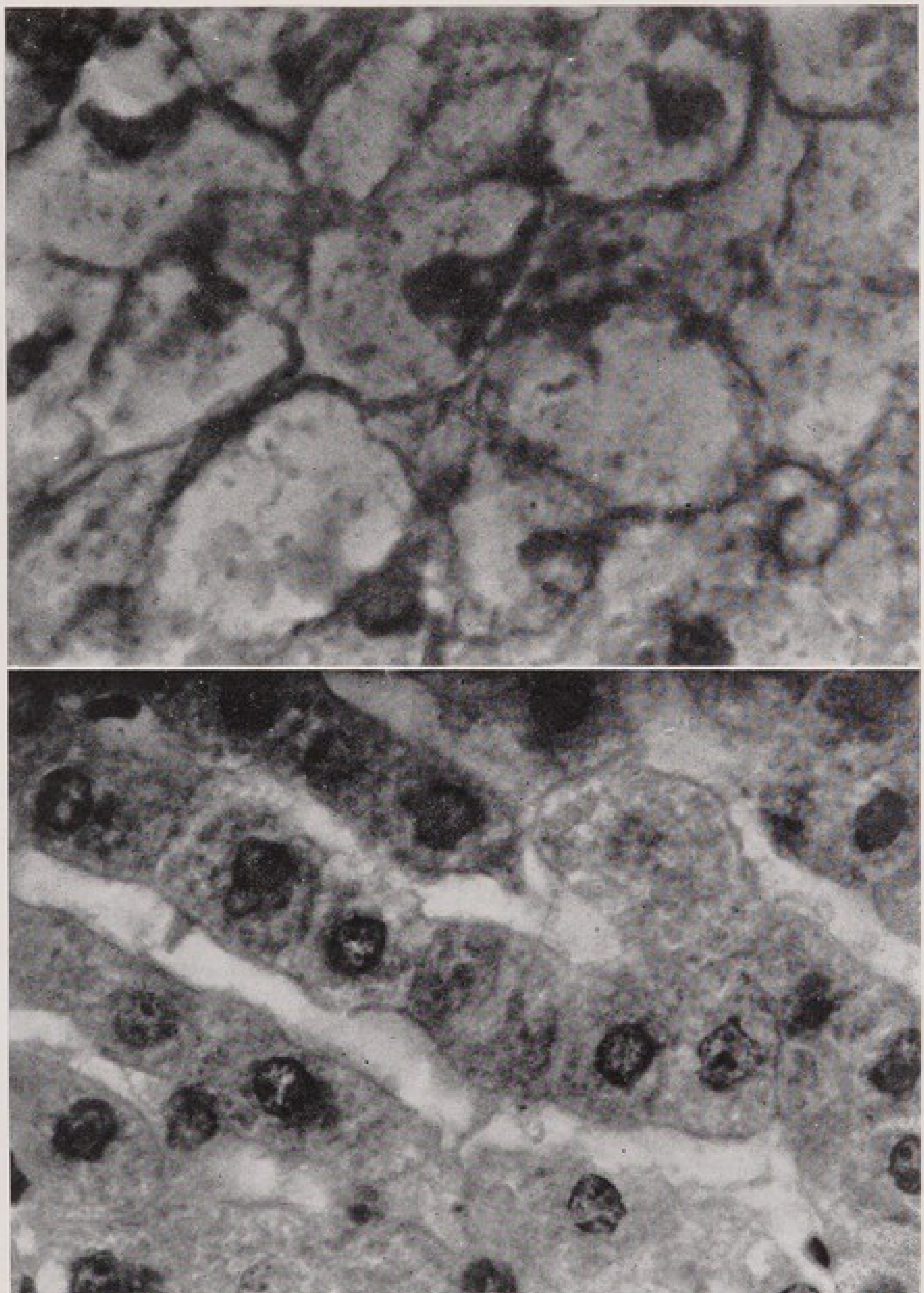
FIG. 3.—NOTE THE DISAPPEARANCE OF THE CELL MEMBRANE AND THE FAINT NUCLEUS AND NUCLEOLUS IN B IN THE ONLY PURKINJE CELL IN FOCUS.



A
Section of normal liver of rabbit (×100).

B
Section of liver of rabbit after insomnia—109 hours (×100).

FIG. 4.—NOTE THE GENERAL DISAPPEARANCE OF THE CYTOPLASM IN B.



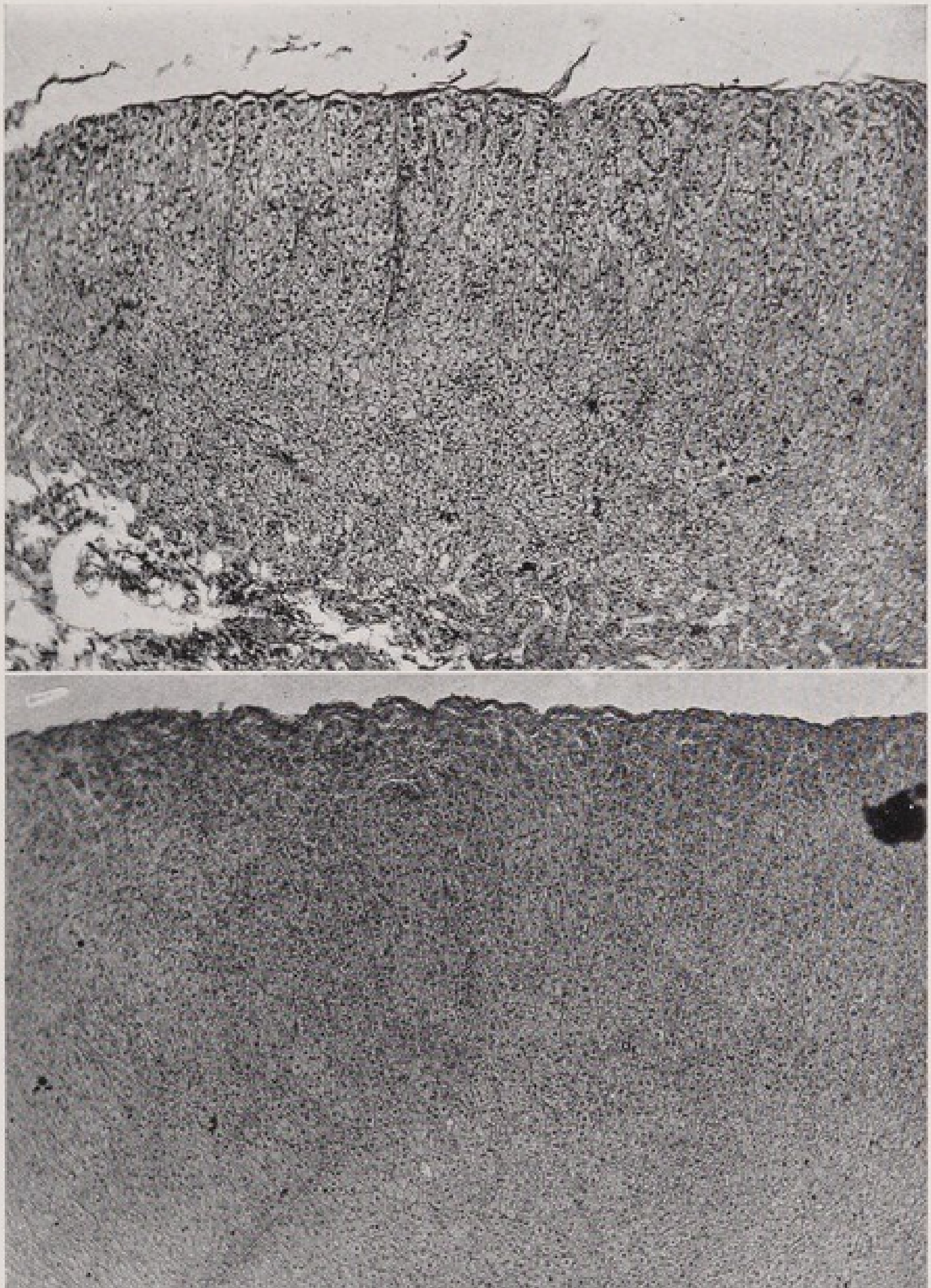
A

Section of normal liver of rabbit (×1600).

B

Section of liver of rabbit after insomnia—109 hours (×1600).

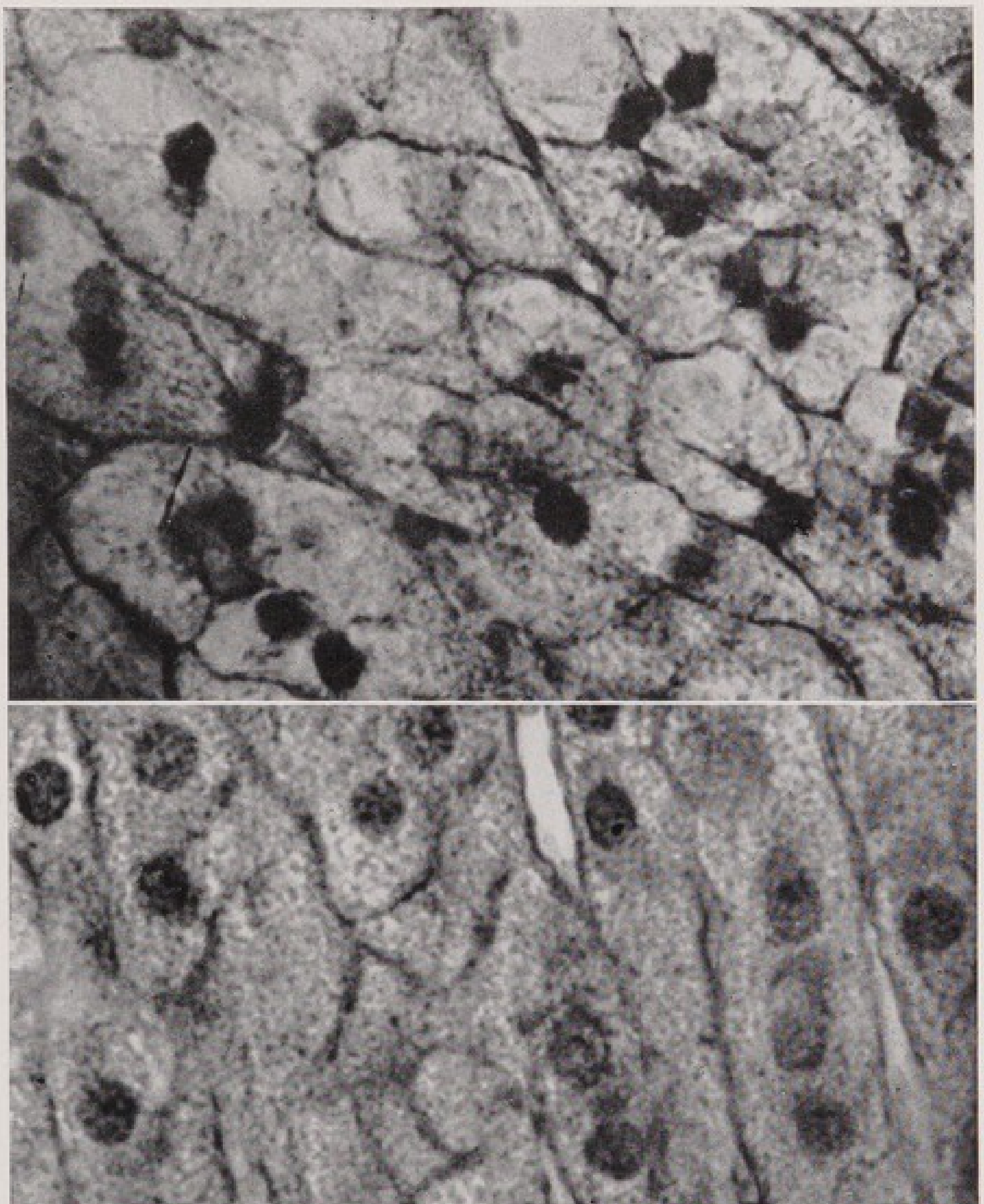
Fig. 5.—Note the Disappearance of Some Nuclei in B and the Misshapen and Eccentric Appearance of the Rest.



A
Section of normal suprarenal of rabbit (×100).

B
Section of suprarenal of rabbit after insomnia—109 hours (×100).

FIG. 6.—NOTE THE VACUOLATED SPACES AND THE GENERAL DISAPPEARANCE OF CYTOPLASM IN B.



A
Section of normal suprarenal of rabbit (×1600).

B
Section of suprarenal of rabbit after insomnia—109 hours (×1600).

Fig. 7.—Note the Eccentric and Irregularly Shaped Nuclei and the Generally Disorganized Appearance of the Cells in B.

of physical injury alone; of physical injury under inhalation anesthesia; of the emotional stimulation of fear alone; and of foreign proteid and toxic stimulation alone.

In our initial researches a working histologic standard for the brain was established and compared in a large number of brains with the immediate and later effects of physical injury under inhalation anesthesia in intact dogs and in "spinal dogs"* of physical injury in dogs with crossed circulation; and of physical injury within the territory of local anesthesia; of injections of toxins; of injections of strychnin and morphin; of various inhalation anesthetics; of severe hemorrhage and of fatigue from both physical exertion and prolonged wakefulness.

These comparative histologic studies were later extended to include the suprarenals and the liver, these organs, as already stated, being the only organs besides the brain whose cells showed immediate structural changes after prolonged stimulation from any cause.

In this thesis we shall describe in detail the brain-cell changes only. The reader should bear in mind, however, that in every case the cells of the suprarenals and of the liver showed corresponding changes (Figs. 2–7).

TRAUMATIC SHOCK

When physical injury alone was inflicted on normal dogs under inhalation anesthesia, a certain number of the brain-cells showed first a stage of hyperactivity characterized by hyperchromatism; and later a stage of exhaustion character-

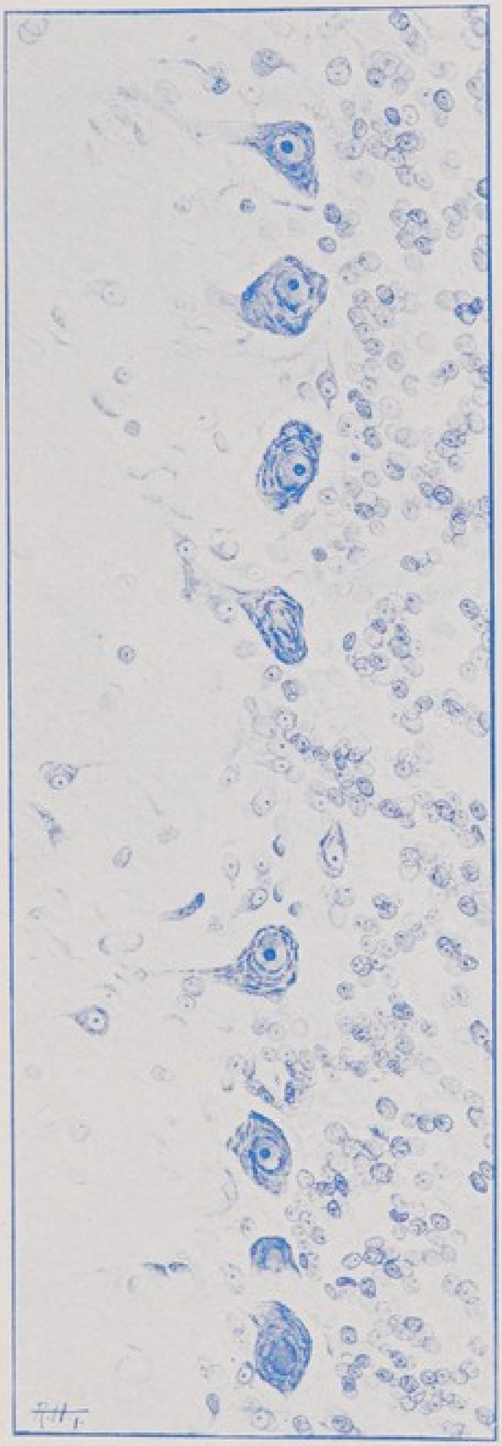
* "Spinal dogs" are dogs whose spinal cords have been divided at the level of the first dorsal segment so that the abdomen and hind extremities have no direct nerve connection with the brain.

After two months or more these animals, if kept in good condition, will show a return of the spinal reflexes,—the "scratch reflex" for example.

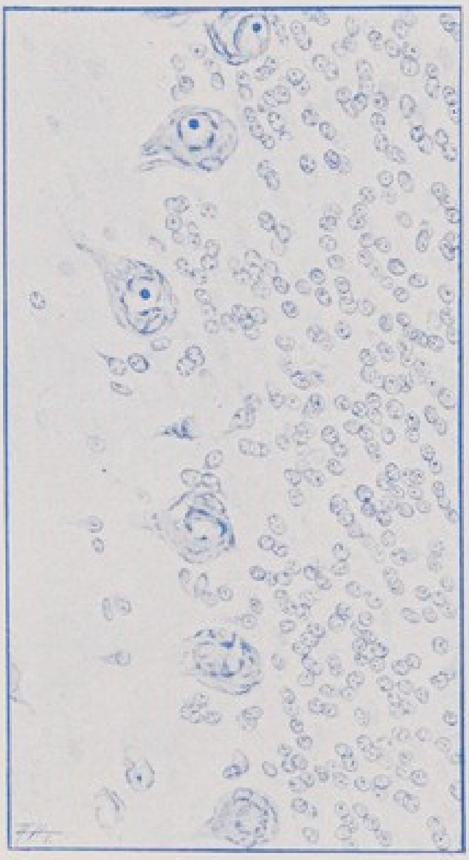
ized (a) by chromatolysis; (b) by alteration of nucleus-plasma relation; (c) by rupture of the nuclear and the cell membranes and finally (d) by disintegration (Fig. 8). These changes were most marked in the cortex and the cerebellum, but were present also in the medulla and the cord.

The brain-cells showed no change when the trauma was limited to territories disconnected from the brain by severing the spinal cord, or by local anesthetization (Figs. 9 and 10). When the circulations of two dogs were crossed and but one dog was traumatized, brain-cell changes were found only in the dog traumatized. Dogs overtransfused—to eliminate the factor of anemia—and traumatized showed brain-cell changes. When the vitality had been previously reduced by emotion, by physical exertion, by toxins, by infection, by hemorrhage, by excessive thyroid feeding, by adrenalectomy—or by any cause that reduces the vital power—greater changes were found after equal trauma, the endurance of the animal being in proportion to its vitality at the beginning of the experiment. We found that trauma under curare caused no more brain-cell changes than approximately equal trauma under ether.

From these observations we conclude that ether anesthesia offers no protection to the brain-cells against the effect of trauma and that the *lipoid-solvent* anesthetics probably break the arc which maintains consciousness beyond the brain-cells somewhere in the *efferent* path. *The afferent path from the seat of injury being unbroken, the afferent stimuli reach and modify the brain-cells as readily as if no anesthetic had been given, and it would seem that the brain-cell changes must be due to the discharge of energy in a futile effort to escape from the injury.*

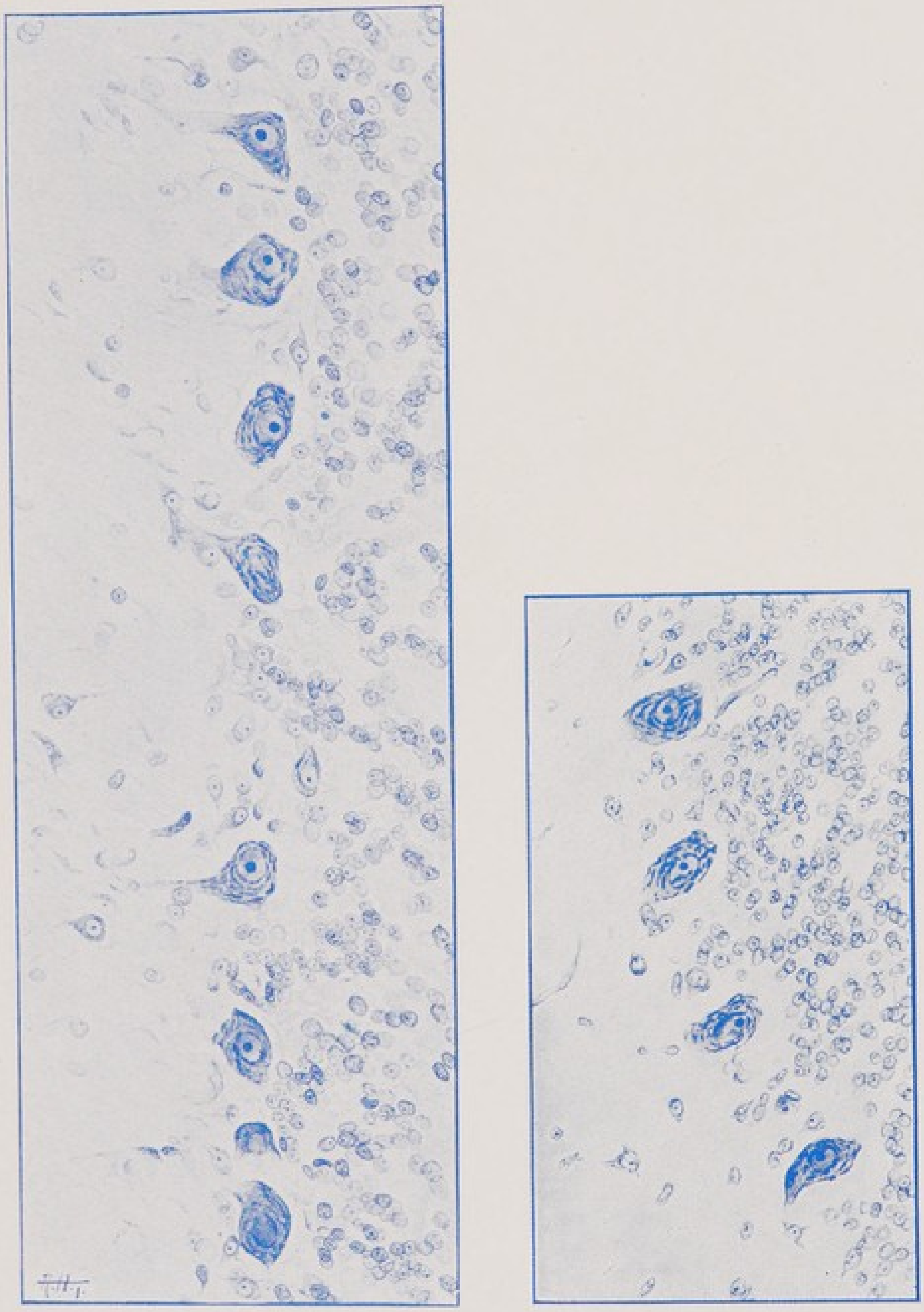


Area from normal cerebellum of a dog.



Area from the cerebellum of a dog subjected to shock-producing trauma under ether anesthesia.

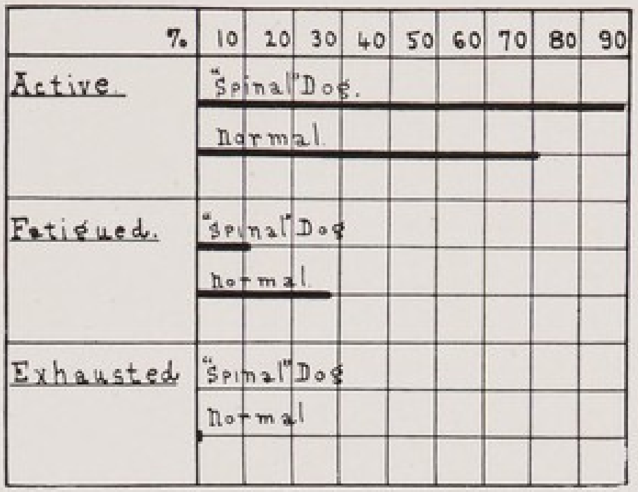
FIG. 8.—COMPARISON OF THE NORMAL BRAIN-CELLS WITH THE BRAIN-CELLS OF A DOG SUBJECTED TO SHOCK-PRODUCING TRAUMA UNDER ETHER ANESTHESIA.



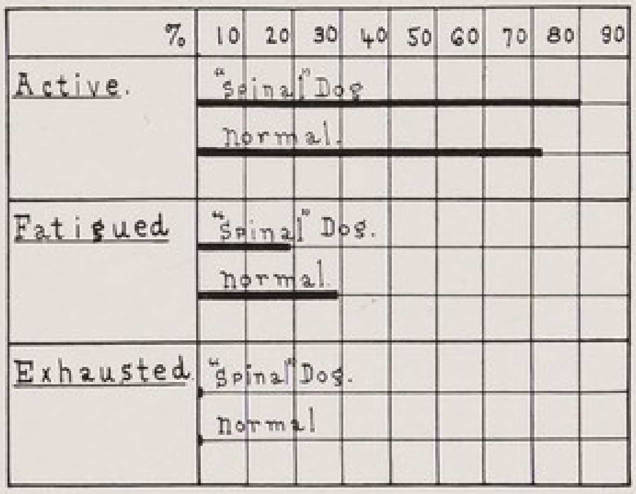
Area from normal cerebellum of a dog.

Area from cerebellum of "spinal dog" after shock-producing trauma (compare with Fig. 8).

Fig. 9.—Comparison of the Normal Brain-cells with the Brain-cells of "Spinal Dog" after Shock-producing Trauma.



Attempted shock of a dog immediately after severing the spinal cord at the seventh cervical vertebra.



Attempted shock of a dog two and one-half months after severing the spinal cord at the seventh cervical vertebra.

The dog's spinal cord was severed at the seventh cervical vertebra, recovery following after a stormy convalescence. At the end of two and one-half months the dog was given ether, and severe shock-producing manipulations were carried on for four hours. At the beginning and end of the experiment, burning both a front and a hind paw caused practically no vasomotor reaction, as shown by the blood-pressure not rising. Moreover, at the end of the experiment the blood-pressure had fallen only 8 mm. of mercury. Examination of the cord at the point of division showed only fibrous tissue. The differential Purkinje cell count showed hyperchromatism and no fatigue or exhaustion of consequence. Hence the shock-producing afferent impulses were blocked by the break in the cord and no shock followed.

Fig. 10.—Differential Purkinje Cell Counts Showing the Percentage of Active, Fatigued, and Exhausted Cells in "Spinal Dogs" after Attempts to Produce Shock by Trauma.

EMOTIONAL SHOCK

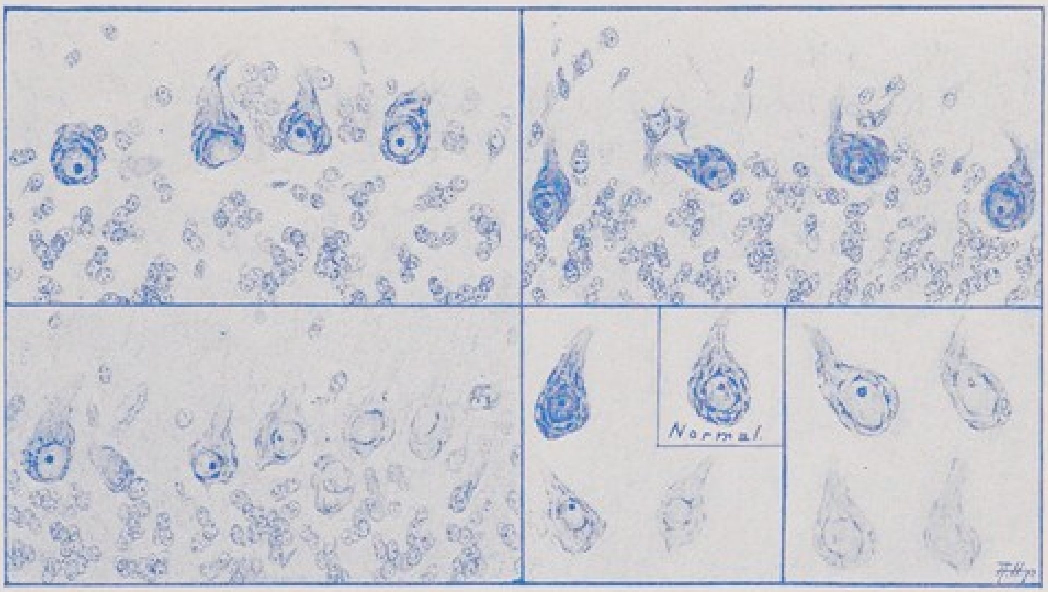
In rabbits subjected to the emotional stimulus of fear alone,—without accompanying trauma or muscular exertions,—the brain-cells show precisely the same changes as those which result from physical injury, that is, an immediate stage of hyperchromatism and a later stage of chromatolysis; a disturbance of the nucleus-plasma relation and the final disintegration of many cells (Fig. 11).

In two experiments in which rabbits were subjected to intense fear daily, in one case for two weeks and in the other for three weeks, ten per cent. of the Purkinje cells were actually destroyed. In cats the emotion of rage caused a striking increase in the output of adrenalin, but in cats subjected to fear and rage a month after the division of the major and minor splanchnic nerves, there was no increase in the output of adrenalin (Fig. 12). In rabbits acute fear caused a rise in temperature of from one to three degrees, excepting in thyroidectomized animals whose temperature remained subnormal.

TOXIC, FOREIGN PROTEID, AND ANAPHYLACTIC SHOCK

To determine the histologic changes produced by toxic, foreign proteid, and anaphylactic shock, the brains of many human beings who had died of infections and of eclampsia have been examined; and laboratory studies have been made of the brains, suprarenals, and livers of many animals into which had been injected toxins of streptococci, staphylococci, colon bacilli, gonococci, and tetanus bacilli; of animals to which had been given intravenously placental extract, peptones, leucin, skatol, extract of feces, alien blood-serum and of animals in anaphylactic shock. Without exception

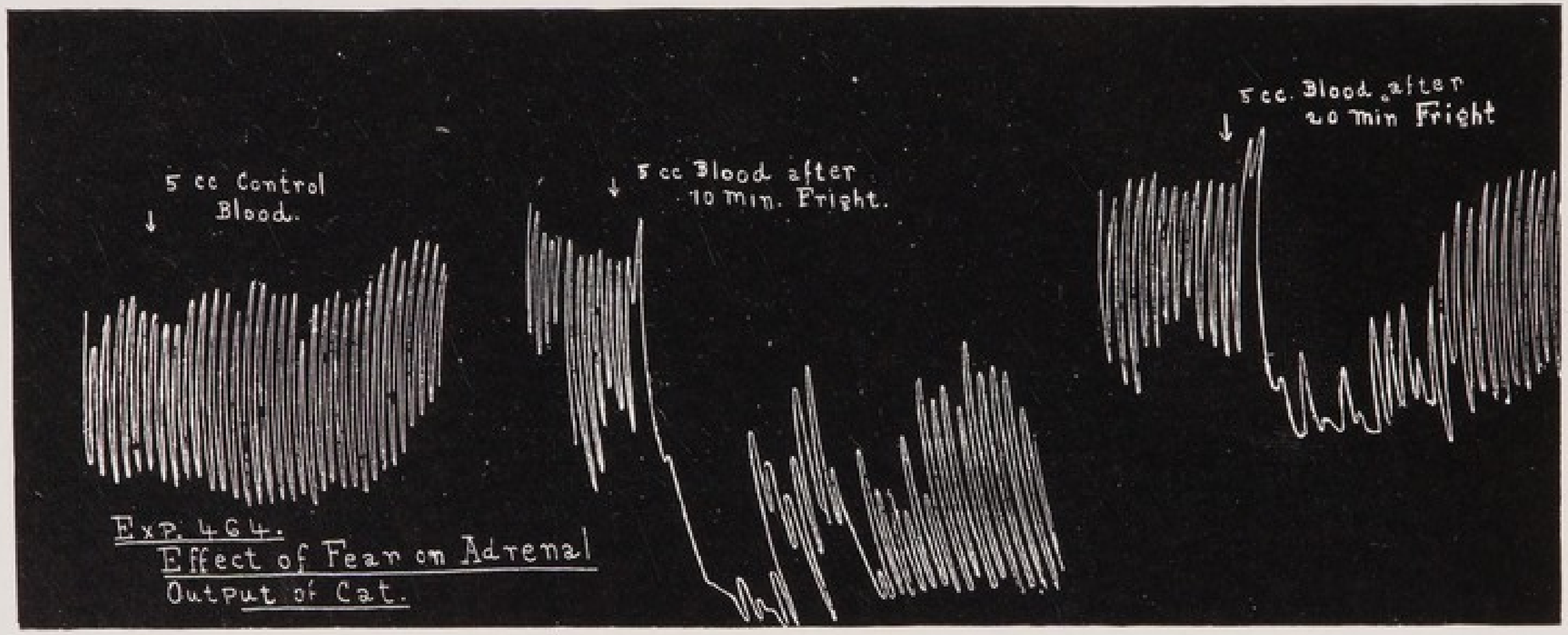
A B



C D

A, Area from cerebellum; normal rabbit.
B, Area from cerebellum; during fright.
C, Area from cerebellum; six hours after fright.
D, Area from cerebellum; characteristic changes in Purkinje cells in fright.

FIG. 11.—CHANGES SEEN IN BRAIN-CELLS OF A RABBIT SUBJECTED TO FEAR.



Control blood negative; no adrenalin present.

Positive adrenalin reaction produced by fright of ten minutes' duration.

Adrenalin still present, but in lesser amounts under the influence of the longer period of fright. The glands had probably become partly exhausted.

FIG. 12.—CANNON TEST FOR ADRENALIN, SHOWING REACTION OF THE SUPRARENAL GLANDS TO STIMULATION—FEAR.

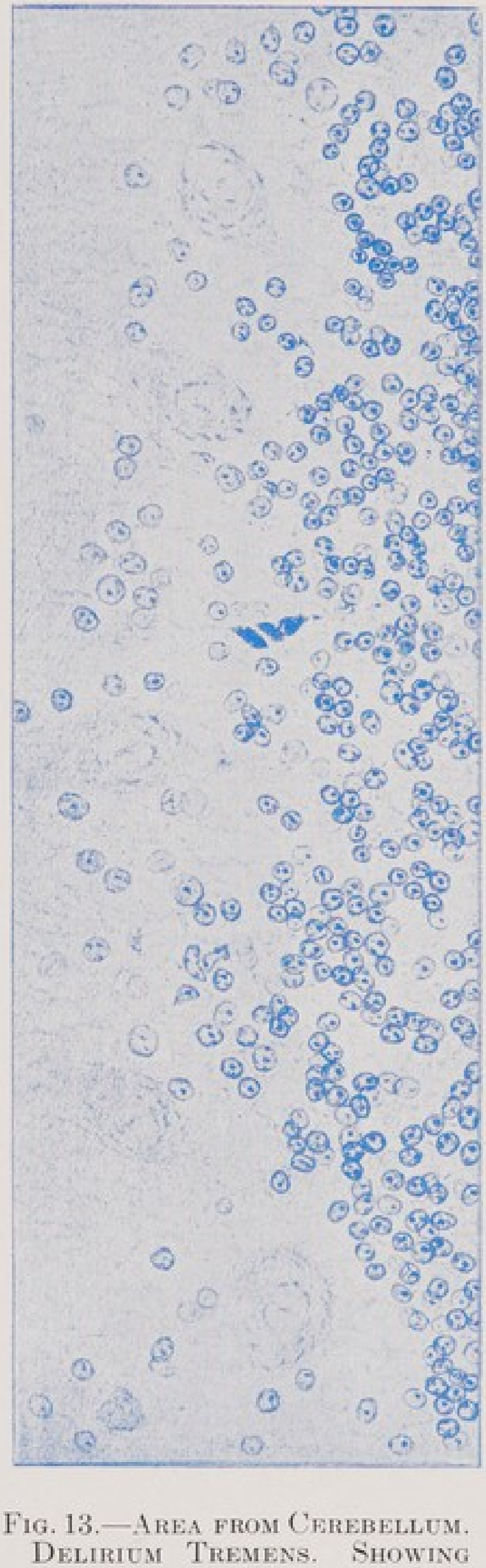
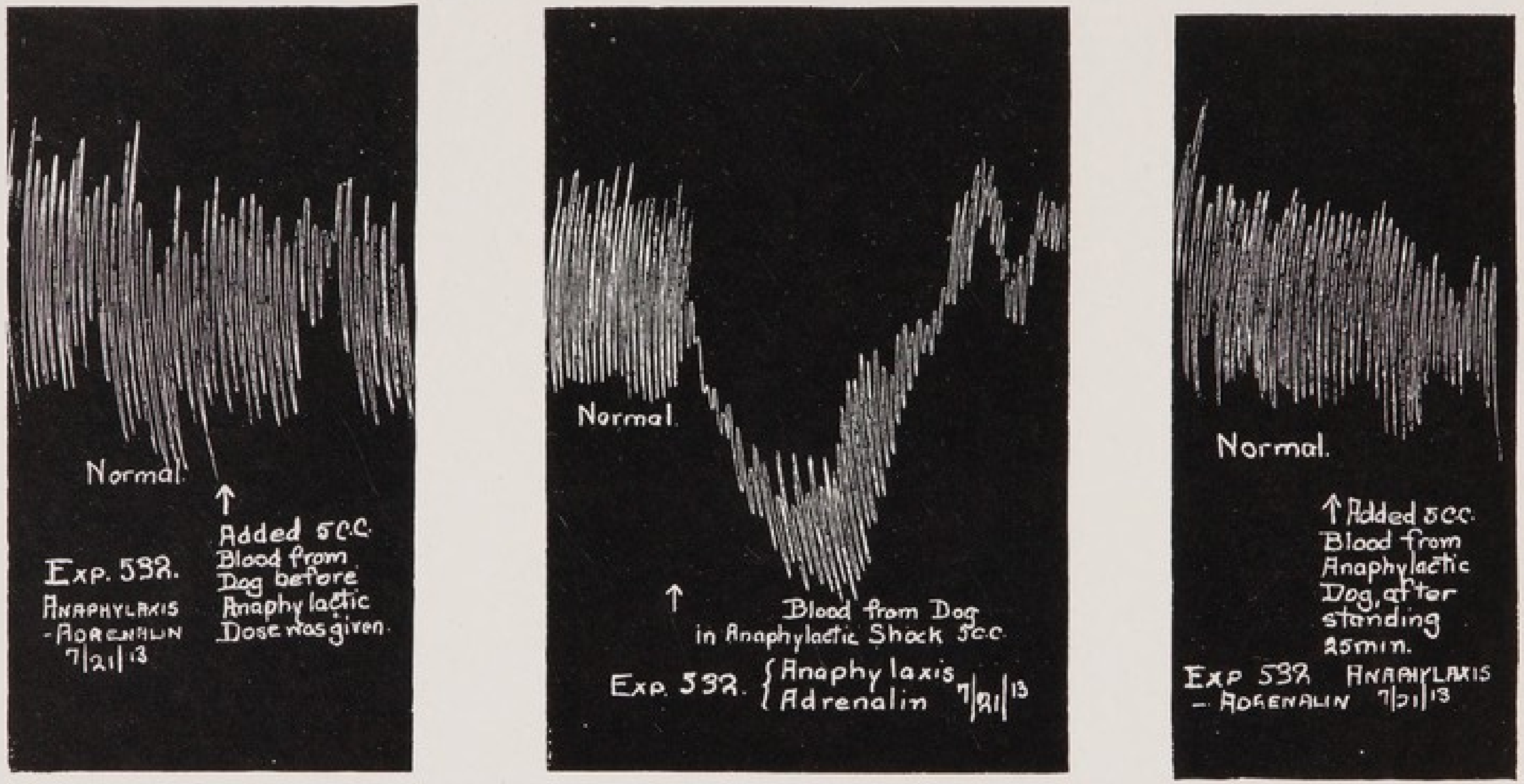


Fig. 13.—Area from Cerebellum. Delirium Tremens. Showing Effect on Brain-cells of Continued Stimulation with Alcohol

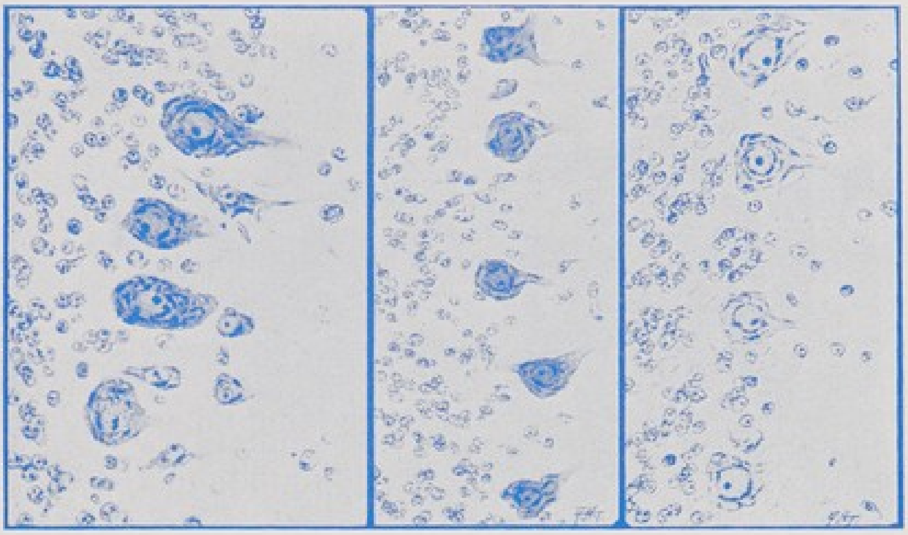


Control test negative; no adrenalin present.

Anaphylaxis test positive—that is, adrenalin has appeared in the blood and causes inhibition of the contraction of the intestinal segment.

Oxidation test negative (made by using a portion of the blood used for the anaphylaxis test after allowing it to stand for twenty-five minutes; the adrenalin has been oxidized and hence the inhibition is not repeated).

Fig. 14.—Cannon Test, Showing the Reaction of the Suprarenal Glands to Stimulation—Anaphylaxis.

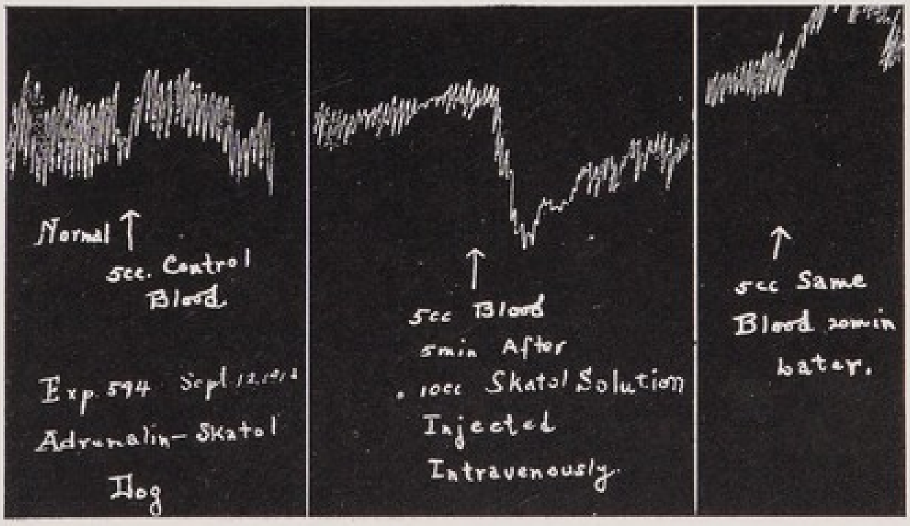


Cells from normal cerebellum.

Cells from cerebellum showing the immediate results of injection of skatol. Note the hyperchromatism.

Cells from cerebellum, showing the late results of injection of skatol. Note the chromatolysis.

EFFECT ON BRAIN-CELLS OF SKATOL INJECTION.



Cannon test for adrenalin, demonstrating the increased output of adrenalin after injection of skatol.

FIG. 15.—ACTIVATION OF KINETIC SYSTEM CAUSED BY INJECTION OF SKATOL. THESE ILLUSTRATIONS INDICATE THE EXPLANATION OF THE GENERAL EXHAUSTION SHOWN IN CASES OF AUTO-INTOXICATION.

the cells of the brain, the suprarenals, and the liver showed precisely the same changes as were seen under traumatic injury, and emotional injury—first a stage of hyperchromatism, followed by a stage of chromatolysis and—in a small percentage—a final stage of disintegration (Fig. 13). Of special interest is the fact that these various toxins and foreign proteids as well as anaphylaxis and placental extract produced a large increase in adrenalin output (Figs. 14 and 15). But these agents caused no increased output of adrenalin under the following conditions: if the nerve supply of the suprarenals had been first divided; if the blood-vessels supplying the suprarenals had been first clamped; or if the suprarenals had been excised (Fig. 16).

DRUGS—ANESTHETICS, NARCOTICS, AND STIMULANTS

Many histologic examinations of the brain-cells and observations of the adrenalin output by Cannon's method were made after the administration of ether, urethane, nitrous oxid, and morphin. None of these caused either brain-cell changes or increased adrenalin output excepting ether during the stage of excitement.

Here again it is of especial significance to note that under heavy morphin dosage there was no especial change in the cells of the brain, the suprarenals, and the liver and no increased output of adrenalin as a result of anaphylaxis, or of the intravenous injection of toxins or of foreign proteids (Fig. 17). It was found also that the *normal* output of adrenalin was diminished by morphin. Strychnin, on the other hand, caused cell changes of precisely the same type as did the emotions, toxins, and foreign proteids; that is, at first *hyperchromatism* and later *chromatolysis;* and there was also increased adrenalin output. Previous division of the suprarenal nerve-supply prevented the increased output of adrenalin, whatever the form of excitation.

These experimental results may be summarized as follows:—All the above mentioned agents that caused the activation of the *kinetic system*, whether emotional, toxic, foreign proteid, or drug, produced identical changes in the cells of the brain, the suprarenals, and the liver and also increased the adrenalin output. On the other hand, the anesthetics and the narcotics caused neither notable brain-cell changes nor increased adrenalin output, while strychnin caused both.

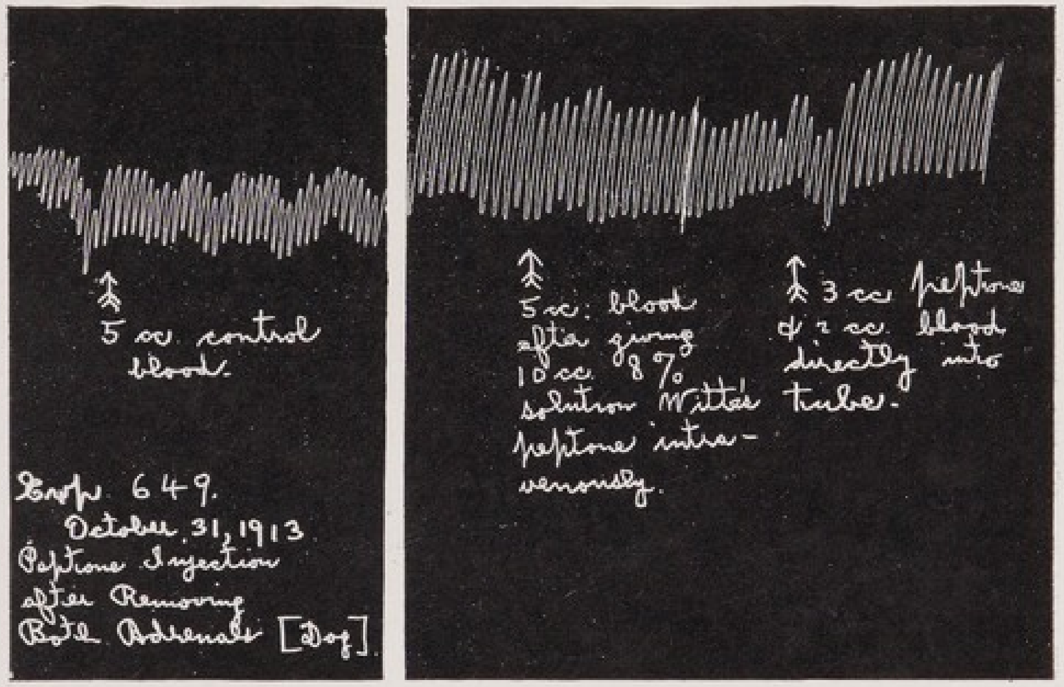
ANEMIA

The loss of blood from any cause, if it be sufficient to cause a low blood-pressure and if it be continued long enough, will cause deteriorating changes in the brain-cells.

If the hemorrhage be continued long enough and the blood-pressure be low enough, some brain-cells will be permanently lost, hence in cases of critical hemorrhage certain—perhaps only a few—brain-cells are permanently lost.

It might be supposed that the brain-cell changes found in cases of surgical shock are entirely due to low blood-pressure. That a low blood-pressure is an important factor is unquestionable in the light of our brain-cell studies, but that it is not the only factor is proved by the following experiment:

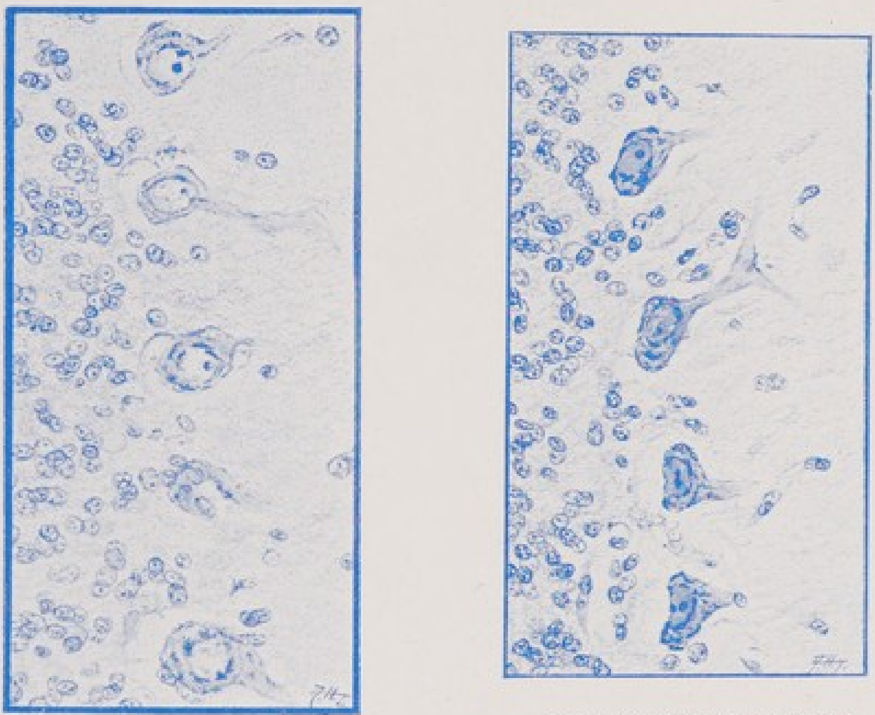
The blood-vessels of two animals were anastomosed, and as the blood-pressure in the traumatized animal began to fall, fresh blood was added, so that during the entire séance of shock trauma the blood-pressure was maintained at the normal level. Specimens of the brain were removed from the living animal and brain-cell changes were found, *but it*



Control test; no adrenalin present.

Peptone test negative because the adrenal glands have been removed and hence no adrenalin could be thrown into the circulation, as it would have been if stimulated by the peptone. This shows that adrenalin and not peptone causes inhibition.

FIG. 16.—CANNON TEST FOR ADRENALIN, SHOWING LACK OF REACTION TO STIMULATION AFTER REMOVAL OF SUPRARENAL. (Compare with Fig. 14.)



Brain-cells from dog after anaphylaxis, without morphin.

Brain-cells from dog after anaphylaxis with morphin, showing protective effect of heavy morphin dosage.

FIG. 17.—COMPARISON OF THE BRAIN-CELL CHANGES PRODUCED BY ANAPHYLAXIS ALONE AND UNDER HEAVY MORPHIN DOSAGE.

required much more trauma to produce brain-cell changes in animals whose blood-pressure was kept at the normal level than in the animals whose blood-pressure was allowed to take its downward course.

ARE THE CELL CHANGES SEEN IN SHOCK DUE TO THE PRODUCTS OF PATHOLOGIC METABOLISM OR TO ALTERED GASES IN THE BLOOD?

Thus far we have described various causes which injure the cells of the brain, the suprarenals, and the liver and contribute in varying degrees to the causation of surgical shock.

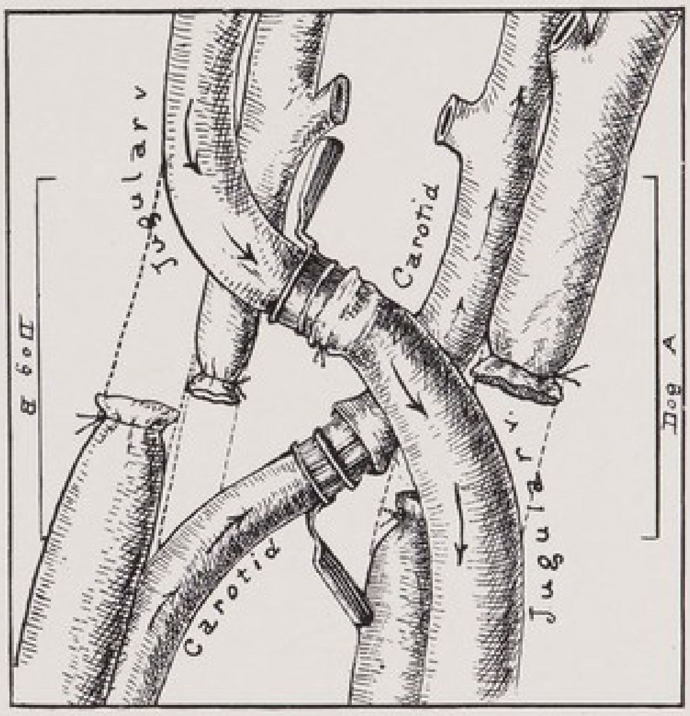
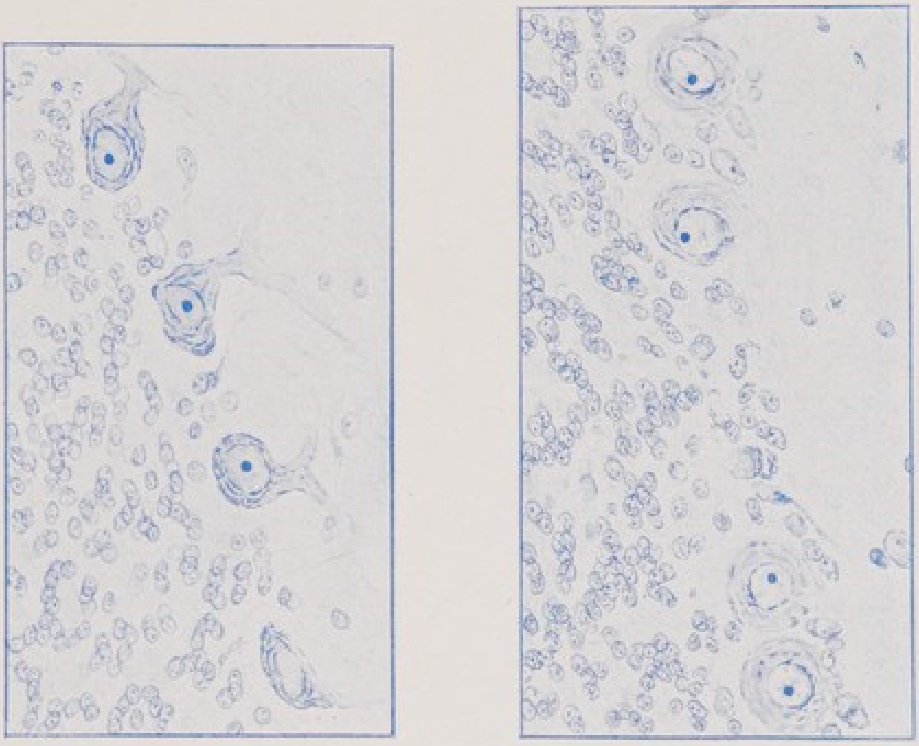


Fig. 18.—Diagram Showing Anastomosis of the Circulation of Dog A and Dog B.

We will now introduce evidence that the principal cause of these cell changes is not any gaseous change in the blood nor any noxious products of metabolism resulting from the trauma.

If the kinetic theory of shock be correct, then, if the circulation of two dogs be so anastomosed that their blood streams intermingle freely, and if only one animal be traumatized, the functional impairment and the brain-cell changes will be limited to the animal which receives the injury. On the other hand, if shock be due to the altered composition of the blood whereby the brain-cells are affected secondarily, then both dogs will suffer equally and the brain-cells of both will show like signs of deterioration. To test this crucial point, the following experiment was performed:

The proximal end of one carotid artery of Dog A was anastomosed with the distal end of the corresponding carotid artery of Dog B (Fig. 18) and one jugular vein of Dog A was then anastomosed with the corresponding vein of Dog B so that the blood streams of both animals intermingled with entire freedom and in large volume. The dogs were approximately of equal weight and physical condition. For two hours Dog A was traumatized. The animals were killed simultaneously, and their brain-cells were studied by parallel technique. The examination showed brain-cell changes—typical shock changes—only in Dog A, the dog whose body had been traumatized, and no brain-cell changes in Dog B (Fig. 19) whose body had not been traumatized, but through whose brain the blood of the traumatized dog flowed freely during the two hours. This result strongly supports the kinetic theory, and with equal strength opposes any theory which implies that gaseous changes in the blood or the formation of noxious products are the leading cause of the brain-cell changes, though undoubtedly they are a secondary cause.



Brain of untraumatized dog (dog B) Brain of traumatized dog (dog A)

Fig. 19.—Symbiotic Shock. Experiment. The Cerebellum from the Untraumatized Dog (Recipient) and from the Traumatized Dog (Donor).

THE INFLUENCE OF THE INHALATION ANESTHETICS UPON SHOCK-PRODUCTION

On our theory that the morphologic changes in the brain-cells are produced by the conversion of potential into kinetic energy, and that in this conversion of potential energy into kinetic energy oxygen is a necessary factor, one would expect to find that a given amount of trauma under an anoxyemic anesthetic like nitrous-oxid-oxygen would pro-

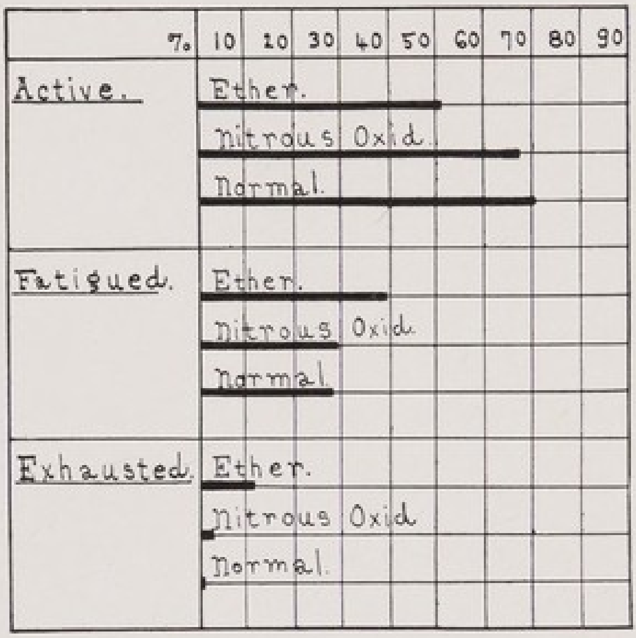


Fig. 20.—Differential Purkinje Cell Counts. Comparison of the Effects of Shock under Ether Anesthesia and under Nitrous-Oxid-Oxygen Anesthesia.

duce less change than an equal amount of trauma in an animal under ether; for nitrous oxid, unlike ether, owes its anesthetic property to its interference with the use of oxygen by the brain-cells. Testing this point experimentally, we found that under approximately equal trauma the changes in the brain-cells were approximately three times as great under ether anesthesia as under nitrous-oxid-oxygen anesthesia (Fig. 20); that the fall in the blood-pressure was on the average two and a half times greater under ether than under nitrous-oxid-oxygen; and finally, that the condition of the animal was worse after trauma under ether than after equal trauma under nitrous-oxid-oxygen. In the course of

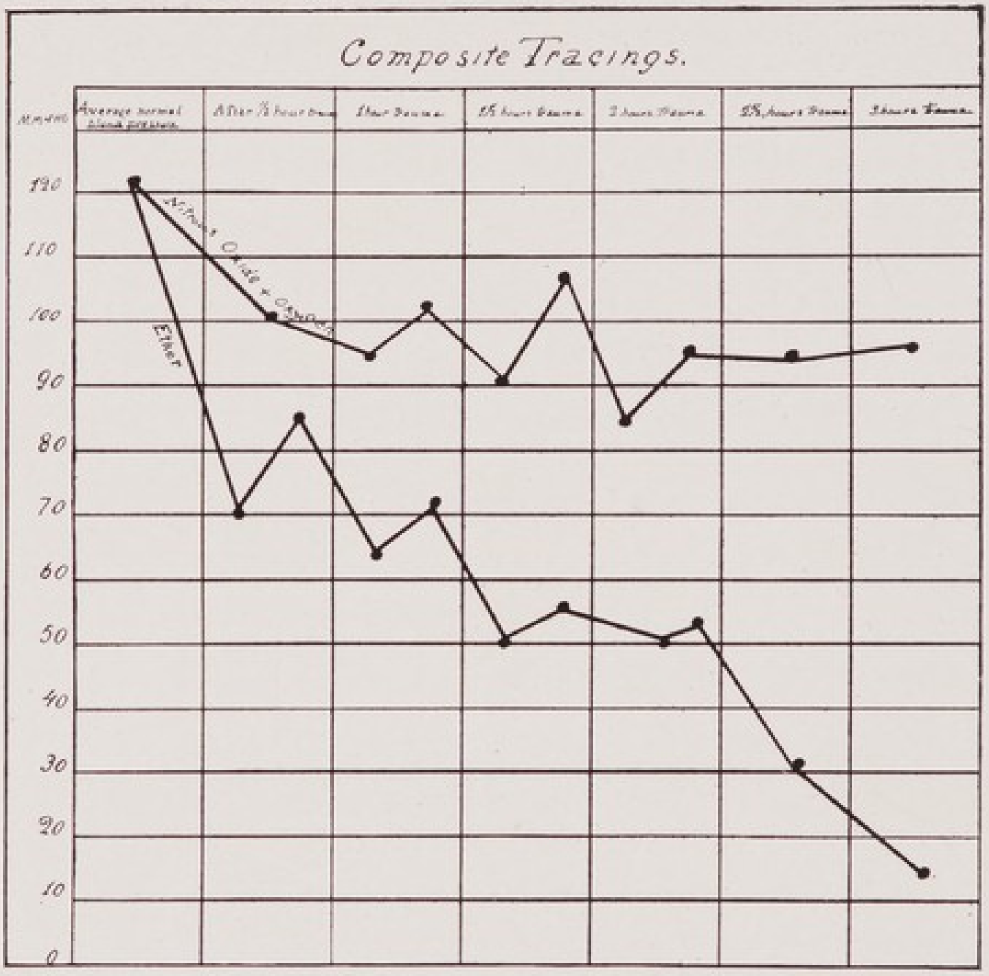


Fig. 21.—Chart Compiled from Laboratory Experiments Illustrating the Protective Effect of Nitrous-Oxid-Oxygen Anesthesia in Cases of Shock, as Evidenced by the Maintenance of the Blood-pressure.

operations on the human body one observes constantly the protective effect of nitrous-oxid-oxygen anesthesia. This, however, is what one should expect if the kinetic theory of shock be true (Fig. 21).

Then, too, the mere excitation due to the feeling of suffocation while inhaling ether causes a certain amount of exhaustion from which the patient taking nitrous-oxid-oxygen is spared.

We may conclude, therefore, that while the brain-cell changes resulting from a surgical operation are not due to the inhalation anesthetic *per se*, yet their extent is to a considerable degree determined by the anesthetic which is used. As these changes are less marked under nitrous-oxid-oxygen than under ether, the former should be the inhalation anesthetic of choice.

CHAPTER III

THE CLINICAL PATHOLOGY OF SHOCK

Shock-Producing Effect of Stimulation of the Contact Ceptors. Comparative Shock-Producing Effects of Traumata of Different Parts of the Body. Comparative Effects of Different Types of Trauma. Specificity of Nerve-Muscular Response to Adequate Stimulation. Shock-Producing Effect of Stimulation of the Distance Ceptors—the Emotions, Especially Fear.

SHOCK-PRODUCING EFFECT OF STIMULATION OF CONTACT CEPTORS

The clinical clue to the cause of the discharge of energy in a surgical operation, with the consequent physiologic exhaustion and morphologic changes in the brain, the suprarenals, and the liver, was given by the observation of the behavior of animals under deep and under light anesthesia during the infliction of physical injury. Under surgical anesthesia, rough handling of the tissues is usually accompanied by a marked increase in the respiratory rate and an alteration in blood-pressure.

Muscular response to trauma under inhalation anesthesia may be only purposeless moving, but if the anesthesia be sufficiently light and the trauma be sufficiently strong, movements—unmistakably purposive—may be produced. To injury under inhalation anesthesia every grade of response may be seen, varying from the slightest change in respiration or in blood-pressure to a vigorous defensive struggle. As to the purpose of these subconscious movements, there can be no doubt—*they are efforts to escape from injury.* The respiratory centers and the circulatory centers are doing their part in crying out—in trying to effect escape. So, too, all the rest of the brain-cells are doing their part by stimulating the motor mechanism for defense or escape, but, because of the anesthetic paralysis, the voluntary muscles cannot express themselves. Were it not for the muscular paralysis, the patient's face would, without doubt, express motor activity as strongly as it is expressed in the accompanying picture of the athlete whose motor mechanism is driven by voluntary impulses only (Fig. 22). *The motor mechanism of a patient under inhalation anesthesia may be driven even more powerfully, though in silence, throughout the course of a surgical operation.*

The result is the same as it would be if a major surgical operation were to be performed under curare alone. Curare completely paralyzes all voluntary muscles, but produces no anesthesia. It therefore gives complete muscular relaxation—a dead paralysis that would satisfy the roughest surgeon. During such an operation there would be absolute stillness, but after the paralyzing effect of the curare had worn off and the patient had again become able to express himself, what would he say? What would the surgeon think? Yet the surgeon daily inflicts equally great injury upon the brain of the anesthetized patient. For this reason a patient who enters the operating room in the flood of health and with composed face may emerge broken and shattered and with the facies of the tortured from a severe, perhaps rough, operation under inhalation anesthesia.

COMPARATIVE SHOCK-PRODUCING EFFECTS OF TRAUMATA OF DIFFERENT PARTS OF THE BODY

It is significant that the facility with which shock may be produced depends upon the part of the body injured and upon the type of trauma to which the part is subjected. We have stated that shock is the result of brain-cell exhaustion caused by powerful or frequently repeated stimuli received through the nerve ceptors. We should then expect that the greatest brain-cell exhaustion and consequent shock would result from injuries to those parts of the body most richly supplied with nociceptors.

We have stated also that the nociceptors are most abundant in those parts of the body which, in the course of evolution, have most frequently been subjected to injuring contacts with environment. That is, the nociceptors are a part of the mechanism for self-defense which during the ages of evolution has been gradually developed for the preservation of the individual and consequently of the race.

On this basis the hands and feet, and the trunk, should have many nociceptors, while the brain, which through probably the greater part of man's evolution has been protected by a skull, should have none. The first premise needs no experimental proof—daily experience is sufficient to prove to every one the rich endowment of the exposed portions of the body with these warning nerve guards. As to the second premise—it is known clinically that even in conscious patients, explorations for brain tumors with a probe elicit neither pain nor any evidence of altered physiologic functions. Realizing, however, the importance of conclusive proof of the fact that the brain possesses no nociceptors, a series of careful experiments were made. The cerebral hemispheres of dogs were exposed by the removal of the skull and dura under ether and local anesthesia. Then in each animal one entire hemisphere was slowly but completely destroyed, either by rubbing it with a piece of gauze or by burning. In no instance was there more than a slight response of the centers governing the circulation and res-

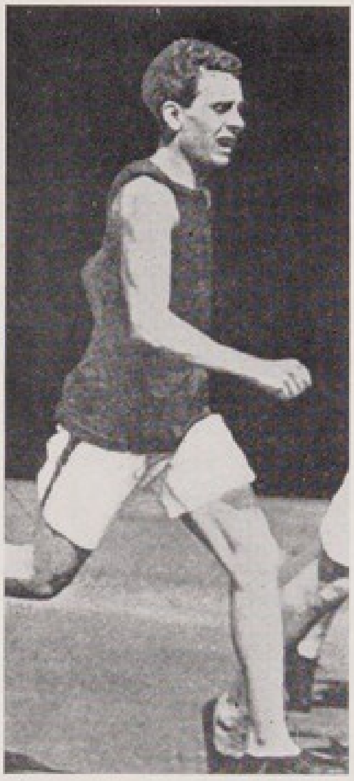


Fig. 22.—Athlete. Note the Activation of his Motor Mechanism as Portrayed in his Facial Expression.

piration and *no morphologic change was noted in the brain-cells of the uninjured hemispheres.* Collapse from interference with the medullary centers is not, of course, true surgical shock.

We must conclude, therefore, that the brain contains no mechanism—no nociceptors—the direct stimulation of which causes a discharge of nervous energy in a self-defensive action. That is, direct injury of the brain can cause no purposeful nerve-muscular action, while direct injury of the hand, for example, does cause purposeful nerve-muscular action. In like manner the deeper portions of the spinal region, the lungs, and parts protected within the thoracic cavity, have been sheltered from trauma, and they show but little power of causing a discharge of nervous energy in response to injury. Since, in the harsh period of man's evolution, injury to the heart, the brain, and the lungs led to immediate fatal results, there was no opportunity through natural selection for the development of a protective muscular reaction. These parts of necessity, therefore, were placed under special structural protection. On the other hand, injuries of the abdomen and of the chest cause intense discharges of nervous energy—these regions standing first in their capability for shock-production.

Next in order follow the extremities, the neck, and the back. In the extremities the sole and the palm are more susceptible to shock-producing injury than are the dorsa; within the abdomen, the region of the diaphragm is more susceptible than that of the pelvis; the kidneys, the ureters, and the urinary bladder have a relatively low shock-producing value, while the omentum is practically a negative tissue. As one would expect, however, injuries to the peripheral nerve trunks produce intense shock.

COMPARATIVE SHOCK-PRODUCING EFFECTS OF DIFFERENT TYPES OF TRAUMA

Not only is the degree of shock dependent upon the *part* of the body injured, but it varies also with the *type* of trauma inflicted. Powerful response is made to crushing injuries by environmental forces; to such injuring contacts as resemble the impacts of fighting; to such tearing injuries as resemble those made by teeth and claws. That is, injuries which resemble those inflicted by physical environment or by the carnivora in fighting each other and in killing their prey are the most efficient shock-producing traumata that are known.

As a significant corollary to these observations we must note that there is no nerve-muscular response—and consequently no shock—as a result of injuries inflicted by forces which are of such late development that they played no part in evolutionary history. For example, heat is a stimulus which has existed since the days of prehistoric man, while the *x*-ray is a discovery of to-day. Every one knows the intense shock produced by burns with fire, while the *x*-ray may injure the bodily tissues to the point of their destruction even without producing shock. There was no weapon in the prehistoric ages which could move at the speed of a bullet from a modern rifle; therefore, while slow penetration of the tissues produces great pain and muscular response, with consequent exhaustion, there is slight, if any, response to the swiftly moving bullet—the only obvious defense against such injury is strategy. For the same reason, the sharp division of tissues by cutting produces less response than blunt injury; *indeed, one might imagine that the body could be cut to pieces by a superlatively sharp knife ap-*

plied at lightning speed without material nerve-muscular response—hence without shock.

On this phylogenetic premise also we should at once conclude that there are no nociceptors for heat within the abdomen, because during countless years of evolution the intra-abdominal region never came into contact with heat. That this inference is correct is shown by the fact that the application of a thermo-cautery to the intestines when completing a colostomy in a conscious patient is absolutely painless.

On the other hand, just as the outer portions of the body—the skin, the ear, the nose, the sole of the foot, etc.—have developed the specific types of nociceptors best adapted for their specific protective purposes, so the abdominal viscera have developed equally specific nociceptors as a protection against nocuous influences. We must believe that there has always been the danger of perforations from ulcers in the gastro-intestinal tract; of infections following tearing injuries from without; of appendicitis; of gall-stones; of peritonitis from various causes; and of overdistention of the hollow viscera from various forms of obstruction. So we find that while the division of the intestines with a sharp knife causes no pain and consequently no nerve-muscular response, pulling on the mesentery does elicit pain and protective response because such pulling *resembles the pulling of distention.* Ligation of the stump of the appendix causes sharp, cramp-like pain; distention of the gall-bladder and of the intestines causes pain; and all these conditions may be accompanied by prostration and exhaustion.

In the course of abdominal operations, rough manipulation of the parietal peritoneum often causes a marked increase in the respiratory rate, especially in the expiratory force. Under light anesthesia severe manipulation of the peritoneum often causes such vigorous contractions of the abdominal muscles that the operator is greatly hindered in his work.

As to the reason for these subconscious movements, there can be no doubt,—they are efforts to escape from injury. Pain, wherever or however produced, or manipulations and injuries, which, in a conscious person, would cause pain, are invariably a stimulation to motor activity, whose ultimate object is protection. Thus by the muscular action resulting from pain we are protected against heat and cold; against too intense light; against local anemia caused by prolonged pressure upon any portion of the body. So, too, pain of greater or less intensity compels the required emptying of the pregnant uterus, and the evacuation of the intestine and of the urinary bladder.

As muscular activity is always the result of discharges of brain-cell energy, brain-cell exhaustion in varying degrees must be the inevitable sequence of pain. Even if the resultant muscular activity be prevented, the pain stimuli still bear their message to the brain and the brain responds, to receive again new and more powerful stimuli from the parts to which helpful activity is denied.

SPECIFICITY OF NERVE-MUSCULAR RESPONSE TO ADEQUATE STIMULATION

It should be noted that in every instance the muscular activity resulting from pain is specific in its type, its distribution, and its intensity. This specificity is true not only of pain which is the result of external stimulation, but is true also of the pain associated with certain types of infections. The infections which are associated with pain are those in which the danger may be spread by muscular action or in which the fixation of parts by continued muscular rigidity is an advantage. As a striking corollary to this fact we find that the type of infection which may cause muscular action when it attacks one region of the body, causes no such action when it attacks another region. On the contrary, in the case of the painless exanthemata, the protective response is not motor but chemical. That is, in the case of the painless infections, the defense is by the formation of immune bodies in the blood. In the case of the painful pyogenic infections, the defense is phagocytic. In these cases the parts of the body not invaded must be protected, and this protection is secured by various forms of motor activity. First, large quantities of lymph are poured out; second, the part is fixed by continuous contraction of the neighboring muscles; third, those muscles are inhibited which by their ordinary action would spread the infection; and wherever there is protective muscular rigidity, there is also pain.

In all these infections the accompanying exhaustion—shock—is in proportion to the muscular activity excited in response to the pain stimuli. This postulate is substantiated by the brain-cell findings in persons who have died as a result of pyogenic infections and in animals which have been inoculated with various pyogenic organisms. To the extent that the brain-cells are damaged by infection, the patient's margin of safety is reduced.

We must observe also as a further proof of our hypothesis that no muscular rigidity and consequently no pain is produced by pyogenic infections in those organs whose muscular contraction can in no way assist in localizing the infection. This is true of pyogenic infections in the substance of the liver; in the parenchyma of the kidney; within the brain; in the retro-peritoneal space; in the lobes of the lung; in the chambers of the heart; in the blood vessels of the chest and abdomen.

The peritoneum in its relation to vast fields of possible infection has through the law of natural selection been wonderfully endowed with the means of resisting and overcoming infection. If the focus can be localized, almost any infection can be overcome by the peritoneum. This localization is accomplished by holding the muscular abdominal wall still and rigid; by holding the muscular intestinal wall still and rigid against a large volume of gas; and by quickly throwing out a fixative fluid—or exudation. As a secondary adaptation the stomach contents are ejected by vomiting so that a protective anorexia against useless food is an added guard. Any perforation of the intestine awakens this great anti-infective adaptive motor activity. Every entrance to the abdominal cavity will awaken to some degree this protective muscular action, since the accidental openings by the forces of environment in the past must have been followed nearly always by pyogenic invasion.

If these conclusions are correct, why are certain cases, familiar to every surgeon, of wide-spread general peritonitis, or of cholecystitis, or of other abdominal lesions unaccompanied by pain, often without muscular rigidity or tenderness even, so that the surgeon may be misled, and the result may be fatal? Such patients are almost invariably found among the aged or the very young, and their existence is but a further proof of our hypothesis.

The reason why there is no pain in the aged or in the very young is because in senility the brain is so deteriorated, and in infancy it is so undeveloped that the cerebral mechanism of associative memory is inactive; hence pain and tenderness, which are among the oldest of the associations, are lacking. This same principle—the loss or obliteration of associative memory—underlies the freedom from pain in the patient under the influence of narcotics and anesthetics. Hence it is, that in the extremes of life, the diagnosis of injury and disease is beset by special difficulties, the entire body becoming as silent as are the brain, the pericardium and the other symptomless areas.

It is plain from these premises that the discharge of energy caused by an adequate mechanical stimulation of the nociceptors is best explained by the laws of evolution and association. That is, injuries awaken such reflex actions as have been developed by natural selection for the purpose of self-protection. Adequate stimulation of the nociceptors for pain, however, is not the only means of causing a discharge of nervous energy. Vast amounts of energy are discharged as a result of the gentlest stimulation of the so-called ticklish areas of the body. The resultant motor activity in such a case is a self-protective action evolved for the purpose of guarding delicate areas from gentle contacts which might be the precursors of serious injury in most important regions of the body. The ear in man and in animals is acutely ticklish—the adequate stimulus being any foreign body, but especially an insect-like contact. The discharge of energy and consequent motor activity in horses and in cattle on adequate stimulation of the ticklish receptors of the ear is so extraordinary that we must conclude that in the course of evolution such activity was of great importance to the safety of the animal. A similar ticklish zone guards the nasal chambers; here the resultant activity is sufficiently powerful to dislodge and expel the foreign body causing the ticklish contact. In fact, a sudden transition from darkness to intense light is of itself sufficient to cause sneezing. The larynx is exquisitely ticklish; the exhausting results of the coughing which may follow even slight laryngeal stimulation prove how powerful has been the consequent discharge of energy. With the ticklish areas might be classed the mouth and pharynx which possess active receptors which respond so powerfully to the presence of noxious substances that violent motor activity is excited as a result of which the most profound exhaustion is experienced. Other areas which are capable of discharging vast amounts of energy in response to ticklish contacts are the lateral chest walls, the abdomen, the loins, the neck, and the soles of the feet. Under present conditions the motor activity resulting from ticklish contacts with these regions is of little value to man, excepting perhaps the sole of the foot, where the strong muscular response which is the immediate result of even the slightest contact often is the means of escape from a painful injury.

Should anyone doubt the energy-producing power of the ceptors in the ticklish regions of the body, let him be bound hand and foot and then tickled for an hour. He would emerge from this test as completely exhausted as though he had experienced a major surgical operation or had run a Marathon race. Another witness to the exhausting effects of stimulation on one of the sensitive regions is the testimony of travellers to the prostrating results of the infliction of the bastinado, one of the most painful punishments known.

Examples of specific reaction to adequate stimulation might be multiplied indefinitely. Enough has been said, however, to show that in the course of evolution certain portions of the body were constantly exposed to danger, and that as a consequence a special mechanism was evolved for their adequate defense. This mechanism consists of nerve ceptors to receive the injurious contact; of fibers to convey the message of danger to the brain; of a store of energy in the cells of the brain which, upon the receipt of an adequate stimulus, is spontaneously released to produce a protective muscular activity. The truth of this postulate being granted, it becomes evident that the sum total of brain-cell energy must be diminished by each stimulus, and it follows as a self-evident corollary that the brain-cell energy will be most greatly diminished by injuring contacts with those parts of the body most richly supplied with nociceptors. The comparative shock-producing effects of operations upon different portions of the body are thus explained—and in the explanation appears *prima facie* one key to the achievement of the shockless operation—the use in these shock-producing regions of gentle manipulations and of a technique which—as far as possible—differs from the forces as an adaptation to meet which the defensive mechanism was evolved.

SHOCK-PRODUCING EFFECT OF STIMULATION OF THE DISTANCE CEPTORS—THE EMOTIONS, ESPECIALLY FEAR

As self-preservation is the most deeply rooted instinct in all living beings—so fear is the most widely distributed of the emotions, and the most powerful in its effect upon the organism. As the injured body tries to withdraw from painful, dangerous contacts, so the perception of threatened danger causes the body to activate itself for withdrawal. So powerful has this instinct to flee from anything which endangers the safety of the individual become that distant dangers even, or the mere memory of them, may cause all the phenomena associated with the activity once experienced by the individual or his ancestors when escaping from a present danger. The extreme prostrating effect produced in many people by the mere sight of blood can be explained only on this phylogenetic basis.

In rabbits frightened by dogs, but not injured and not chased, the principal clinical phenomena are rapid heart, accelerated respiration, prostration, tremors, and a rise in temperature. The dogs show similar phenomena, excepting that instead of muscular relaxation, as in the rabbits, the dogs show aggressive muscular action. Both the dogs and the rabbits are exhausted, but the exhaustion of the rabbits is greater even though the dogs may exert themselves actively and the rabbits remain physically passive.

The analysis of the phenomena of fear shows that, as far as can be determined, all of the bodily functions which are of no direct assistance in the effort toward self-preservation are suspended. In a voluntary expenditure of muscular energy, as in the chase or in athletic exercises, the suspension of the other bodily functions is by no means so complete. Fear, therefore, and above all fear associated with trauma may drain the dischargeable nervous energy of the body to the lowest depths and as a consequence, produce the greatest possible exhaustion, even to the point of death. Not only is this true, but fear causes a low brain threshold and, therefore, to the person obsessed by fear, all stimuli—both physical and psychical—are augmented.

After fear, anger is probably the emotion most damaging in its effects upon the body mechanism. Animals which have no natural weapons for attack do not experience anger, but when danger threatens, energize the muscles to be used for flight. On the other hand, those animals which possess weapons of defense energize these muscles for attack when in the presence of danger. Man partakes of the nature of both the fighting and the fleeing animals, and consequently fear alone may possess him, or anger alone, or his body may be shaken by the combined force of both emotions. A proof of the phylogenetic origin of anger is shown by the fact that, though the efficiency of the hands of man has largely supplanted the use of the teeth as defensive weapons, he still sets his jaw and shows his teeth in moments of great emotional excitement.

On this basis the disastrous effects of worry are readily comprehended, for worry partakes of the nature of both fear and anger. It is a chronic state of attempt to escape from some threatening evil or of futile efforts to combat the cause of some anticipated disaster. This conception explains many bodily impairments and diseases; it explains the viciousness, alternating with sulkiness, the progressive weakness, to death even, shown by animals in captivity; it explains the grave digestive and metabolic disturbances resulting from prolonged financial strain, or anxiety for one's self or others; it explains the comprehensive physical changes that are wrought by sexual love and hate; it shows how almost any factor in the environment, through phylogenetic and ontogenetic associations, may influence the functions of the bodily organs. It is because, in the uncompromising law of the survival of the fittest, man was evolved as a motor being, that each of his organs has at some time in its development served in the relentless struggle.

On this mechanistic basis the emotions may be explained as activations of the entire motor mechanism for fighting, for escaping, for copulating. The sight of an enemy stimulates in the brain those patterns formed by the previous experiences of the individual with that enemy, and also the experiences of the race whenever an enemy had to be met and overcome. These many brain patterns in turn activate each that part of the body through which lies the path of its own adaptive response—these parts including the special energizing or activating organs.

The effect of the emotions upon the body mechanism may be compared to that produced upon the mechanism of an automobile if its engines are kept running at full speed while the machine is stationary. The whole machine will be shaken and weakened, the batteries and weakest parts being the first to become impaired and destroyed, the length of usefulness of the automobile being correspondingly limited.

Since, then, deleterious effects upon the body are the result of a lack of faith, justifiable or unjustifiable, on the part of the individual in his own ability to protect himself against real or fancied hostile environmental elements, so we see that any agency which can dispel worry or can overcome fear will at once stop these body-wide stimulations and inhibitions which cause lesions that are as truly physical lesions as are fractures. The striking benefits of good luck, success and happiness; of changes of scene; of hunting or fishing; of optimistic and helpful friends, are at once explained on this hypothesis. One can also understand the sudden change from the broken body and cowed spirits of an animal in captivity to a buoyant normal condition when freed.

These facts, proved by common daily experience in the clinic and in the laboratory, show how disastrous may be the effect of the terror and anxiety natural to the patient who contemplates a surgical operation upon himself, even if all effects of the actual trauma are obviated (Fig. 23).

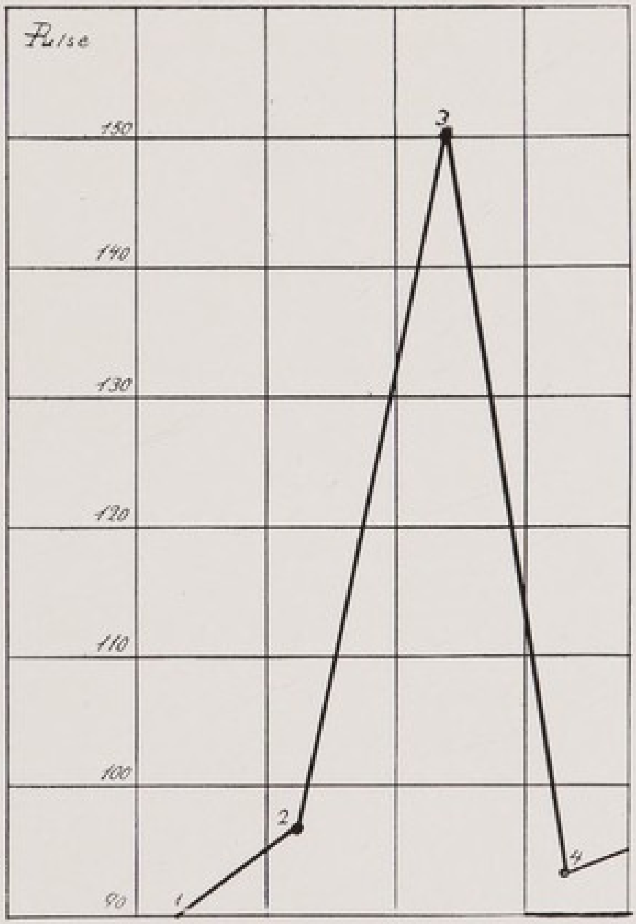


Fig. 23.—Effect of Strong Emotion—Fear—upon the Pulse.

The patient, a foreigner, was brought to the operating-room from the accident ward. Pulse and temperature normal. When he found himself in the operating-room he was greatly disturbed. It was impossible to make him understand that his leg was not to be amputated, but only a plaster cast applied. Under this physical stimulus his pulse rose to 150, and soon he developed a temperature of 101.2° F.

Every surgeon knows how much better are his results in the case of the phlegmatic patient, who views with unconcern the preparations for the approaching ordeal, than in that of the high-strung, nervous patient, whose terror may reach such a degree that the fear phenomena are evident throughout the operation in the increased circulation, the irregular heartbeat, the rapid and shallow respiration, sweating, tremors, etc.

In addition the patient who, prior to his operation, is convinced that he will die, usually does die. The quiet settled conviction is as potent in its effect as is the terror which holds the bird motionless as he watches the approaching serpent. The operation may be an exploration for a suspected cancer, of the existence of which the patient feels absolutely certain. If, after the operation, he is told that no cancer was found, he is sure that the surgeon has invented a fiction for his encouragement and that an inoperable cancer actually exists. The patient has heard often of such means being taken to bolster up the courage of the hopeless. If he be a physician, he may himself have been a party to such a deception. The force of this conviction will probably overbalance all the efforts of his surgeon. The overwhelming stimulus in such a case is the same as that which depresses the animal in captivity, or that which in our laboratory injured the brains of our frightened rabbits, and threw excessive amounts of glycogen and adrenalin into the blood of our frightened cats; the same as that which is evident in the strain and stress of life everywhere.

In these hopeless patients one sees a drawn face; the expression is despairing; digestion and metabolic changes are arrested; and insomnia is almost if not quite unconquerable. These clinical observations are at variance with the pulse and temperature, but the hopeful chart ultimately becomes as grave as the facies and to the astonishment of all but the experienced, death follows.

Internists as well as surgeons recognize that recovery is impossible or is at least prolonged in the patient who does not try to get well; and every epidemic attests the fact that many of the victims are half-killed by fear before the disease begins its easy task.

In the hospital, then, as in sports, in competition of every kind, in war, in every phase of life, faith in the outcome makes a good fighter and is half the battle. The surgeon who confines his curative measures to the operating room has fought but half his battle, for a favorable outcome will depend not only upon his operative skill but upon the success with which he can dispel doubts of the outcome and bolster up the confidence of his patients in their own inherent ability to meet the stress of the ordeal.

CHAPTER IV

THE KINETIC THEORY OF SHOCK—SUMMARY

There is a group of organs whose function is the conversion of potential into kinetic energy. These organs form what may therefore be designated a *Kinetic System*. Among the organs forming this system are the brain, the thyroid, the suprarenals, the muscles and the liver. The *Kinetic System* converts latent energy into motion or heat in response to adequate stimuli. If the stimuli are overwhelmingly intense, then the *Kinetic System*—especially the brain—is exhausted, even permanently injured. *This condition is acute shock*. If the stimuli extend over a period of time and are not so intense as to cause an immediate breakdown or acute shock, their repetition may cause the gradual exhaustion of the *Kinetic System*—a condition which may be called chronic shock. Either acute or chronic shock may be measurably controlled by weakening or breaking the *kinetic chain* at any point.

In other words, shock is the result of an intense stimulation of the *Kinetic System*,—by physical exertion, emotion, trauma, toxins, anaphylaxis, strychnin, etc.—which leads to physical changes in the *Kinetic System* and which if carried far enough exhausts that system. The *Kinetic System* is constantly activated as long as there is life, but normal activation does not produce exhaustion. If normal activity of the *Kinetic System* be exemplified by walking, shock might be exemplified by the exhaustion caused by a Marathon race.

The difference between normal processes and shock is that of intensity, not of kind. From these premises it becomes obvious that the exclusion of both traumatic and emotional stimuli will wholly prevent the shock of surgical operations.

PART II

THE TREATMENT OF SHOCK AND ITS PREVENTION THROUGH ANOCI-ASSOCIATION

BY GEORGE W. CRILE, M. D., AND WILLIAM E. LOWER, M. D.

"There are surgeons who operate upon the 'canine' principle of savage attack, and the biting and tearing of tissues are terrible to witness. These are they who operate with one eye upon the clock, and who judge the beauty of any procedure by the fewness of the minutes which it has taken to complete. There are other surgeons who believe in the 'light hand,' who use the utmost gentleness, and who deal lovingly with every tissue that they touch.

* * * * * * * * * * * * * * *

"The scalpel is, indeed, an instrument of most precious use—in some hands a royal sceptre; in others but a rude mattock. The perfect surgeon must have the 'heart of a lion and the hand of a lady'; never the claws of a lion and the heart of a sheep."—Sir Berkeley Moynihan, F. R. C. S.

CHAPTER V

THE TREATMENT OF SHOCK

Since shock is the result of over-activation and consequent exhaustion of the kinetic system, however that condition has been induced, then the two important points to be borne in mind in its treatment are (1) the prevention of further shock by the amelioration or elimination of the conditions which produced it; and (2) the support of the circulation: in other words, (1) the energy still remaining in the kinetic system must be conserved; and (2) the destructive effects of anemia must be overcome.

(1) To accomplish the first end the surgeon "must check hemorrhage; he must relieve pain; he must remove anxiety and distress. Even in those cases of shock which have suffered their misfortune before the surgeon sees them he can assist greatly by helping to blunt the sensibilities and to quiet apprehension. For this purpose morphin is the surgeon's sheet-anchor" (Mumford).

In our histologic studies of shock, we have proved that stimulating drugs cause brain-cell exhaustion. Their use in the treatment of shock, therefore, is as illogical as would be an attempt to ward off bankruptcy by spending more money. In fact we have found that the administration of large doses of strychnin is one of the most efficient means of producing shock. On the other hand, morphin and sedatives generally do not cause the expenditure of energy but aid in its conservation; such drugs, therefore, are of the greatest value directly by preventing the further exhaustion of the kinetic system and indirectly by inducing a quiet state of mind and body which further serves the same purpose.

(2) Our extensive researches to discover whether brain anemia might be safely overcome by saline infusions showed conclusively that the blood can only temporarily be safely diluted with saline solution, and that the only medium that will remain in the circulation, that will do the work of blood, and that when introduced in large enough quantities will develop a peripheral resistance by distending the elastic blood-vessels, is human blood.

This point having been determined, it became necessary to work out the problem of the transfusion of blood, first by experiment in the laboratory, later by practical application in the clinic. This has proved to be the ideal treatment for grave cases of shock. Indeed, almost no case of shock will die from the shock alone if given an adequate and timely transfusion of human blood. The transformation of the patient is dramatic, especially in those cases of shock in which hemorrhage is an important factor. It should be noted also that since low blood-pressure deteriorates the brain-cells, the collapse itself may be obviated by timely infusion. Several years ago, we found in our investigation that beheaded dogs could be kept "alive" a half day or longer either by slow adrenalin infusion or by overtransfusion of blood, by which means a normal blood-pressure was maintained without assistance from the brain. The transfusion of blood is a specialized technique, the details of which should be mastered in advance of the emergency.

Prophylaxis is of more value than treatment, however, and to the efficient *prevention of shock*, the Kinetic Theory has found the way. If shock be the result of exhaustion of the organs of the kinetic system, especially of the brain, this exhaustion being caused by traumatic stimuli, then if all *noci-stimuli*, traumatic and psychic, can be removed, the patient will be in a state of complete *anoci-association*. In as far as this ideal state can be approached, in so far will surgical operations become shockless.

CHAPTER VI

ANOCI-ASSOCIATION

Principle. General Technique; Morphin and Scopolamin; Nitrous-Oxid-Oxygen; Novocain; Quinin and Urea Hydrochlorid; Gentle Manipulations; Sharp Dissection.

PRINCIPLE

On the Kinetic Theory already enunciated in the foregoing chapters of this book a new principle of operative surgery has been founded, the "paramount object of this new technique (being) to reduce the toxic action of the general anesthetic and the traumatic factor of the operative manipulations to a minimum" (Bloodgood).

As already stated, every adequate stimulus with or without inhalation anesthesia, whether from trauma or emotion, activates the kinetic system, causing the brain-cells to discharge some of their stored energy—that is to say, the sight of the operating room, the spoken word implying danger, the taking of the anesthetic, the instrumental injury of tissues in the course of the operation, and the traction of the stitches after the operation, all are adequate stimuli. Obviously the only practical method of preventing the consumption of the energy stored in the brain-cells is the development of an operative technique which will exclude from the brain the stimuli of the special senses and the stimuli of common sensation.

The principle of *anoci-association* may be illustrated by the wrecked *Titanic*. The story of the stress and the psychic strain of the survivors is known, that of the lost may be easily imagined; the future haunting memory of this experience in the minds of the survivors may be safely predicted. Now, if a survivor of this ship had been so skilfully anesthetized in his bed just before the accident that he knew nothing of the impending disaster, and if he then had been gently carried up on deck, lowered into a lifeboat, and taken aboard the rescue ship without being allowed to awaken from his anesthesia until he was safely in bed again in a comfortable state-room,—if then he had been told that he had been transferred from the sinking ship, but that now he was safe and would soon see his home, he would have passed through the accident in a state of *anoci-association*.

Is there a single anesthetic that will exclude all nocuous or harmful physical and psychic stimuli from the brain? By blocking nerve conduction local anesthetics protect the brain from the effects of local operative injury, but *they do not protect the brain* against destructive psychic strain; inhalation anesthetics exclude the psychic stimulation of the brain-cells, but *do not exclude the operative stimulation;* and general anesthetics introduced hypodermically, being uncontrollable, are excluded on principle. Each anesthetic covers a part of the field, but there is no single agent that *alone* can produce *anoci-association*, which is the goal of operative surgery. We, therefore, do not advocate ether alone, nor chloroform alone, nor nitrous-oxid-oxygen alone; we do not advocate local anesthesia alone, nor morphin and scopolamin alone, nor spinal anesthesia alone, but through *selection* and *combination* of anesthetics we aim to attain the anesthesia that in the case in hand will exclude all stimuli from the brain, and thereby attain *anoci-association*.

We propose to discuss the technique by which a state of *anoci-association* has been attained in certain major operations; to show that not only the immediate operative results but the postoperative morbidity and mortality as well are lessened or eliminated. It may be well first, however, to say a few words regarding the *anoci-association* environment which should be sought and which has a scarcely less important bearing upon the outcome of the operation than has the operative technique itself.

The surgeon's best assurance for the successful outcome of a serious operation would be to have the patient come under his care long before the development of the trouble from which relief is desired. Unfortunately—or fortunately, according to one's point of view—this possible factor of success is not within the reach of any individual or surgeon. The surgeon, however, who too often must deal with patients heavily handicapped by factors which, if known in time, might have been controlled, is finding that by a careful, unhastened preparation of his patient he may do much to counteract the adverse conditions.

In other words, the work of the surgeon does not begin in the operating room, nor with the immediate mechanical preparation of the patient for operation, nor does it end with the healing of the physical wound. In the operating room and during the process of healing also the patient must be considered *as a whole*. That is, the surgeon, and the members of his office staff, the hospital superintendent, the intern, the nurse, the orderly—every one who comes into relation with the patient—must bear in mind that even apparently slight factors may contribute—mightily even—to his ultimate welfare. Already we have come to realize to some extent that human beings are integral organisms and that one part cannot suffer without the coincident suffering of all the rest. Yet we are prone to forget that the reverse of this proposition must be true also,—that any factor which contributes to the welfare or improvement of the condition of one part will contribute also to the welfare of all the rest.

We have stated the importance of the emotional factor in producing shock. If the natural fear of the approaching ordeal, which is felt by every normal individual, be augmented by tactless words in a surgeon's consulting room; by an ungracious reception at the hospital; by inconsiderate treatment by a nurse or orderly; by the sound of clanking instruments; by the rough or forced administration of an anesthetic; then the resistance of the patient, which is already depleted by his diseased condition, will be lowered still further. No matter how perfect and non-shocking in itself may be the technique of the operation, the results are still prejudiced by these other adverse factors.

By an assuring preoperative environment; by the definite dulling of the nerves through the administration of a narcotic; by a non-suffocating odorless inhalation anesthetic; by a local anesthetic to cut off all afferent impulses during the course of the operation; by a second local anesthetic of lasting effect to protect the patient during the painful postoperative hours; by gentle manipulation and sharp dissection,—by the combination of all these methods,—the patient is protected from damage from every factor excepting those which exist in the diseased condition from which relief is sought (Fig. 24).

The *anoci-association*, however, does not end in the operating room, nor with the return of the patient to his bed.

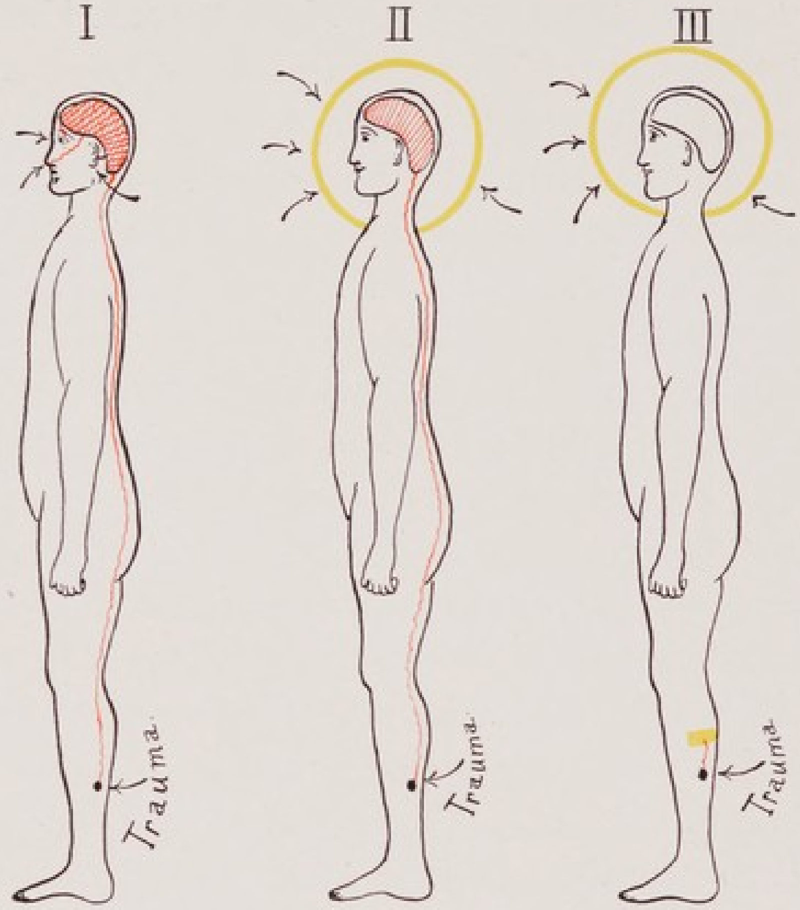


FIG. 24.—SCHEMATIC DRAWING ILLUSTRATING PROTECTIVE EFFECT OF ANOCI-ASSOCIATION.

I. Conscious patient in whom auditory, visual, olfactory and traumatic noci-impulses reach the brain.

II. Patient under inhalation anesthesia in whom traumatic noci-impulses only reach the brain.

III. Patient under complete *anoci-association;* auditory, visual, and olfactory impulses are excluded from the brain by the inhalation anesthesia; traumatic impulses from the seat of injury are blocked by novocain.

Postoperative environmental conditions are no less essential than preoperative. To perform a shockless operation on a bad risk and then have the patient distressed and nagged by poor after-care is like putting tacks on the smooth pavement in the path of an automobile after driving it safely over rough roads. To achieve the shockless operation the patient must be received and carried through a complete *anoci-association;* not only the surgeon himself, but assistants, interns, anesthetists, hospital officials and nurses must be intelligently and specially trained—but above all, it must be borne in mind that no detail is too petty for the careful attention of the surgeon himself.

General Technique

MORPHIN AND SCOPOLAMIN

To mitigate the preoperative dread and to facilitate the induction of anesthesia, a solacing dose of morphin and scopolamin (usually morphin, $\frac{1}{6}$ gr., scopolamin, $\frac{1}{150}$ gr.) is given an hour before the operation to all patients excepting the aged, the very young, and those whose feeble condition contraindicates the use of these narcotics. The use of morphin serves the double purpose of diminishing the preoperative psychic strain and of actually preventing, to some extent, the damage to the organs of the kinetic system by the trauma of the operation. Laboratory experiments have shown that in morphinized animals subjected to trauma, the changes in the cells of the brain, the suprarenals, and the liver are less than in traumatized animals without this protection.

That deep morphinization will almost completely prevent shock has been abundantly proved in both the laboratory and the clinic. A striking confirmation of this fact is found in the following case:

The patient was a woman 46 years of age with obstruction of the bowels from a large solid tumor which occupied the entire abdomen and caused distention greater even than pregnancy at term. This tumor had been explored six months previously by a skilful colleague who had wisely judged the case to be inoperable, the urgent condition of obstruction not being present at that time. When the patient came to us she was weak, emaciated and was running a slight daily fever. Under *anoci-association* the abdomen was opened and a careful search was made for the obstruction.

The widespread adhesions and the actual inclusions of the viscera in the growth soon showed us that we could not relieve the obstruction without attempting the apparently impossible removal of the tumor. When this decision was reached, the pulse had mounted to 142 and the respiration to 38.

The completion of the operation would mean resection of the bladder and of part of the small intestine. Nerve blocking in these deep fused structures was impossible. Transfusion would be insufficient to relieve the situation. Death was certain if we retreated and apparently equally certain if we proceeded. In no case could a new resource be more urgently needed.

It was at once decided to apply our laboratory findings regarding the protective effects of morphin. The operation was interrupted—the patient being kept under the lightest possible nitrous-oxid-oxygen anesthesia—while morphin was given in quarter-grain doses at ten-minute intervals until the respiration had fallen from 32 to 12 per minute. We then resumed the tedious and difficult task of separating the huge, solid, adherent, semi-malignant tumor by means of sharp dissection. To accomplish this separation, it was necessary to resect a portion of the small intestine, the entire fundus of the bladder and several inches of the right ureter, the proximal end of which was implanted into the back by Bottomley's method. The tumor had been unable to gain a sufficient blood supply through its original pedicle and had, therefore, made many vascular connections with the neighboring organs and consequently much blood was unavoidably lost during the operation. To counteract the resultant anemia a transfusion of blood from the patient's sister was given.

At the close of the operation and the transfusion, the respiration ranged from 6 to 10 per minute and the pulse rate was 134.

The patient was placed in bed in a modified Fowler position and sodium bicarbonate and glucose were given immediately by the drop method per rectum, while sufficient morphin was given in repeated doses during the first 24 hours to hold the respiration to 12 per minute. The patient made a splendid recovery from the operation.

The protective effect of morphin is remarkably exhibited also in those cases of exophthalmic goiter in which some exceptional local condition causes a break in the complete *anoci-association* of the patient, as a consequence of which the pulse and respiration increase markedly during or after the operation. In these cases, if morphin be given in repeated doses until the respiration and pulse are held stationary or fall, the dangerous exhaustion of the patient will be avoided. The morphin may be given at any time during or after the operation when it is seen that the patient's energy is being expended at too rapid a rate.

Morphin is especially useful also in those cases of acute infection in which emergency operations must be performed. In such cases morphin affords a double protection—it protects the brain against both the infection and the operative trauma, the effects of which are increased, because during the activations of a toxin, the brain thresholds are greatly lowered. Here also morphin should not be given in one dose, but in repeated doses until the physiological effect is produced. This point will be indicated by the reduction of the respiration to the normal rate or less.

In brief, by proper use, morphin to a large extent controls the metabolic processes. It should be added that it is not our intention to suggest an increase in the use of morphin in average cases, but to emphasize its usefulness when employed in physiologic dosage in certain exceptional cases.

NITROUS-OXID-OXYGEN

A full description of the technique in use in the authors' clinic for the administration of nitrous-oxid-oxygen will be given in a later chapter by Miss Hodgins. Here it is in place to repeat that nitrous-oxid-oxygen is the anesthetic of choice, as it is odorless; a few inhalations are sufficient to induce unconsciousness; it is less apt to cause nausea than is ether; and, in a great measure, it protects the brain-cells from exhaustion.

In the choice of the anesthetic, however, it should be emphasized that *the patient is the first consideration* and not the prejudice of the surgeon for a certain method. If nitrous-oxid-oxygen does not fully anesthetize the patient, as may happen in some cases and frequently does with inebriates, then in addition sufficient ether should be given to attain the desired end.

It should also be borne in mind always, that while nitrous-oxid-oxygen is the *safest* of all anesthetics in the hands of an *expert* in the technique of its administration, it is perhaps the most *unsafe* in the hands of the *inexperienced* and, therefore, it should never be administered except by an anesthetist specially trained in its use.

In training our first nitrous-oxid-oxygen anesthetist, we experimented on dogs not patients. Only after the dangers and pitfalls had been discovered and mastered in the laboratory did we cautiously introduce this anesthetic into our clinic. The training of the second anesthetist was more easily accomplished, as the first was ready to supervise every administration of the anesthetic. Lakeside Hospital now has three trained nitrous-oxid-oxygen anesthetists.

In the days when nitrous-oxid-oxygen was first used, injuriously impure gas was sometimes sold, the short anesthesia for dental purposes scarcely disclosing the defects. With the new demand, the methods of manufacture have improved. The best assurance of pure gas supplied at an even flow is secured when nitrous-oxid-oxygen is manufactured at the hospital and supplied from large gasometers to the operating room. The nitrous-oxid-oxygen used at Lakeside Hospital is supplied from a plant which has been perfected by Dr. A. R. Warner and is described by him in a later chapter.

The anesthetists at Lakeside Hospital and Dr. Teter have administered nitrous-oxid-oxygen 18,250 times for general surgical operations, and 16,714 times for oral operations —making a total of 34,964 general anesthetizations without a fatality.

NOVOCAIN

Every division of a sensitive tissue—that is, of a tissue supplied with nociceptors—is preceded by the injection of novocain in 1:400 solution. This is used routinely in all parts of the body, in all ages, in the debilitated and in the strong, in small and in extensive operations under all sorts of conditions. There are certain salient points to be observed in its use:—the tissue to be divided should be completely infiltrated—no nerve filament should be omitted. One might think of the novocain as a stain and consider that only the stained parts are ready for the knife. The infiltrated parts should be subjected immediately to pressure, as firm pressure with the hand greatly increases the efficiency of the anesthetic and the extent of the anesthetized area.

It is well to make the first infiltration between the superficial and deep layers of the skin in such a manner as to cause a pig skin appearance. This is facilitated by putting the skin on tension and then while making the injection, pushing the needle along *in* the skin parallel to the surface.

Experience in operating under local anesthesia alone is almost essential for learning how to use novocain infiltration effectively, for the conscious patient promptly protests if the infiltration is incomplete. As a result of an abundant experience with conscious patients, the surgeon, even when operating on anesthetized patients, will automatically plan the infiltration and handling of the viscera in the manner which would cause the least response were his patient conscious.

It is obvious that the anesthetic solution should be most carefully prepared and sterilized. In our clinic this is done as follows: Normal saline solution is prepared with distilled water and boiled for twenty minutes. A sufficient number of novocain crystals are added to make a 1:400 solution which is then boiled for ten minutes on two successive days.

Novocain when properly injected anesthetizes the part immediately; the anesthesia lasts for approximately an hour; and it presents no interference to the healing of the wound.

QUININ AND UREA HYDROCHLORID*

To minimize postoperative discomfort, especially in abdominal operations, quinin and urea hydrochlorid in a $\frac{1}{6}$

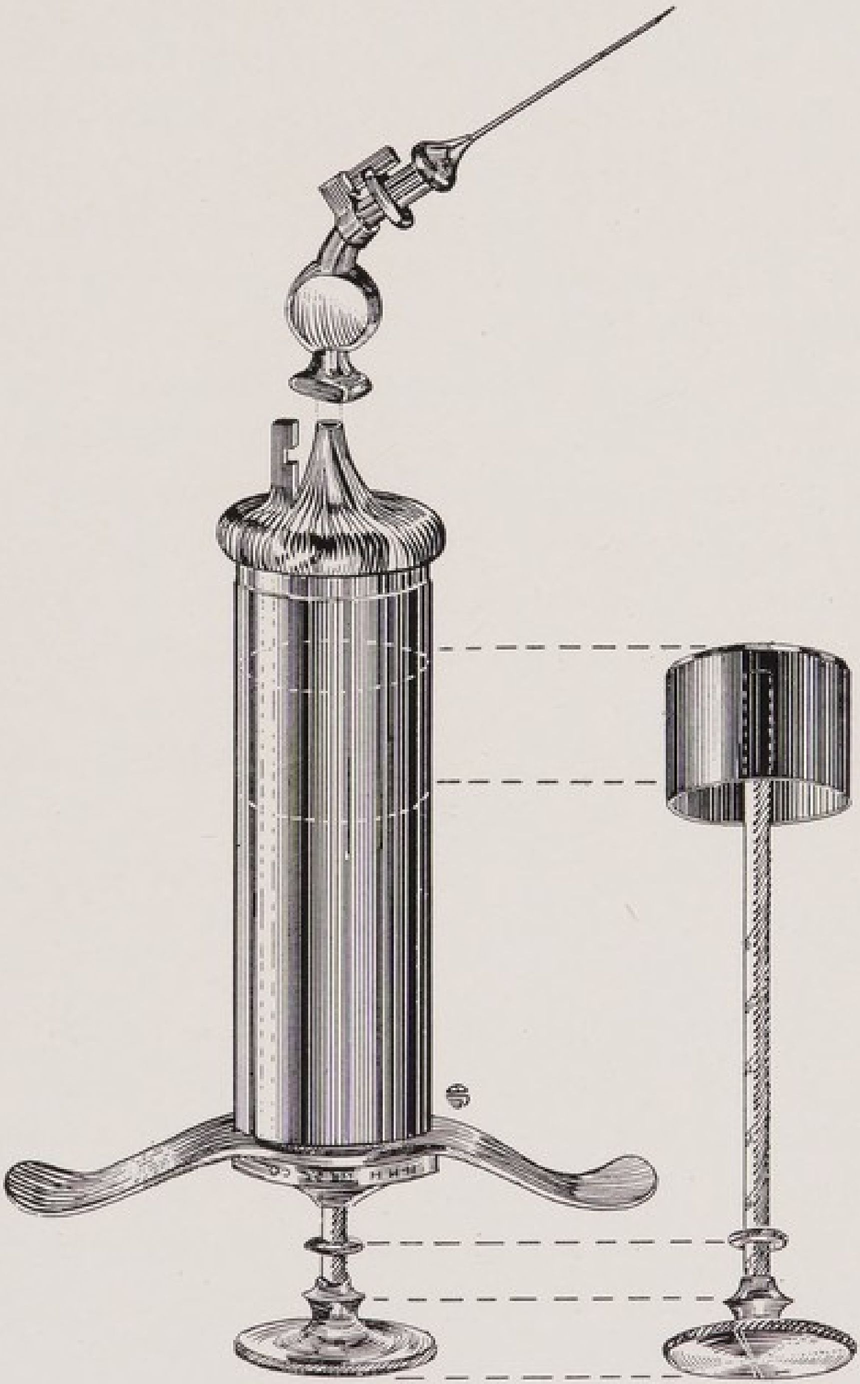


FIG. 25.—MOYNIHAN SYRINGE FOR THE INFILTRATION OF QUININ AND UREA HYDROCHLORID *at a Distance* FROM THE INCISION.

*The anesthetic properties of this drug were discovered by Thibault, of Scott, Arkansas.

to ½ per cent. solution is injected *at a distance* from the wound. The effects of this local anesthetic last for several days, so that by its use the patient is protected from noci-impulses from the operative field until the healing process has well begun. This local anesthetic can be safely used in all cases in which no infection is present, but is unsafe in the presence of infection because it to some extent diminishes the resistance of the tissues. Quinin and urea hydrochlorid usually causes some edema of the infiltrated part which may last for weeks, but which ultimately disappears. The solution used at Lakeside Hospital is prepared by boiling distilled water for twenty minutes; adding a sufficient number of sterile quinin and urea tablets to make a solution of the required strength and boiling again for ten minutes.

Moynihan has devised an excellent syringe having an obtuse-angled needle by means of which the quinin and urea hydrochlorid may be injected *at a distance* from the incision so that the entire operative field will be anesthetized for two days or more after the operation, while the wound itself is not exposed to the irritation of the quinin and urea (Fig. 25).

GENTLE MANIPULATIONS: SHARP DISSECTION

The phylogenetic facts upon which the kinetic theory of shock is founded indicate the necessity for the use of the gentlest manipulations throughout the operation. In this respect the surgeon should at all times govern his movements as he would if the patient were to be conscious of each step in the operation. Pulling, tearing, and crushing manipulations awaken phylogenetic noci-associations with consequent activation for defense, and exhaust the organs composing the kinetic system, especially the brain. In addition actual coincident trauma is produced by traction in the tissues beyond the zone which is protected by the infiltration of the local anesthetic. On the other hand the division of the tissues with a sharp scalpel is a form of injury which awakens less phylogenetic association and, in addition, produces the least amount of damage to the tissues. Gentle manipulation and sharp dissection by producing the least amount of tissue injury in turn necessitate the minimum amount of healing. *Clean-cut wounds give the least postoperative discomfort.* It should be borne in mind also that trauma, by diminishing their vitality, predisposes the tissues to infection. For every reason, therefore, the tissue trauma should be as slight as possible.

CHAPTER VII

ANOCI-ASSOCIATION IN ABDOMINAL OPERATIONS

Biologic Considerations. General Technique.

BIOLOGIC CONSIDERATIONS

Adequate stimulation of the nociceptors implanted in the abdominal wall, like adequate stimulation of the nociceptors elsewhere, causes muscular response. In the contractile response of the abdominal muscles, however, an increased intra-abdominal pressure is produced, as a result of which, when the abdomen is opened, the smooth, lubricated intestinal coils slip with wonderful facility out of the wound. Not only does this expulsion of the intestines greatly hinder the operator in his work, but it is an additional source of injury to the patient, for the added manipulation of the intestines required to replace them adds greatly to the production of shock.

Muscular contractions of the abdominal wall may be prevented by the administration of an anesthetic which will produce in the brain such a deep state of anesthetic paralysis that no adaptive muscular response will be made to the operative stimuli which are received by the brain-cells. Less muscular relaxation is produced by nitrous-oxid-oxygen anesthesia than by either of the lipoid-solvent anesthetics—chloroform and ether. For this reason nitrous-oxid-oxygen—a less paralyzing anesthetic—does not prevent the adaptive contractile response of the strong abdominal muscles during injury to the abdominal wall as completely as either chloroform or ether.

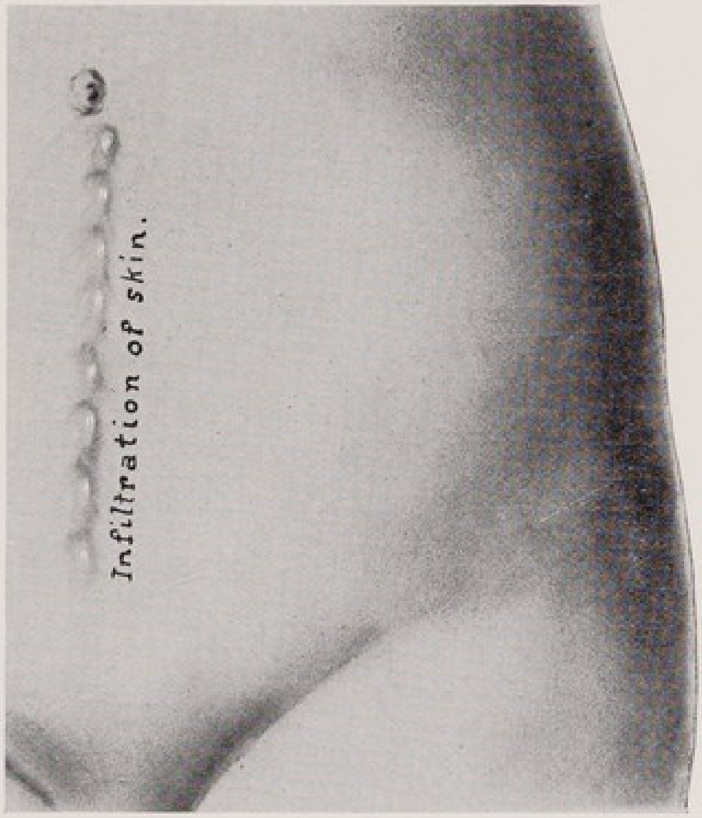


FIG. 26.—ABDOMINAL OPERATIONS: INFILTRATION OF SKIN AND SUBCUTANEOUS TISSUES WITH NOVOCAIN.

To prevent expulsion of the intestines, therefore, one must either employ the lipoid-solvent ether in rather large dosage, or one must prevent the impulses of the operative trauma from reaching the brain. This latter result may be accomplished by the use of either spinal anesthesia or local anesthesia.

(a) *Spinal anesthesia* would be the method of choice had it not three disadvantages: first, spinal anesthesia causes a considerable fall in the blood-pressure because it cuts off nerve communication with the vasomotor center in the brain from a large vascular field—the splanchnic territory and the lower extremities; second, thus far the mortality rate with spinal anesthesia is higher than with ether or nitrous-oxid-oxygen; and third, since the patient is conscious he undergoes a heavy psychic strain. Minor disadvantages are postoperative headache and the fact that analgesia is occasionally incomplete.

(b) *Local Anesthesia.*—There is ample evidence that many abdominal operations may be painlessly performed under local anesthesia alone; but as with spinal anesthesia, in the average patient that stringent and most exhausting emotion—fear—is excited by the knowledge that the abdomen is open, that serious conditions may arise, and that grave consequences may ensue. Such a psychic ordeal may break down the bravest patient and cause not only mental distress, but, as we have shown elsewhere, actual physical injury as well. The flushed or pallid and sweat-covered face of the conscious patient portrays all too well his deep apprehension and distress—far beyond the possibility of assuagement by any effort on the part of the operator. In routine operations, therefore, *the laparotomized patient should be asleep.*

GENERAL TECHNIQUE

Excepting to the very young, the aged and patients with depressed vitality, $\frac{1}{6}$ gr. morphin and $\frac{1}{150}$ gr. scopolamin are administered one hour before the operation. The young, the old, and certain handicapped patients are not given this preoperative sedative dose.

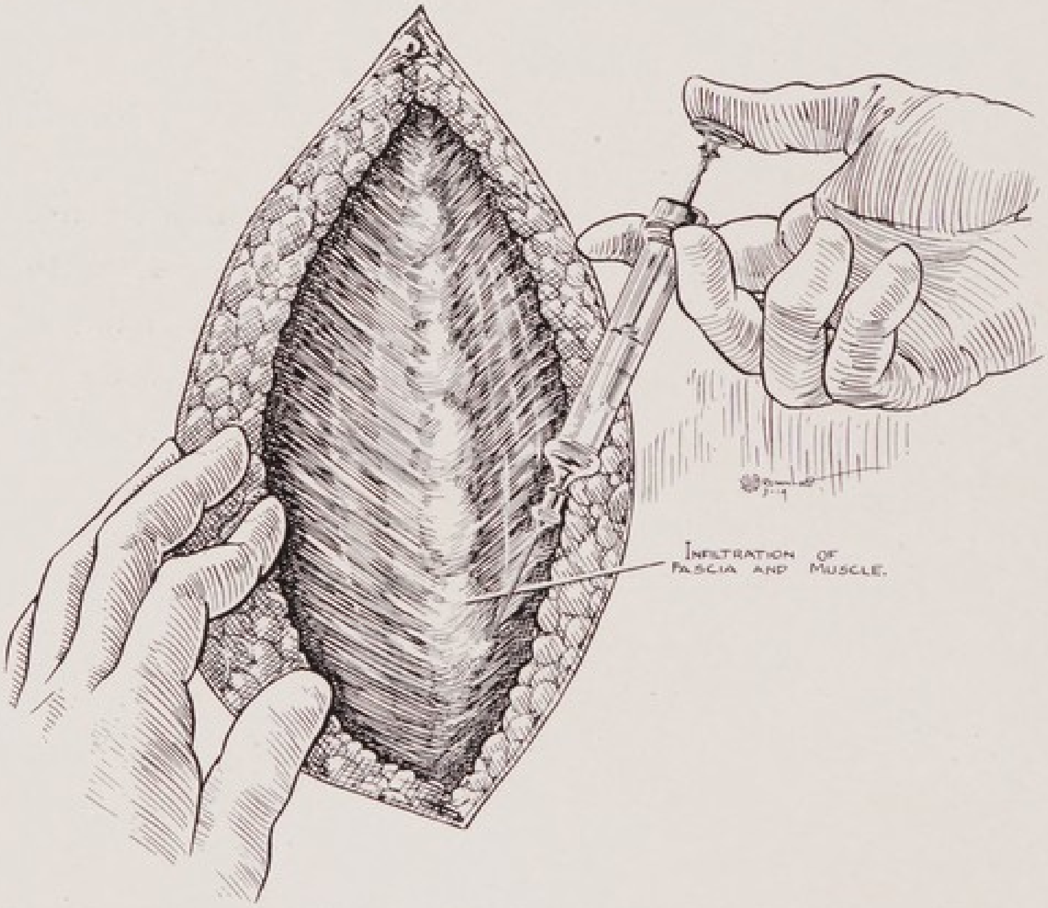


Fig. 27.—Abdominal Operations: Infiltration of Fascia and Muscle with Novocain.

The skin is infiltrated with novocain in 1:400 solution in such a manner as to produce a broad, white elevated strip of skin within which—*strictly within which*—the incision is made (Fig. 26). The razor-edged knife, at a low speed so controlled that the line of incision may not pass the anesthetized zone, divides the skin and the underlying fat. As fat is but sparsely supplied with nociceptors, this tissue may be divided down to the external fascia without novocain infiltration.

The external fascia is next infiltrated carefully and is divided by the controlled passage—*not sweep*—of a sharp

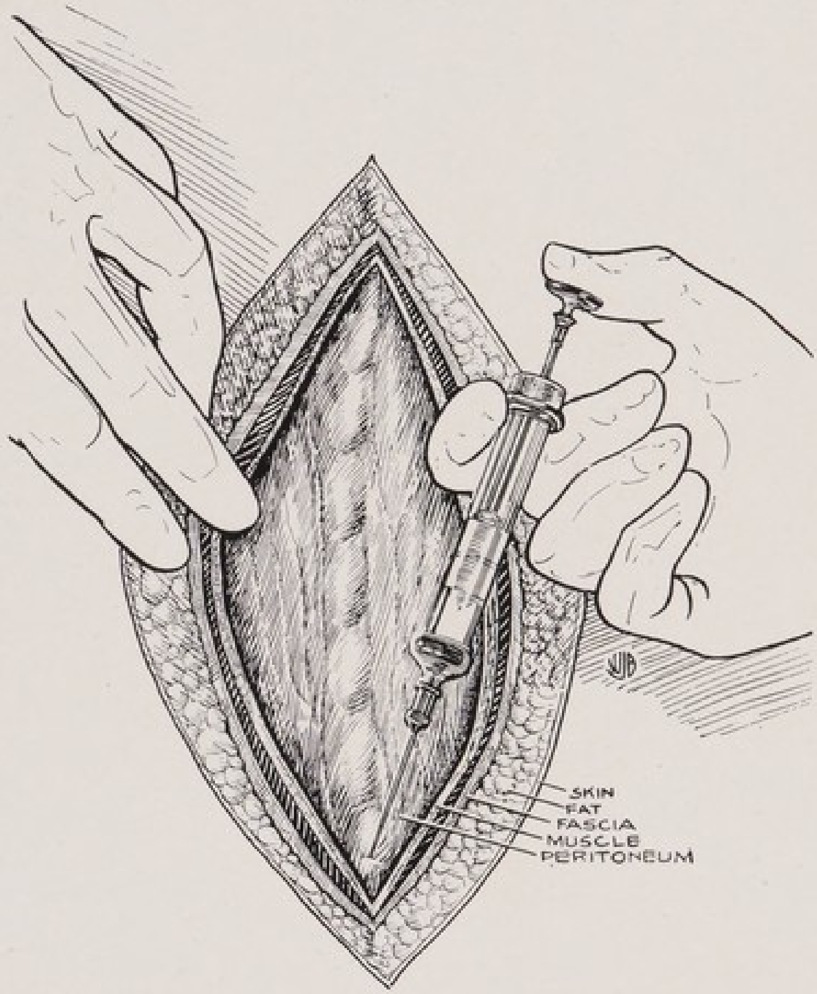


FIG. 28.—ABDOMINAL OPERATIONS: INFILTRATION OF POSTERIOR SHEATH AND PERITONEUM WITH NOVOCAIN.

scalpel, and then in succession the muscles, the posterior sheath and the peritoneum are anesthetized and divided (Figs. 27 and 28).

As soon as the abdomen is opened quinin and urea hydrochlorid in a $\frac{1}{6}$ to $\frac{1}{2}$ per cent. solution is used in a massive infiltration of the abdominal wall,—*at a distance from the* *incision,*—the infiltration being so complete that the entire operative field is physiologically severed from the brain (Fig. 29). The effect of quinin and urea hydrochlorid lasts

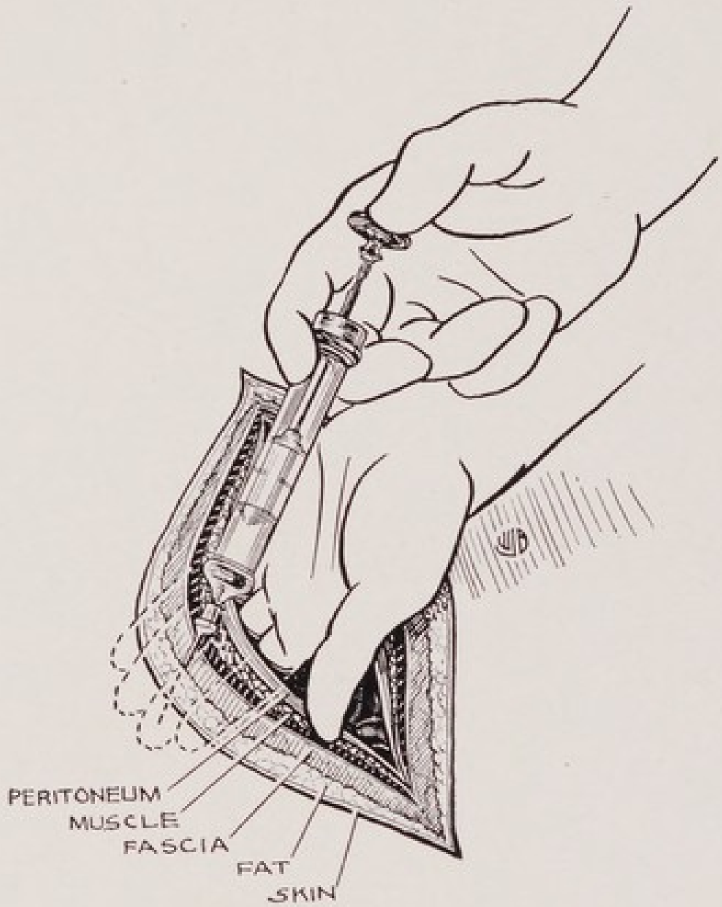


FIG. 29.—ABDOMINAL OPERATIONS: INFILTRATION WITH QUININ AND UREA HYDROCHLORID *at a Distance* FROM THE INCISION.

for two days or more and minimizes postoperative shock and gas pain.

If the principle of *anoci-association* be carried out in every detail, then, no matter what may be the location or the length of the abdominal incision, the intestines will be within the abdominal cavity and the abdominal muscles will be completely relaxed (Fig. 30). Under these conditions the entire abdomen may be explored without awakening the nociceptor sentinels. If the incision be long, the en-

Fig. 30.—Completely Relaxed Abdominal Wall and Intestines, the Result of *Anoci-Association*.

tire wall may be elevated with the warm, moistened, gloved hand and most of the viscera inspected literally. The hand may then go gently but completely over every viscus and explore every nook and corner of the abdomen without disturbing the original complete muscular relaxation.

It may happen, however, in spite of biologic strategy, that the existing conditions may make it impossible to avoid the stimulation of nociceptors, so that muscular contractions are present. In such a case the nitrous-oxid-oxygen should not be pushed an atom beyond the pink stage, but ether should be added until the needed relaxation is reached—a few minutes and but little ether are usually sufficient to attain this end. In rare instances ether may be administered on a cone during the delivery of an adherent tumor.

Owing to the entire relaxation of complete *anoci-association* but few if any intra-abdominal pads are required. Nowhere is the law of consequences more truly exemplified than in abdominal operations. In no instance does the punishment more truly fit the crime. Sow roughness and reap a harvest of postoperative distress.

CHAPTER VIII

ANOCI-ASSOCIATION IN ABDOMINAL OPERATIONS—CONTINUED

Operations on the Gall-Bladder. Common Duct Operations. Operations on the Stomach. Resection of the Intestines. Herniotomy. Perineal Operations.

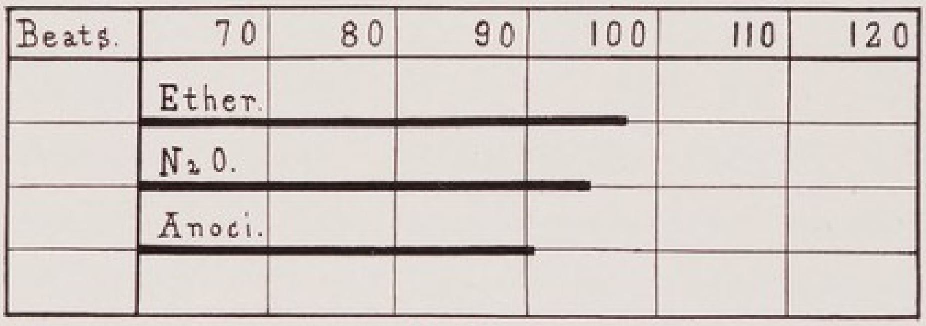
OPERATIONS ON THE GALL-BLADDER

If the mucous membrane of the gall-bladder be gangrenous; if there be a stone embedded by ulceration in the cystic duct; if the wall of the gall-bladder be thickened by scar tissue as a reaction to infection; and if there be no bile in the gall-bladder,—these conditions usually are followed by recurrent obstruction and infection. On the other hand, if the gall-bladder have approximately normal walls, and if the cystic duct be approximately normal, then no matter what the size or the number of stones, if the operation be performed with gentle manipulation so as to avoid any unnecessary trauma, there will be no postoperative pathologic cycle. Too much stress cannot be laid upon the necessity for gentle manipulation in the performance of the operation. What would happen to the urethra if a clumsy hand attempted to guide into the bladder a metal catheter or sound which had become corrugated by age and neglect? Or what would be the result of so forcibly stuffing rough gauze into the urethra as to cause copious bleeding? The urethra would swell, become infected, obstructed, and later, perhaps, strictured. The base of the gall-bladder and the cystic duct resent no less the bruising and wounding of their mucous membranes by gauze or by instruments. Following such needless injury there may be occlusion by strictures, for the normal cystic duct is very small and is easily closed by stricture. Finesse can accomplish a more certain exploration and a more difficult extraction than can rough manipulation.

In the cases in which cholecystectomy is indicated, the pathologic condition of the gall-bladder would make cholecystectomy safer than cholecystostomy, as the former obviates the necessity for prolonged drainage and limits the extent of infection, especially of infection of the incised wall. The mortality of cholecystectomy depends also on the technique. The gall-bladder should be exposed by an ample wound so that there is free access to its base; the freeing and separation of tissue should be made by sharp dissection, care being taken not to cut into the liver, that bleeding and infection in that organ may be avoided. The entire gall-bladder should be freed from its attachment so that ample opportunity may be given for determining the exact place where the gall-bladder ends and the cystic duct begins. This technique causes but little reaction.

An ample field, anociated by novocain and by a massive injection of quinin and urea hydrochlorid in 1:600 solution into the abdominal wall *at a distance from the line of incision*, gives the operator his maximum opportunity for carrying out the intra-abdominal part of the operation without dragging or pulling, but with sharp dissection and the minimum amount of bleeding. Thus the operation becomes shockless while the postoperative morbidity is minimized by the lasting effects of the quinin and urea hydrochlorid injection.

In cases showing chronic infection without febrile reaction the risk of cholecystectomy is less than that of cholecystostomy. But in cases of acute cholecystitis with protective adhesions in which the cystic duct is obstructed, cholecystectomy will give a higher mortality than will mere drainage of the gall-bladder, for the reason that during the excision of the viscus, even with the most careful technique, it is necessary to traumatize the surrounding tissues to such an extent that the local immunity of the tissues is impaired. In such cases it is probably wiser merely to drain the gall-bladder, interfering with the local tissues as little as possible. Later, if necessary, the gall-bladder may be excised.



The Pulse.

Each heavy line represents the average 5 P. M. pulse-rate of ten patients during the first four days after operation.

Fig. 31.—Comparative Clinical Results of Consecutive Cholecystostomies Performed under Ether Anesthesia, under Nitrous-Oxid-Oxygen Alone, and under Complete *Anoci-association*.

COMMON DUCT OPERATIONS

Operations for stone in the common duct, even in the hands of the most experienced and expert operators, yield a high mortality rate as compared with operations on the gall-bladder, or with operations on the pelvic organs, or with operations for exophthalmic goiter, for suppurative appendicitis, etc.

In the common duct operation no vital organ is involved —but merely a duct. Death cannot usually be attributed to the loss of bile or to infection of the peritoneum from bile, but is due to the gradual development of an asthenic state characterized by dullness of the mental and motor reactions, a dry tongue, partial suppression of bile, anorexia, scanty urine,—together with the impairment of the entire digestive system—a progressive adynamic state which is extremely resistant to any known treatment. All common duct cases by no means follow this course, but the severity of the postoperative symptoms is in proportion to the difficulty of the technique, which in turn depends upon the number of the stones and their impactions. One most impressive example of this morbid development was in the case of a fairly good risk patient whose entire common duct and a large part of the hepatic duct were impacted solidly with sixty-five stones. The task of extracting these was most difficult and though the patient went through the operation splendidly, he died on the fifth day with the symptoms above mentioned. Neither infection, nor hemorrhage, nor shock, nor ileus, nor pneumonia, nor urinary suppression were accountable. What then did cause death?

A clue to the real explanation of this hitherto baffling sequence of common duct operations was found just at this time in the following facts established by certain experiments on the ductless glands which were being made at the time of this patient's death. The liver performs its function in part through hormone action and in part through direct innervation. It is curious that for the performance of at least a part of its function the liver requires to have a simultaneous hormone and nerve stimulation. Now the nerve supply of the liver is derived from the sympathetic system, the nerve fibers passing along the blood-vessels and the common duct. As during the processes of evolution these nerves have been thus abundantly sheltered against injury, they have not evolved physical qualities for their protection as have the peripheral nerves. It would appear that in the course of common duct operations for stone, performed by an operator who is unaware of this grave danger, the nerve supply to the liver will be more or less blocked traumatically. If the block be light and the patient have sufficient endurance, the temporary loss of liver function will be safely bridged; on the other hand, the more severe the trauma of the nerves, the more completely will the nerves be blocked and the longer will that block last. This conclusion corresponds precisely with our clinical facts. It gives an adequate explanation of the unexpected death of certain patients, and makes it evident that surgery has been riding rough-shod over a serious danger.

To obviate this danger as far as possible the following operation was planned: Gentle manipulations and sharp dissection are employed throughout, the whole operation being planned so as to subject the tissues to the least possible amount of trauma. A long, vertical, right rectus skin incision is made with a transverse incision at its upper end extending an inch or more across the upper abdomen, the skin along the line of incision having first been infiltrated thoroughly with novocain. The muscular tissues are then thoroughly infiltrated with novocain and the incisions carried down to the peritoneum. The peritoneum is anesthetized and opened. By sharp dissection all adhesions are carefully divided, the dissection being strictly confined to the white, bloodless hair-line between the peritoneum and the adhesion. No blood-vessel crosses this dead-white line. The whole line of dissection being bloodless, every tissue is accurately identified and no sponging is needed. The stones are laid bare by an ample incision through the duct wall, and are picked out without injuring the duct mucosa. The duct is then closed with fine chromic

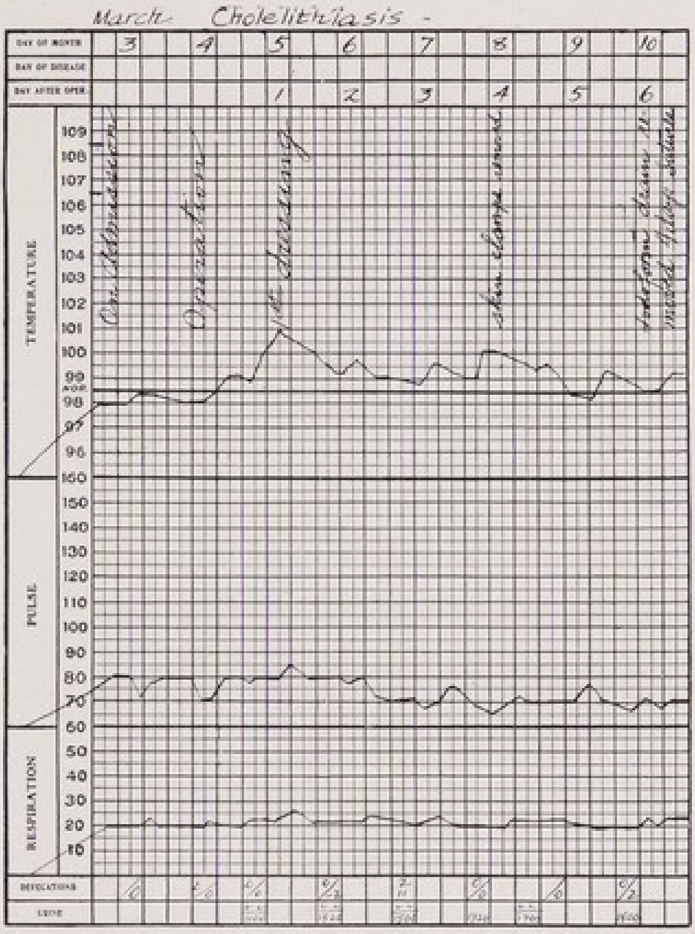


FIG. 32.—CHART SHOWING THE UNEVENTFUL CLINICAL COURSE AFTER AN OPERATION FOR COMMON DUCT STONE PERFORMED UNDER *Anoci-association*.

gut on a French needle, just as wounds of the intestine are closed, provided, of course, that bile drainage through the ampulla or the gall-bladder is assured. If drainage of the duct itself be not required, an iodoform drain is placed near but not against the line of sutures. The pre-incision infiltrations with novocain prevent shock, while the sharp dissection and gentle manipulations cause the least possible damage to the important portal nerves and to an exceedingly vulnerable environment. As far as the operation alone is concerned, therefore, convalescence should be and is quiet and uneventful. Thus in gall-bladder and duct surgery, *anoci-association* plays an especially beneficent rôle. (Fig. 32).

OPERATIONS ON THE STOMACH

Anoci-association in operations on the stomach requires that the abdominal wall be blocked by novocain infiltration and that sharp knife dissection be used for the division of adhesions and the preparation of the operative field, that is, the principle of *anoci-association contraindicates absolutely the tearing division of adhesions by blunt force*, the *forcible* insertion of the blade of the forceps under the stomach, or the *forcible* traction of the stomach up into the wound. The reason is clear—while the stomach and intestines have no nociceptors for cutting, burning, or even for crushing, they do make vigorous protests against distention, traction, and friction.

By *biologic strategy*, however, shock may be eliminated from gastric operations—gastric resection and gastroenterostomy.

A preliminary transfusion of blood will bring back the vitality of patients exsanguinated by hemorrhage. Transfusion is useful in starvation cases also, although these patients cannot be as successfully reclaimed. For here the risk is not one of shock and depression, but of a broken metabolism which will express itself in acidosis. Since they have employed transfusion, the authors have seen more clearly the danger of acidosis, for occasionally cases all but moribund which have passed through the operation with apparent safety have died later from acidosis. A large volume of blood and a fair blood-pressure cannot prevent the fatal issue of the acidosis which results from the too extreme previous starvation.

In cases of gastric ulcer, partial gastrectomy is the operation of choice, partly because of the uncertain cure by gastroenterostomy; and partly, as Mayo has convincingly shown, because of the probability of cancer development. In cases of duodenal ulcer, however, there is but slight probability of cancer development and the ulcer is curable by gastroenterostomy. The cure of duodenal ulcer may be hastened by the temporary closure of the pylorus. The physiologic adjustment of the stomach and the intestines will occur more promptly when the principle of *anoci-association* is strictly adhered to.

To diminish the postoperative discomforts of stomach operations the entire operative field is infiltrated with quinin and urea hydrochlorid injected with the Moynihan syringe *at a distance* from the incision. This *distance* blocking is especially necessary in these cases, since in both gastrectomy and gastroenterostomy, as in gall-bladder and duct operations, the wound may become infected. In addition, *the relatively painless state resulting from the quinin and urea infiltration insures freedom of expansion in the bases of the lung, and, therefore, lessens the possibility of postoperative pneumonia.*

An ample abdominal incision, such as is seen in the Mayo Clinic, allows the most favorable opportunity for light intra-abdominal manipulations. Surgeons should be keenly dissatisfied with the high mortality which still follows gastrectomy even in the best clinics.

We are now encouraged to believe that through *anoci-association* the full benefits of the two-stage gastrectomy will be realized. This vitally important matter will be considered in the chapter on the Two-Stage Operation.

RESECTION OF THE INTESTINES

Gangrene resulting from acute intestinal obstruction and the presence of cancer are the two conditions for the relief of which a resection of the intestines is most often indicated. Whatever the condition the first step in the operation is an exploration for the purpose of planning the operation and developing the operative field.

The first important step is to make an ample abdominal incision under complete local blocking with novocain, for whatever condition may be found, the muscles of the abdominal wall will then be relaxed; the exploration will be facilitated; and the use of gauze pads will be reduced to a minimum.

The preliminary exploration may unavoidably cause a certain amount of trauma in the unblocked territory especially in case of intestinal obstruction. In such a case enough ether should be added to the nitrous-oxid-oxygen to ensure complete relaxation until the completion of the exploration and of the development of the operative field. The ether may then be omitted and the operation carried on under nitrous-oxid-oxygen alone.

As soon as the abdominal wall is opened a deep infiltration with quinin and urea hydrochlorid is made at a distance from the line of incision. As it requires from fifteen to twenty minutes for the quinin and urea hydrochlorid to become effective, novocain is depended upon to produce immediate anesthesia in the local field. Before the effects of the novocain have disappeared, the quinin and urea hydrochlorid will have become effective and the whole abdominal field will then remain anesthetized and relaxed throughout the operation and indeed for several days thereafter.

In a resection of the intestines the most important consideration is the proper planning of the scope of the operation. The ample incision gives the optimum opportunity for exploration and obviates the necessity for dragging the viscera out of the wound. In other words, it makes it possible for the operation to be taken to the intestines. The intestines need not be pulled out beyond the point at which definite traction on the mesentery is being made.

The only shock-producing factors in operations on the intestines are traction on the mesentery and traumatization of the peritoneum. Suturing, cutting, burning, and even crushing the intestines, independently of other factors, cannot produce shock, as no nociceptors have been evolved against these types of trauma.

Anoci-association in intestinal operations is simple enough, therefore, as it means merely that the surgeon must avoid dragging manipulations, packing with gauze, and heavy retraction of the abdominal wall, and that he must minimize bleeding, a small amount of which is inevitable.

The end results of resection of the intestines, therefore, depend very largely upon the precision and care with which the operation is performed. The more the shock-producing factors are controlled, the better will be the condition of the patient at the end of the operation, and the more certainly will he overcome infection, if any be present. The authors have seen a great improvement in both the immediate and the later results of resections of the intestines since they have used *anoci-association*.

HERNIOTOMY

After a herniotomy performed without the protection of *anoci-association* the following morbid conditions are prominent:—gas pain, painful swollen testicle, and occasionally retention of urine. The testicular and the gas pain may be distressing and both are responses to needless operative trauma. If, in the course of a herniotomy, the sac and the cord be grasped and torn asunder with rough gauze, the assaulted cord and the testicle will later bear testimony to their injury by swelling and pain. Such harsh treatment of these delicate tissues is no less damaging than would be the procedure of removing a cinder from the eye by sand-papering the entire cornea. Here, as elsewhere, however, the untoward results may be obviated by strategy and by gentle manipulations.

As in all operations under *anoci-association*, every division of tissue supplied with nociceptors is preceded by the infiltration of the part with novocain. The field of operation is kept free from blood by catching the few blood-vessels in the skin and subcutaneous tissues. The white glistening fascia has no blood-vessels and its parallel strands may, therefore, be bloodlessly divided by a sharp knife. The under surface of the fascia has no vessels running through it at right angles and the sharp-knife, bloodless dissection is therefore carried down to the glistening border of Poupart's ligament. In like manner the inner fascia is bloodlessly divided. The sac, hernia, and cord are thus exposed and appear bloodless and translucent, but the bloodless dissection does not stop here even if the sac be old and have for a long time been irritated by a truss. The sac is picked up with forceps and is freed for a short distance with a sharp knife. It is then opened between two small Halstead hemostats and the forefinger is introduced, the sac being stretched over it like the finger of a glove. The true peritoneum contains no blood-vessels, hence there is a white, bloodless line between it and its neighbors. Therefore, no matter how old, how large, or how adherent the sac may be, the knife can be passed all the way around it along this bloodless line. The blood-vessels are the key to this bloodless line of fusion between the sac and its environment, and the presence of the smallest blood-vessel will mean that some extra-peritoneal tissue is still on the sac. After the dissection is well started, the separation of the sac well within the internal ring will be easily accomplished if the assistant keep the tissue taut by tension with small forceps. Not a single vessel below the subcutaneous veins needs to be tied; and the cord is not handled at all, the sac being sharply and precisely cut free from it.

By this technique, the sac is completely excised; the cord is uninjured; the testicle does not suffer at all and no suspensory support will be required. As a result of the bloodless dissection, the pillars are translucent and their strength and value can be more accurately estimated so that more intelligent use may be made of them in the repair.

The procedures we have described apply particularly to operations for the radical cure of inguinal hernia, but in umbilical and postoperative hernia, the need for sharp bloodless dissection is equally clear.

Before the wound is closed the stump of the sac and the tissue at a distance which contains the nerve-supply to the field of operation may be infiltrated with quinin and urea hydrochlorid, in 1:600 solution, though even without this protection there should be little postoperative discomfort if the *anoci-association* technique has been rigidly observed. In an old hernia, however, at the site of a protracted suppuration, quinin and urea hydrochlorid should not be used. The spores of the colon bacillus, in particular, may be dormant for many years, and the added irritation of quinin and urea hydrochlorid may facilitate—certainly will not hinder—the reawakening of the infection.

PERINEAL OPERATIONS

In perineal operations the field to be dissected is blocked as thoroughly as if the operations were to be performed under local anesthesia alone. Stitch tension is made as slight as possible, as tight stitches not only are painful but cause tissue damage from pressure. After the operation is completed the area included in the stitches is blocked by quinin and urea hydrochlorid in 1:600 solution, injected *at a distance from the mucous membrane and the line of incision.*

RECTAL OPERATIONS

In rectal operations one has a splendid opportunity to test the value of novocain infiltration. The divulsion of the sphincter ani causes strong reflex action and is a momentary strain on the anesthesia. In collapse from any cause it is a classic procedure to make use of the vitalizing effect of sphincter dilatation. If, however, novocain be infiltrated into the soft tissues around the anus, and the parts be then subjected to momentary pressure, then, even under nitrous-oxid-oxygen alone, the sphincter may be completely divulsed without any noticeable reaction.

Postoperative discomfort is an almost invariable sequel of anal and rectal operations—especially when an anal tube is worn. This may be greatly diminished if the entire anal zone be blocked by quinin and urea hydrochlorid in 1:600 solution injected *at a safe distance*. Bloodgood states that the results of quinin and urea infiltration "in its elimination of postoperative pain are seen chiefly in rectal work."

The amount of postoperative lumbar and sacral pain and of pain radiating down the thighs is in direct proportion to the precision and gentleness with which the operation is performed as well as to the care with which the quinin and urea infiltration is made.

CHAPTER IX

ANOCI-ASSOCIATION IN ABDOMINAL OPERATIONS—CONTINUED

Acute Abdominal Infections. Acute Appendicitis. Acute Infections of the Upper Abdomen. Pelvic Infections. Summary.

ACUTE ABDOMINAL INFECTIONS

In describing the histologic pathology of shock, we showed that deterioration of the cells of the brain, the suprarenals, and the liver may be caused by infection alone, by trauma alone, by fear and worry alone. It is of the utmost importance, therefore, that the patient handicapped by the presence of infection should be scrupulously protected against any further drain upon the organs which have already been to some degree depleted. Fear and worry must be mitigated; ether avoided; and the local field completely blocked as far as the zone of the actual infection. In these cases, however, not only the cells of the brain, the suprarenals, and the liver, but certain other cells—the phagocytes—must be protected as well, for in the pyogenic infections, the safety of the individual depends almost exclusively upon these organisms. One of the constituents of the phagocytes is lecithin, which is soluble in ether. Ether, therefore, by *anesthetizing the phagocyte as well as the patient*, causes a weakening of the body's defense which lasts for from twelve to twenty-four hours—a break in the defense which has undoubtedly cost the life of many a patient.

To anesthetize the phagocytes in the presence of infection is as serious a tactical error as would be that committed by the commander of a fort were he to anesthetize his soldiers in the midst of an attack. *Ether and chloroform should never be employed in the acute infections.* Nitrous-oxid-oxygen does not in any way affect the phagocytes and it therefore causes no appreciable alteration in the mechanism of the body designed for its defense against infection. In addition, nitrous-oxid-oxygen, unlike ether, causes no waste of energy as a result of the intense feeling of suffocation which so frequently is incident to the inhalation of ether, hence to that extent nitrous-oxid-oxygen conserves the body's energies, and, as already explained, nitrous-oxid-oxygen in some manner also protects the brain-cells from the damage caused by the trauma of the operation. It is, therefore, *par excellence*, the anesthetic of choice in infections. The evil effects of trauma and of ether in the presence of acute infection have long been known and have been strongly emphasized by Murphy and by Deaver, the former calling special attention to the necessity of limiting the trauma; the latter urging that the operation be performed as quickly as possible to shorten the damaging effects of the ether.

To demonstrate the protective action of *anoci-association* in the acute infections, we shall discuss its application in acute appendicitis; in infections of the upper abdomen; and in pelvic infections.

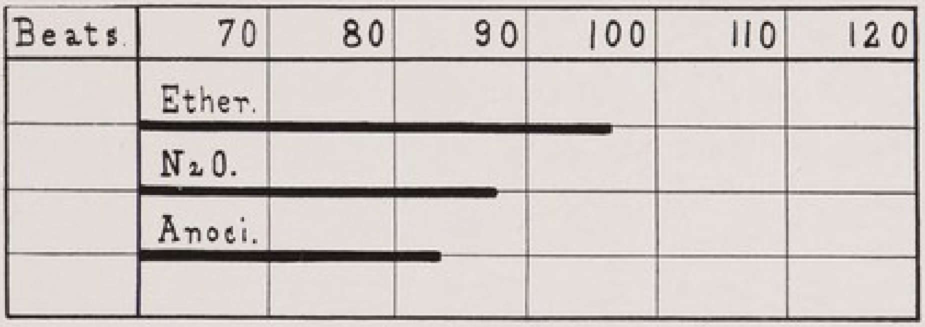
ACUTE APPENDICITIS

If the infection be limited to the appendix, the operation may be performed under *anoci* protection like an ordinary interval appendectomy. We wish here to discuss the procedures in appendicitis with spreading peritonitis or abscess.

The patient should receive hypodermic injections of morphin until he is in a quiescent state and should then be conveyed in the Fowler position to the hospital (Van Buren Knott), *that posture being maintained throughout his journey to the operating-room, the operation, the return to his room and until the abdominal infection is safely overcome.*

The operation is performed under nitrous-oxid-oxygen anesthesia. The line of incision is made over the center of inflammation, the division of the abdominal wall being preceded by novocain infiltration. The incision is always *intermuscular*, never *transmuscular*. In the majority of cases the incision will fall upon the right iliac fossa. If a localized abscess be present, it is opened gently and cautiously explored with the finger, the appendix being carefully lifted up, tied off and excised in its place, *if it be found at once* and be not too firmly imbedded in the wall of the abscess. If the appendix *be not found readily*, then its removal should be left for a second operation after the abscess has completely healed. In other words, the protective wall of granulation must not be broken through, for a breach in this protective structure may mean spreading peritonitis, new abscesses, pylephlebitis, and subphrenic abscess.

The next step, though extremely simple, is of the greatest importance as it is a measure by which the formation of multiple abscesses in the course of convalescence may be prevented. Through the McBurney incision a slender, straight, flexible retractor is slid along the pelvic wall to the very bottom of the pelvis. A second straight, flexible retractor is then slipped along the first retractor to the very bottom of the pelvis. The pus wells up freely between the two retractors; it is not even mopped out but is let alone while a long cigarette drain or rubber tube, held by long, slender, dissecting forceps, is passed down between the retractors through the pus to the bottom of the pelvis and held there while the two guarding retractors are smoothly withdrawn. The blades of the dissecting forceps are then spread apart so that neither blade is in contact with the drain, and they too are carefully withdrawn so that the drain is left as a line of communication between the McBurney intermuscular incision and the bottom of the pelvis, the point to which the pus from all parts of the abdomen will



The Pulse.
Each heavy line represents the average 5 P. M. pulse-rate of ten patients during the first four days after operation.

Fig. 33.—Comparative Clinical Results of Consecutive Appendectomies Performed under Ether Anesthesia, under Nitrous-Oxid-Oxygen Alone, and under Complete *Anoci-association.*

naturally gravitate. If this maneuver be employed, a second abscess, pylephlebitis, or subdiaphragmatic abscess will rarely occur (Fig. 33).

In the after-care, two distinct objects are to be sought: (1) the encouragement of the local immunity and (2) the protection of the kinetic system against injury by toxins.

(1) *Encouragement of local immunity.* The entire abdomen from the costal border down to the pubes and around to the lumbar muscles is covered with massive hot packs which are kept in place day and night. A broad electric

pad is a great help. The Murphy rectal drip and the Ochsner dietary are employed, and stomach lavage is rarely required; no cathartics are given, the bowels being moved by enemata. The wound is never irrigated, but the deep pelvic drain is left undisturbed until the acute stage is past.

(2) *Protection of the kinetic system:* The free installation of water attained by the Murphy method apparently protects the kinetic system to some extent, but in *extreme* cases their protection is directly accomplished by deep narcotization with morphin or some other opium product. It was well known to the older clinicians, especially to Alonzo Clark and to Flint, that deep opium narcotization was an efficient treatment for peritonitis. These wise and resourceful clinicians gave opium until the respirations were much below normal, as low even as ten or twelve per minute. The appearance of patients so treated would seem to indicate that they are perilously near death, but the condition continues unchanged until the local immunizing forces overcome the infection. Not until that is accomplished is the patient allowed to come out from his prolonged sleep.

Striking proof of the protective action of morphin against the toxins of infection is shown in our laboratory experiments. It is obvious that in the infections the kinetic system is being driven by nocuous influences. Since these nocuous influences cannot be blocked at their sources, then the kinetic system itself must be protected with opium. Trauma, fear, strychnin and toxins all cause the discharge of energy in a muscular defense; apparently toxins in addition drive the kinetic system to discharge energy in producing a metabolic defense—as a result of which fever ensues.

Deep morphinization protects both the muscular and the fever defense mechanisms from the forced activity which otherwise would drive the kinetic organs to exhaustion—perhaps to death.

In the state of deep morphinization but little nutrition is required,—indeed the patient is in a condition closely resembling hibernation. This elimination of the need for food solves also one of the most difficult problems in the treatment of peritonitis.

Under this technique the authors have performed 332 operations for acute appendicitis with but two deaths.

ACUTE INFECTIONS OF THE UPPER ABDOMEN

Acute infections of the upper abdomen are governed by the same principles as those already considered in the discussion of spreading peritonitis arising from an infected appendix. Acute cholecystitis; perforation of the gall-bladder; perforation of the stomach or duodenum; and acute pancreatitis—all demand the most complete *anoci-association*.

In empyema of the gall-bladder the new adhesions about the gall-bladder are separated with the greatest care just enough to permit an opening in the gall-bladder for the establishment of drainage. Aside from this the defenses established by nature are left undisturbed. In severe gangrenous cases no exploration of the gall-bladder should be made, for, as in the case of acute appendicitis, the first issue is to aid nature in establishing local immunity. As a rule, the acute infections of the gall-bladder run a safe if stormy course and the operation may be deferred until the quiescent stage.

Acute pancreatitis calls for prompt drainage. In cases of gastric and duodenal ulcers, in which the point of leakage is closed, sufficient drainage may be established by the Fowler posture and a local drain; if this proves insufficient a small suprapubic drain may be added.

PELVIC INFECTIONS

Most of the infections which arise from child-birth may be guided to a safe termination by the routine treatment for postoperative peritonitis. If the stage of pus formation be reached, however, vaginal puncture must be made. Neglected cases of septic abortion frequently require both the vaginal puncture and the routine postoperative treatment for acute appendicitis.

By vaccine, rest, hot packs, and hot douches acute gonorrheal infection in women may be guided safely, either to resolution or to the more chronic pyosalpingitis.

It should be emphasized again that in the treatment of all acute abdominal infections, psychic, traumatic and painful stimuli or *noci-associations* should be as rigidly excluded as are the toxic stimuli so that the patient may rest within the protection of complete *anoci-association*.

SUMMARY

The value of *anoci-association* in the acute abdominal infections is most strikingly illustrated by a comparison of the pulse-rate during and after operations in cases of acute appendicitis.

A study of 45 consecutive *ether cases* showed an average increase of 8.4 beats in the pulse-rate in the first twenty-four hours after operation, and an average increase of 15.4 beats during operation; while the 45 consecutive *anociated* cases studied showed a *fall of 2.26 beats* in the first twenty-four hours after operation, and a *fall of 1.22 beats* during operation.

CHAPTER X

ANOCI-ASSOCIATION IN GYNECOLOGIC OPERATIONS

Benign Tumors. Suspension of the Uterus. Pus Tubes.

BENIGN TUMORS

The removal of benign tumors, excepting those wedged in the pelvis, may be accomplished under complete *anoci-association* as follows: The tumor is fully exposed through an ample incision in the *novocainized* abdominal wall. As the opening has been made under *anoci-association*, no traumatic impulse has reached the brain, and the muscles are, therefore, completely relaxed, so that almost no retraction will be required; and no gauze pads will be required to prevent the expulsion of the intestines, which the force of gravity will cause to lie within the abdomen.

If the tumor is ovarian and is large and if there are adhesions in the accessible field, these are divided within the narrow, white bloodless line in the peritoneal surface of the tumor by a knife with the keenest possible edge. However old or firm the adhesion may be, no blood-vessel will cross this dead white line. This line of division may be kept straight and its breadth increased if an assistant make steady tension with a large piece of gauze. This tension need not—*must not*—be sufficient to excite nocuous impulses, but should be sufficient to facilitate the sharp division of this white line of fusion between the tumor and the parietal or intestinal peritoneum. This feather-edge division can be made in a much shorter time than can a carnivorous bloody separation, especially since it eliminates the time required by the latter method for hemostasis and for fighting with belligerent coils of intestines. It is surprising to what a depth the sharp dissection may be carried within the pelvis. Even beyond the reach of the knife, however, the advantage of this technique becomes obvious, for the exact cleavage line being established, as a rule the remainder of the tumor—bluntly but with finesse—may readily be separated with the wet gloved hand.

The *anoci* principle obviously demands that the body of the tumor itself shall not be delivered by assault, but by strategy—by coaxing pressure and lifting. An ample field for these maneuvers is secured by the absence of gauze packing, which is rendered unnecessary by the complete abdominal relaxation. Almost any tumor, excepting those molded into the pelvis in the course of their growth, can be delivered without the slightest tightening of the abdominal muscles, without disturbing the even curve of a single respiratory excursion.

As soon as the tumor is delivered, the line of division of its attachments is novocainized. Then and only then are the clamps applied.

Clamp compression alone, even without novocainization, would cause relatively slight nocuous response. Under the old technique, the common error at this point, in the language of golf, was that of "pressing"; that is, the operator became so anxious to get the tumor out that he handled it needlessly and harmfully. As a consequence, the patient awoke locally and made a mute but serious protest against the injury. The surgeon, showing no more control over his movements than did the anesthetized patient, redoubled his efforts to pull open wide the rebellious, protesting, abdominal muscles and to thrust back the protruding intestine with rough gauze, and then ensued a strange contest between the *nocuous* surgeon and the *unconscious* patient until one or the other was overcome. The surgeon having the advantage usually vanquished the patient, who could make only a partial fight—could fight only with his injured abdominal muscles. *If this muscular response of the patient had been utilized in voice and speech, the unequal struggle would have ceased promptly, and the energies of both patient and surgeon would have been conserved.*

In the *anoci* operation the surgeon arrays himself on the side of the patient and by blocking the noci-ceptors of the broad, the round, the utero-sacral and the utero-lateral ligaments, he keeps the nerve-muscular mechanism of the patient in ignorance of his maneuvers.

The authors have never seen any evidence of nociceptors for sharp knife cutting in the body of a tumor or in the normal uterus. When removing a tumor, therefore, it is necessary to anesthetize only that part which is to be grasped with the forceps.

The stump containing the divided vessels should be blocked. In a hysterectomy one is apt to suture too much tissue and to tie it too tightly. Ochsner long ago called attention to this point, and Bartlett has shown that precision in vascular control requires that accurate attention be given to the main vascular trunks, after which the remainder of the wound may be closed as one closes an external wound.

John G. Clark has demonstrated how practical vascular control without excessive suturing may be secured in myomectomy. In this phase of the operation, the golden surgical rule that gentle accuracy should be employed rather than needless force, is especially applicable. If the patient be a bad risk, then the strain from every suture or ligature should be blocked with quinin and urea hydrochlorid injected at a distance from the cut surface.

By means of the strategically curved needle of Kelly, Franklin Martin's long dissecting forceps, the Andrews needle holder and long, flexible retractors, any part of the pelvis may be sutured with accuracy and dispatch in the field relaxed under *anoci-association*.

PUS TUBES

In cases of chronic gonorrheal salpingitis, with or without tubal abscess, the sharp knife dissection gives ready access to the precise cleavage line. Beginning at the most accessible point, the adhesions are divided by sharp dissection as far as possible. The adhesions may be so thick and their fusion with the intestinal coils so firm as to occasion a good deal of difficulty, but usually at some point the tubo-intestinal cleavage line will be reached, after which the separation will be readily made.

By *anoci-association* one may deal readily even with those cases in which the uterine fundus is well up in the pelvis, the proximal end of the tube being thickened but not seriously involved, while at the distal end the fimbriated extremity has grasped the ovary and is pouring into it a burden of infection, causing tubo-ovarian abscess.

With a sharp knife the diseased tube is freed from the uterus by means of a V-shaped cut; the bleeding points being caught with a Kelly needle and plain catgut in an interlocking suture lightly tied. The tubal attachments are divided and sutured. The tube extends down into the pelvis like an inverted pyramid; its attachments may be divided with ease, and finally the pus tube may be lifted out.

In case of a double tubo-ovarian abscess, a part of one or of both ovaries and any uninfected portion of the ovarian attachments are preserved. Division of the ovary does not cause the slightest pain.

If the uterus be down in the pelvis, with the tubes and ovaries above it, it will be found that the abscesses extend well downward toward the fundus uteri. In such a case the ovaries usually fare better and the uterus worse. The latter may be enlarged, edematous, heavy and infected. In many such cases it is necessary to remove a portion of the uterus and the tubes *en masse*. Here *anoci-association* is best attained by taking the operation to the field rather than by dragging the organs up to the level most convenient for the surgeon. In an adequate, relaxed field, by strategic maneuvers, the uterus and tubes may be divided by a sharp knife—the sharp knife division causing not a single break in the respiratory rhythm.

SUSPENSION OF THE UTERUS

In the Coffey operation, which we usually employ, the broad and the round ligaments may in certain cases be blocked.

CHAPTER XI

ANOCI-ASSOCIATION IN GENITO-URINARY OPERATIONS

Bladder. Prostate. Kidney.

BLADDER

In preparation for any operation within the genito-urinary tract, especially for operations upon the bladder and prostate, the bladder is filled with a 5 per cent. solution of alypin after the preliminary dose of morphin and scopolamin has produced its effect. By this means the mucosa is sufficiently anesthetized to prevent nerve-muscular responses to the operative manipulations.

The skin, subcutaneous tissues and muscles are infiltrated with novocain (Fig. 34). After the incision has been made, the bladder is brought up into the wound by gentle traction with a pair of bladder hooks, and the line of incision through the bladder wall is completely blocked (Fig. 35). The combination of the infiltration of the bladder wall, with the preoperative injection of alypin will so completely anesthetize all areas of the bladder that the manipulations of operations for stone, for tumor, or for diverticula, even, may be carried through without the slightest nerve-muscular response on the part of the patient.

PROSTATE

The special sources of danger in prostatectomy are the anesthetic, shock, and hemorrhage. As a result of many efforts to diminish these dangers, the following method has been evolved by means of which the operation may be performed without hesitancy upon patients who, because of their age or because of diminished vitality, have been considered bad operative risks. Patients undergoing a prostatectomy performed by this technique are not only free from shock, but are in splendid condition to combat any other untoward influence that may arise during convalescence.

As in bladder operations, the preliminary dose of morphin and scopolamin is followed by the injection through a catheter into the bladder of 60 or 90 c.c. of a 5 per cent. solution of alypin. The catheter is clamped and allowed to remain. The technique described for bladder operations is followed until the prostate is exposed intravesically (Fig. 36). The bladder mucosa of the projecting prostate is infiltrated with novocain, and a deep infiltration is made along the edge of the capsule (Fig. 37). *With careful and most gentle manipulations the prostate is enucleated with the finger* (Fig. 38). Not "*how rapidly*" but "*how carefully*" is the slogan. Narrow strips of gauze are packed along the catheter above the mucous membrane so that the raw surfaces of the capsule are brought in apposition—a procedure which effectively prevents hemorrhage (Fig. 39). The two ends of the urethra also are brought closely together by this means so that a continuous funnel-shaped mucous membrane results—a most important factor.

At the close of the operation, the color of the patient will be good; the pulse and respiration will not be increased, in fact, may be even lower than before the operation. The patient will rest comfortably, will be free from nausea, can take water easily, and a speedy, uninterrupted convalescence may be looked for.

KIDNEY

The approach to the kidney is through tissues which, in their evolutionary development, have not been subjected to environmental trauma; consequently they are not so richly endowed with nociceptors as are the tissues of the anterior abdominal wall. There are, however, a sufficient number of nociceptors in the skin and muscles to make their infiltration advisable.

Parts of a kidney operation in which the *anoci* technique is urgently demanded, however, are the separation of the adherent kidney from its attachments and its delivery into the wound.

The first and most important requirement in an operation upon the kidney is an *ample incision*. An ample incision with the muscular relaxation obtained through *anoci-association* makes clearly visible the lines of adhesion.

The adhesions should be divided by sharp dissection until the line of cleavage is reached. In the case of a suppurating kidney, the line of easy cleavage is on the rear surface of the kidney itself underneath the thickened capsule. In a tuberculous kidney, however, the separation must be made outside the capsule in order that the wound may not be infected with tubercle bacilli. Old tuberculous kidneys present dense and strong adhesions, most of which, however, may be readily divided by sharp knife dissection.

The easier kidney operations on good risk subjects are relatively safe by even the most nocuous technique; but the protection of *anoci-association* is urgently needed by the patient reduced by hemorrhage or infection, or the functional power of whose kidney has been perilously reduced by any cause.

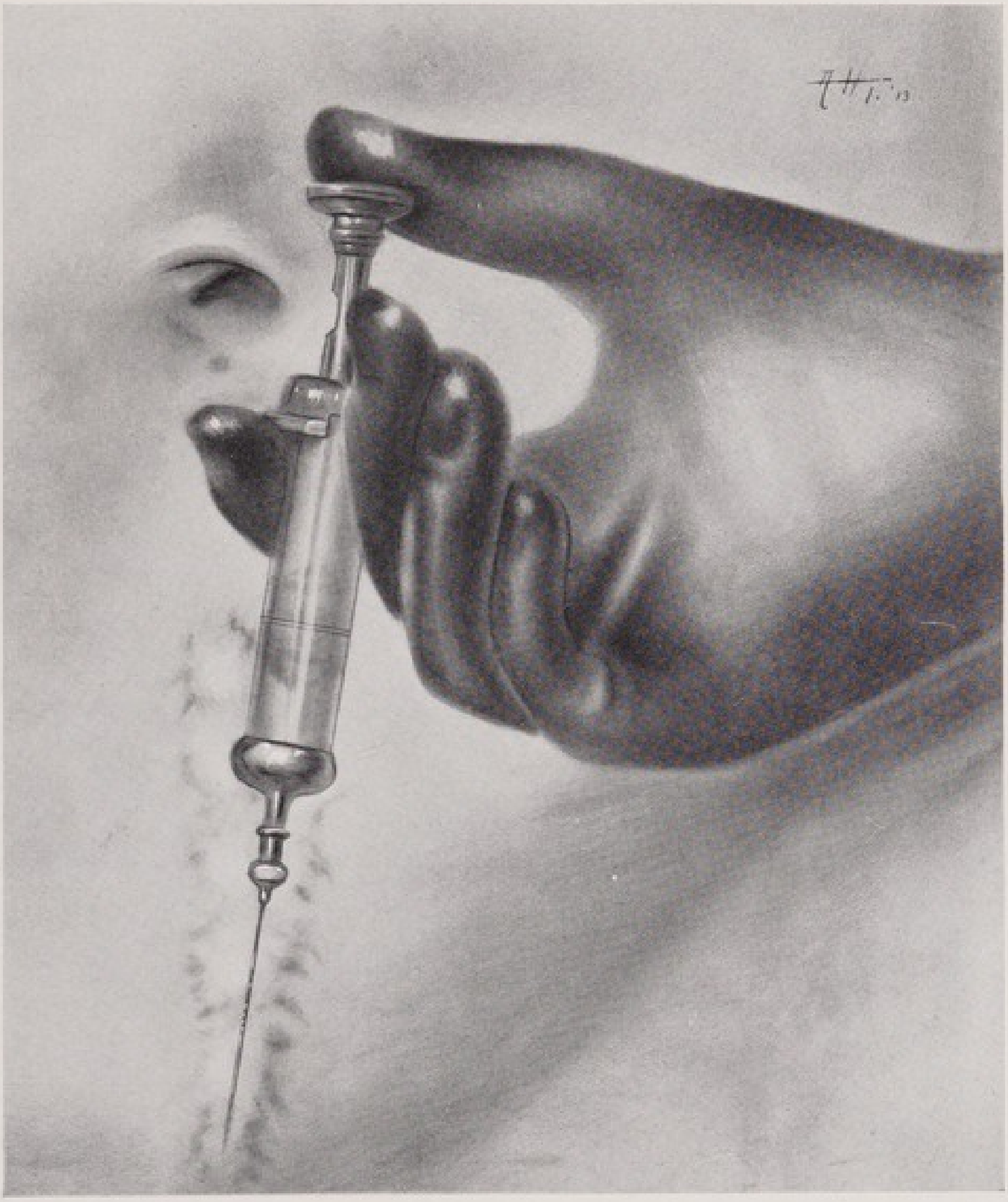


Fig. 34.—Bladder Operations. Infiltration of Skin with Novocain.

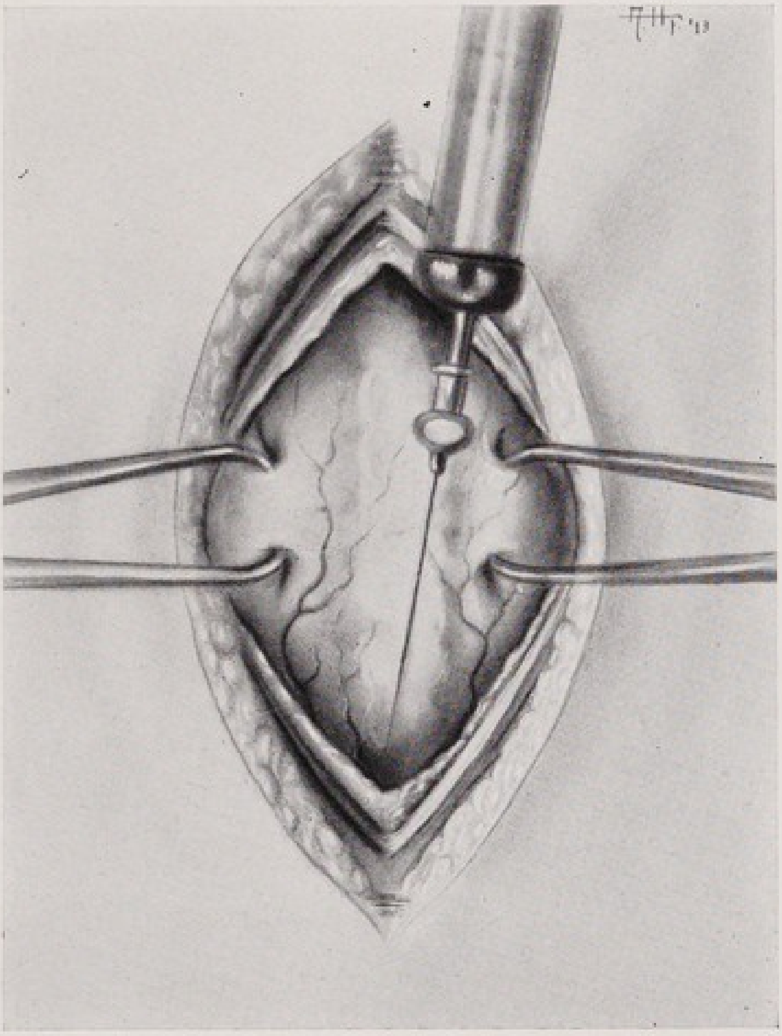


FIG. 35.—BLADDER OPERATIONS. INFILTRATION OF BLADDER WALL BEFORE OPENING.

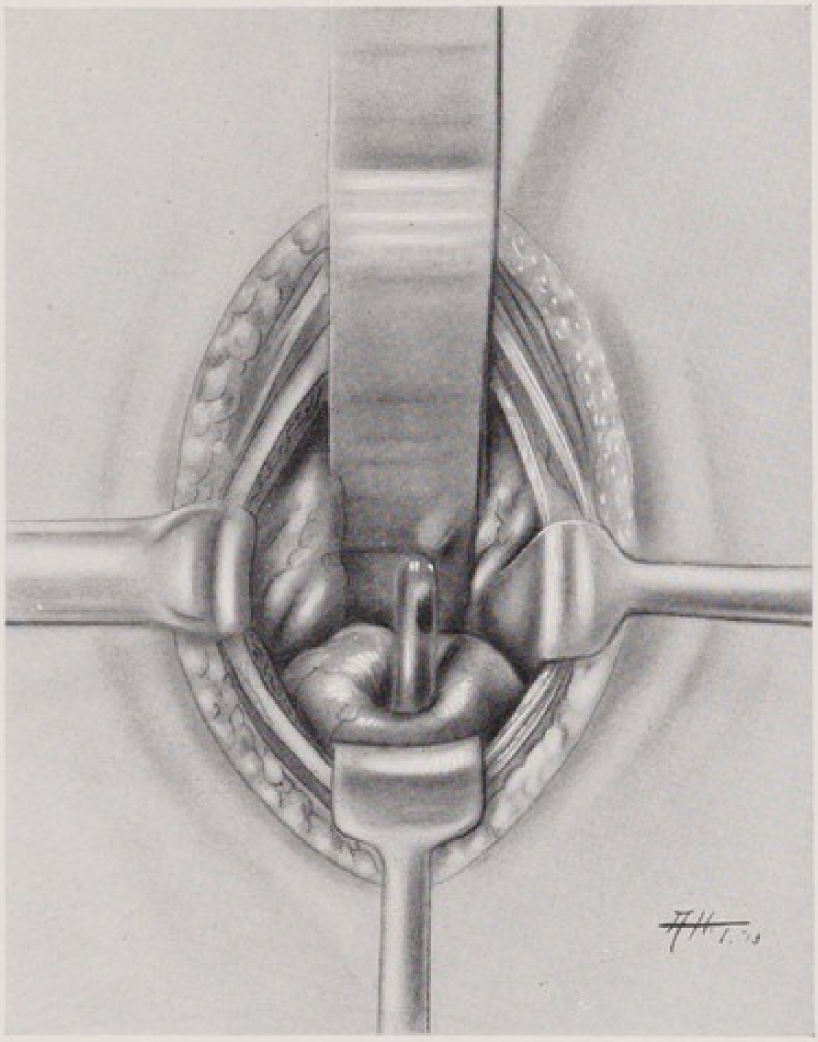


Fig. 36.—Prostatectomy. Intravesical Exposure of the Prostate.

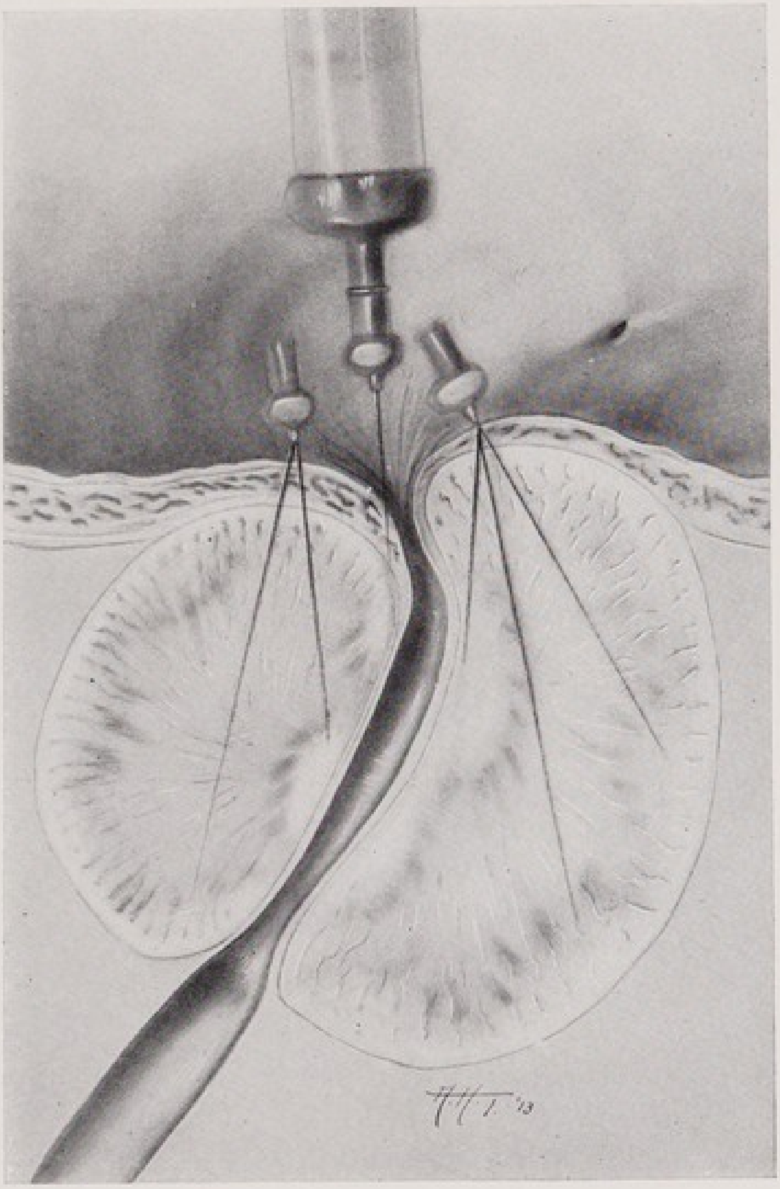


Fig. 37.—Prostatectomy. Infiltration of Capsule of Prostate Gland Before Removal.

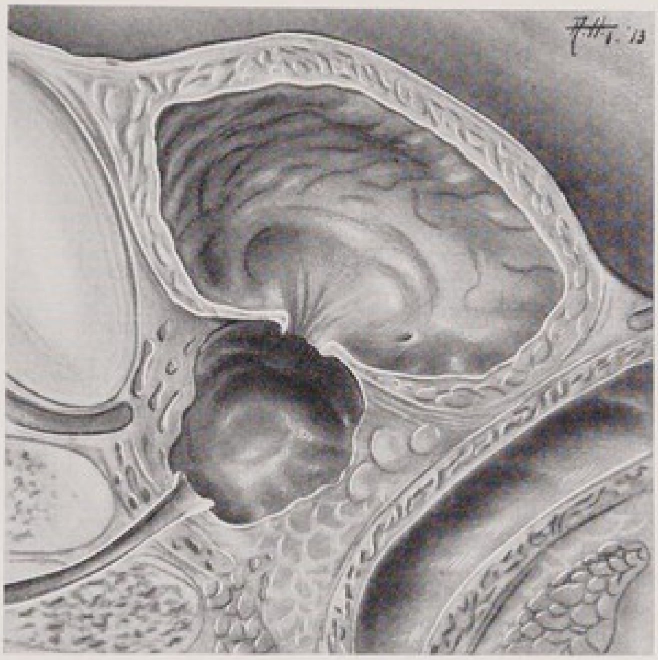


Fig. 38.—Prostatectomy. Cavity Left after Enucleation of the Prostate.

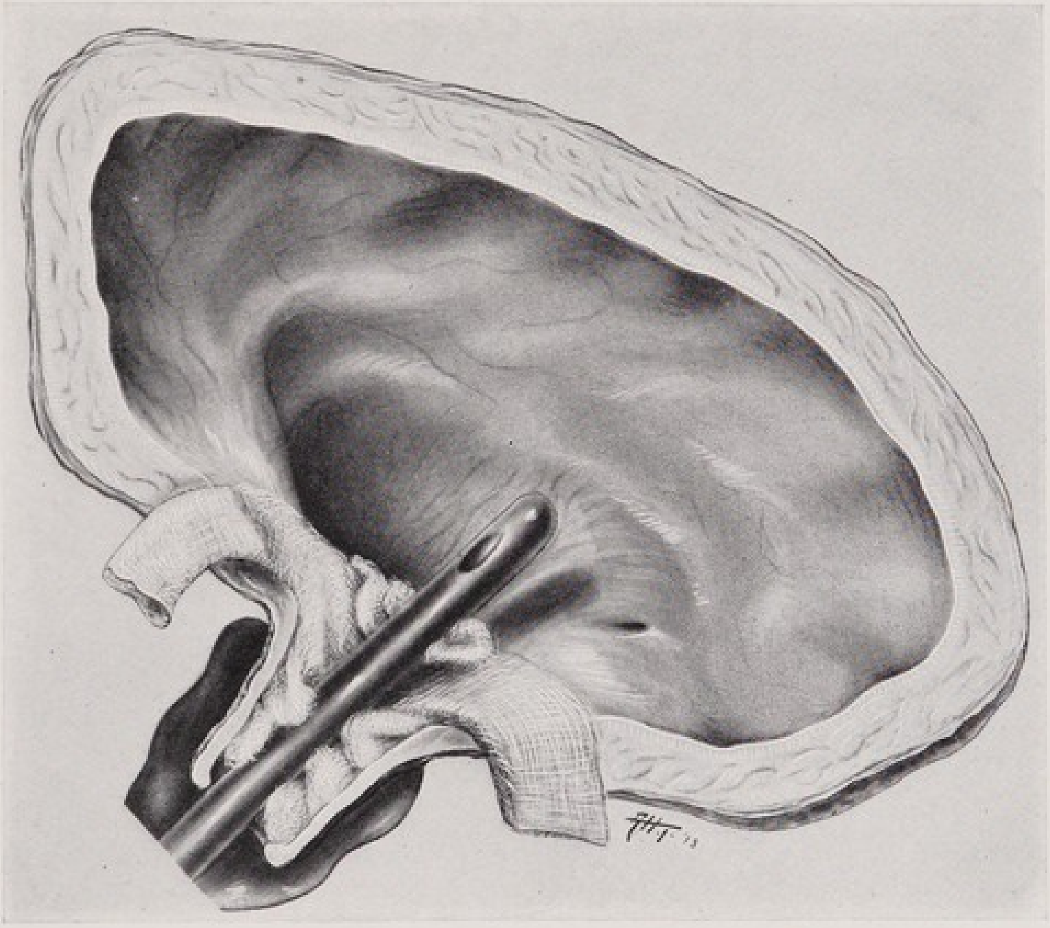


Fig. 39.—Prostatectomy. Gauze Packing by which the Raw Surfaces of the Capsule are Brought in Apposition.

CHAPTER XII

TWO-STAGE OPERATIONS

Cancer of the Rectum. Cancer of the Stomach. Cancer of the Uterus. Cancer of the Larynx. Cancer of the Tongue. Summary.

Certain conditions—cancer especially—may demand a two-stage operation because the patients are too much weakened to endure at one blow the stress of the operation and the subsequent physiological adjustment. As Lilienthal has pointed out, this is especially true of patients weakened by cancer of the rectum, stomach, large intestine, uterus, larynx, or tongue.

A comparison of many two-stage operations carried out under the *nocuous* technique with those performed under *anoci-association* demonstrates quite clearly several fundamental points.

The experience of the *anociated* patient in the first stage of the operation is so much easier than his anticipations—his loss of vitality and change of nervous threshold are so slight—that he is emboldened to meet the second stage with equanimity. It has been gratifying to find that the second, usually the major, stage causes no more disturbance—sometimes less even—than followed the preliminary operation. For example, it has been our experience that in the first of the two stages of a laryngectomy the variations of pulse and temperature were more marked than in the second stage.

CANCER OF THE RECTUM

In cancer of the rectum, the preliminary colostomy prepares the way splendidly for the major operation. In this operation the energy of the patient is conserved, not only by the novocain blocking of the tissues to be divided but also by the complete hemostasis and the sharp dissection.

CANCER OF THE STOMACH

In cancer of the stomach, unless the risk be good, gastroenterostomy is performed at the first operation, resection being performed as soon as the nutritional balance is assured —usually in ten days or two weeks. In starved cases of gastric ulcer Professor von Eiselsberg's method is excellent—a jejunostomy is first performed under local anesthesia, the final operation being delayed until a safe vital margin has been attained by feeding. Gastroenterostomy alone gives a rather light morbidity as compared to gastrectomy, as the wound is not as extensive as in the latter operation, and the physiologic and anatomic readjustment is readily made. This readjustment being accomplished, the gastric resection is performed with a wider margin of safety. By lessening the amount of the trauma inflicted at one seance, and by relieving the patient from the burden of extensive wound recovery simultaneous with the functional adjustment, the probability of recovery is far greater than when one massive chance is taken.

An unexpected advantage in the two-stage operation for gastrectomy is illustrated in a recent case. A large pyloric mass was diagnosed as cancer by an able internist and at the preliminary operation, even, was considered to be cancer. At the second operation which, on account of the extreme emaciation and weakness of the patient, was delayed for an unusually long time, it was found that the large solid mass at the pylorus had disappeared as if by magic. To make certain that no cancer existed at the base, the Rodman operation was performed in this case—a simple, almost a minor, operation. The pathologist reported that there was no trace of cancer—indeed that nothing abnormal could be found excepting a little scar tissue. The second operation caused but slight disturbance. Had the entire operation been performed at the first stage, not only would a great hazard have been taken as to life, but also a needless operation would have been performed.

Another two-stage operation for cancer of the stomach was performed on a patient 72 years of age whose case had been given up as hopeless. She herself insisted on an operation and was brought to the hospital in an ambulance. She was given a transfusion of blood and passed through a two-stage operation with great ease, enduring the second operation more easily than the first. Four years have passed since the operation and the patient is today bright and well at 76.

We are convinced that the present high mortality which attends resections of the stomach in all clinics can be diminished more than one-half by *anoci-association*, and, in the case of handicapped patients, by two-stage operations.

CANCER OF THE UTERUS

Many surgeons now believe that the best method for performing hysterectomy for cancer is by dissection with the cautery, and the arguments for this method are well founded. Whatever method is used, however, in our opinion the operation should be performed in two stages to avoid the fatal implantation of cancer cells in the field of operation.

In cancer of the cervix, at the first operation every vestige of the growth is destroyed by heavy cautery irons which carry enough heat to coagulate protoplasm well beyond the parts in contact with them—*coagulation not eschar* is the aim. After the local cancerous growth is destroyed, the vagino-cervical attachments are severed with a dissecting cautery, in order that all blood-vessels running from the vagina to the uterus may be divided. After this complete wide destruction of the cancer-bearing cervix, so little uterine tissue is present in the vagina that complete vaginal hysterectomy, even of the Schuchardt type, could not well be performed. Even should this be possible, unless it can be completely accomplished by means of a cautery, there should be an interval of at least a day before the completion of the hysterectomy. This interval is required to ensure the death by anemia of every detached cancer cell. The vagina, instruments, gloves,—everything in the neighborhood of the cancer,—may harbor cancer cells. During the interval the vagina is lightly packed with large sponges saturated with alcohol. On the following day abdominal hysterectomy is performed.

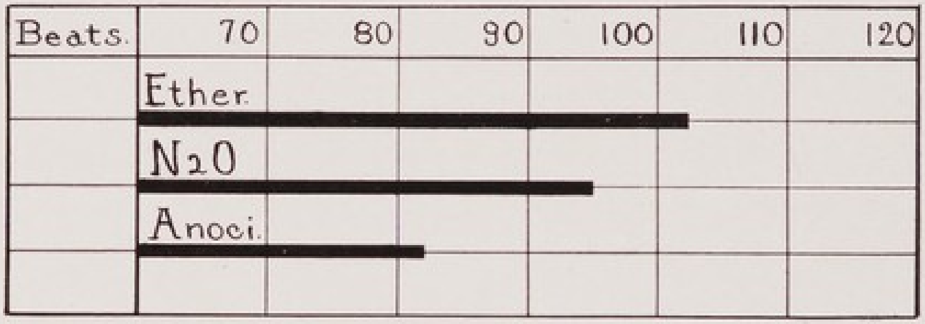
In this, as in all two-stage operations, the use of nitrous-oxid-oxygen plays a most benevolent rôle. The patient has no distressing experience in going under this anesthetic and, therefore, returns for the larger operation in a reassured state of mind.

No nerve blocking is used in the preliminary vaginal operation because in a cancer field whose boundaries are so uncertain as are those of cancer of the cervix there is risk that the cancer cells may be reimplanted by the needle.

In the second operation the *anoci-association* technique varies in several important particulars from that described for the removal of benign tumors. First, only the abdominal wall is infiltrated; second, as the dissection must be carried down against the pelvic wall, and as the widest possible excision of the parametrium is required, a wide field of exposure is necessary. The intestines are kept out of the pelvis by gentle retraction with gauze pads. To secure the needed relaxation at this stage of the operation, it may be necessary to add some ether to the nitrous-oxid-oxygen.

By the following technique opportunity is given for ample dissection and yet it is possible for the patient to be carried through mainly under nitrous-oxid-oxygen anesthesia.

With the patient in the Trendelenburg position, the abdominal wall is thoroughly infiltrated with novocain and an ample incision made. While going through the wall ether is added to the nitrous-oxid-oxygen to secure the necessary relaxation for the next step. The relaxed abdominal wall is raised and by means of large moist gauze pads of the Moynihan type, the intestines are gently pressed out of the pelvis. As soon as the pelvis is clear and has been adequately protected against the return of the intestines during the pelvic dissection, ether is discontinued as nitrous-oxid-oxygen alone is sufficient for the remainder of the operation. Local anesthesia is not used within the pelvis because of the danger of piercing some cancer tissue with the needle. The tissues are protected by *anoci-strategy*, however. The uterus is not pulled up out of the pelvis, but the surgeon goes down into the pelvis to the uterus—so that its fundus need not be grasped by any instrument. The clamps on the broad and round ligaments are sufficient for the required orientation of the uterus. Throughout the dissection sharp knife division or the dissecting cautery only is used. The course of the ureter is easily seen, and the separation from the bladder is readily made. When communication with the vagina is made at any point, the critical part of the operation is past. Only vaginal drains are used (Fig. 40).



The Pulse.

Each heavy line represents the average 5 P. M. pulse-rate of ten patients during the first four days after operation.

Fig. 40.—Comparative Clinical Results of Consecutive Abdominal Hysterectomies Performed under Ether Anesthesia, under Nitrous-Oxid-Oxygen Alone, and under Complete *Anoci-association.*

In this two-stage operation it is especially interesting to note the conservation of the patient's vitality.

In cancer of the fundus of the uterus a different plan is followed. The cervical canal is seared by pressing into it one of Ochsner's heavy cautery irons. The cervix is then tightly closed by through and through stitches with strong catgut. The sutures are tied and long ends are left to serve as tractors. A vaginal hysterectomy is then performed. The cervix is freed by means of either a dissecting cautery or a knife, the tissue being divided very gently until the broad and round ligaments are reached. By this technique the field is well safeguarded against cancer implantation and there is but little shock.

Since their realization and application of the underlying principles involved, the authors have not seen a single death from shock or from exhaustion in any operation for cancer in the pelvic organs.

CANCER OF THE LARYNX

The value of the two-stage operation is perhaps best illustrated by the two-stage operation for cancer of the larynx, in the first stage of which, by means of a preliminary gauze packing, that very vulnerable area, the mediastinum, and the region along the deep vessels and the trachea and esophagus are amply prepared to resist the inevitable exposure to infection when the larynx is removed. This technique eliminates the great danger of mediastinal infection which, after pneumonia, has been the most fatal result of laryngectomy. The explanation of the characteristic painless, tedious and fatal course of mediastinal abscess is probably found in the fact that this region of the body has always been protected from wounds by the bony chest wall. Being closed to wounds through the vast periods of man's evolution, it has been closed likewise to infection. The tissue of this protected region, therefore, has not been endowed with the elements required to efficiently meet and overcome infection, as have been, for example, the peritoneum and the external parts of the body. In view of this fact, we must guard this helpless territory with special care, by means of preoperative protection. An ideal defense is made by opening and packing the deep planes of the base of the neck, and, at the same seance, making a low tracheotomy. By this means the mediastinum is put under strong guard, and at the same time the later technique of the laryngectomy is measurably reduced.

The danger of vagitis also may be eliminated if the dissection be carried on one side of the larynx all the way to the upper margin of the field of final operation, this territory being packed with iodoform gauze just as the deep planes of the neck are packed. By this procedure one

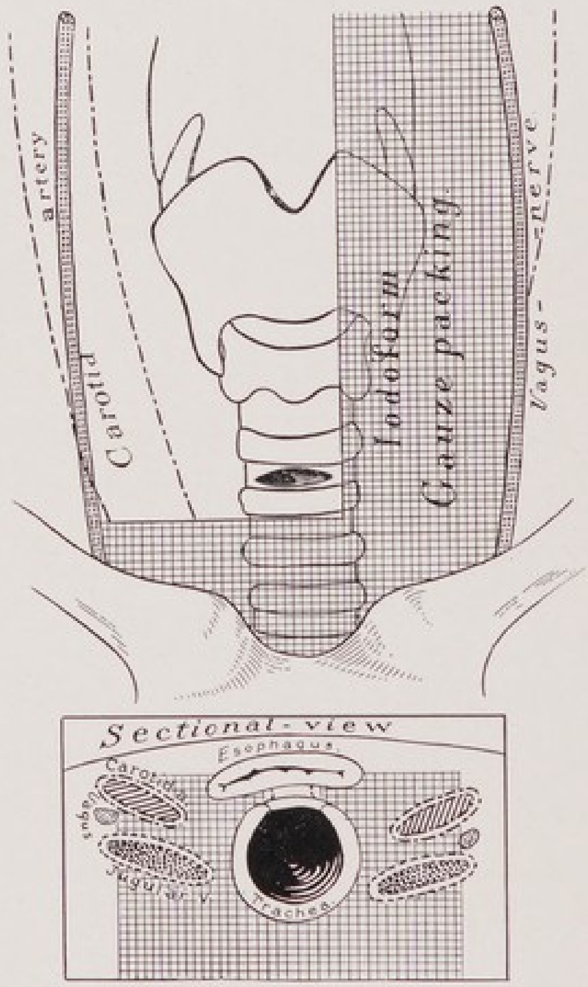


Fig. 41.—Laryngectomy. Schematic Drawing to Illustrate the Method of Packing the Lateral Planes of Neck with Iodoform Gauze at Preliminary Operation.

vagus must take the brunt of exposure and adjustment before the larynx is removed. By the time the laryngectomy is done this vagus will be readjusted and ready to resume its function in case it be affected at all, and so the heavy on-

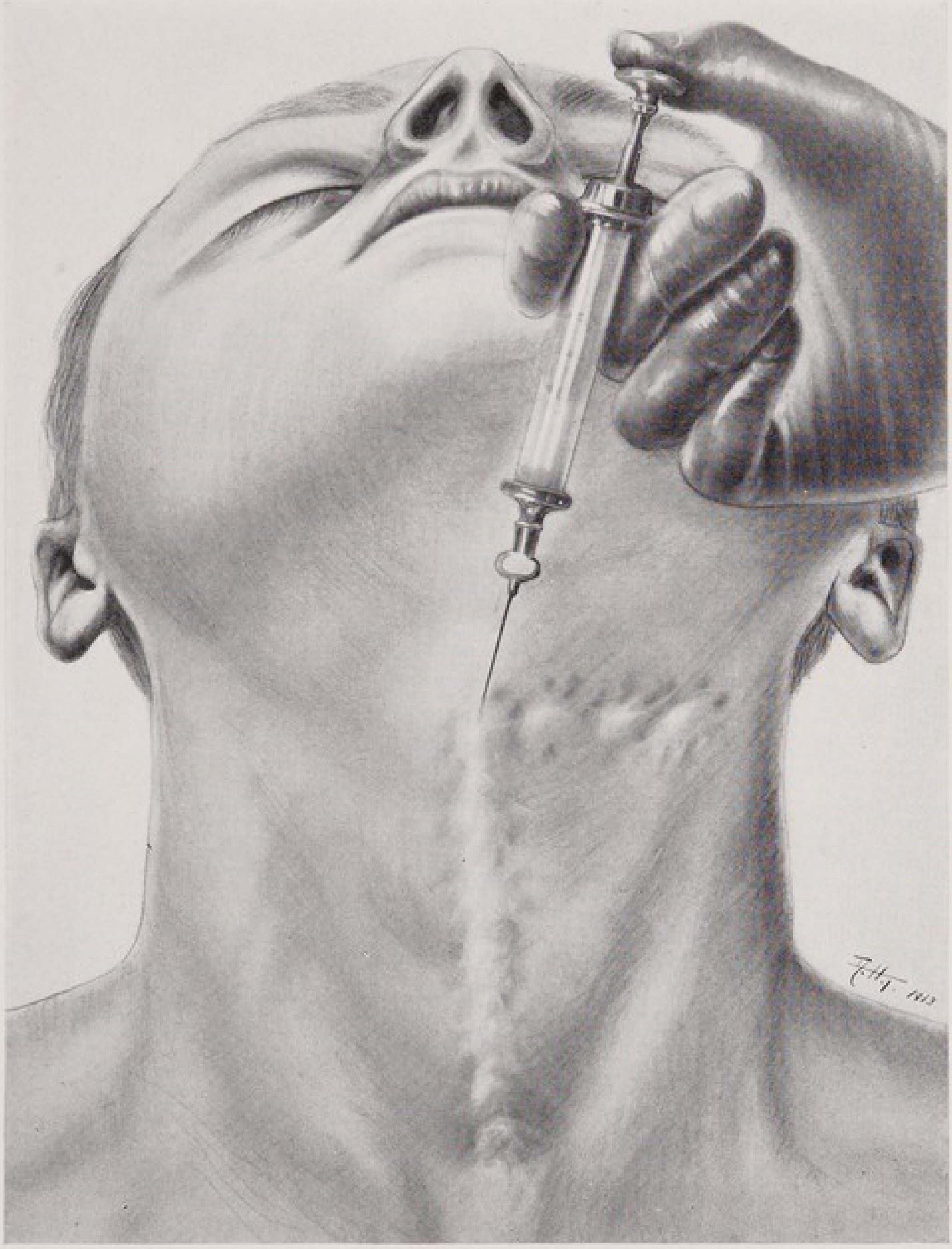


FIG. 42.—LARYNGECTOMY. INFILTRATION OF SKIN WITH NOVOCAIN.

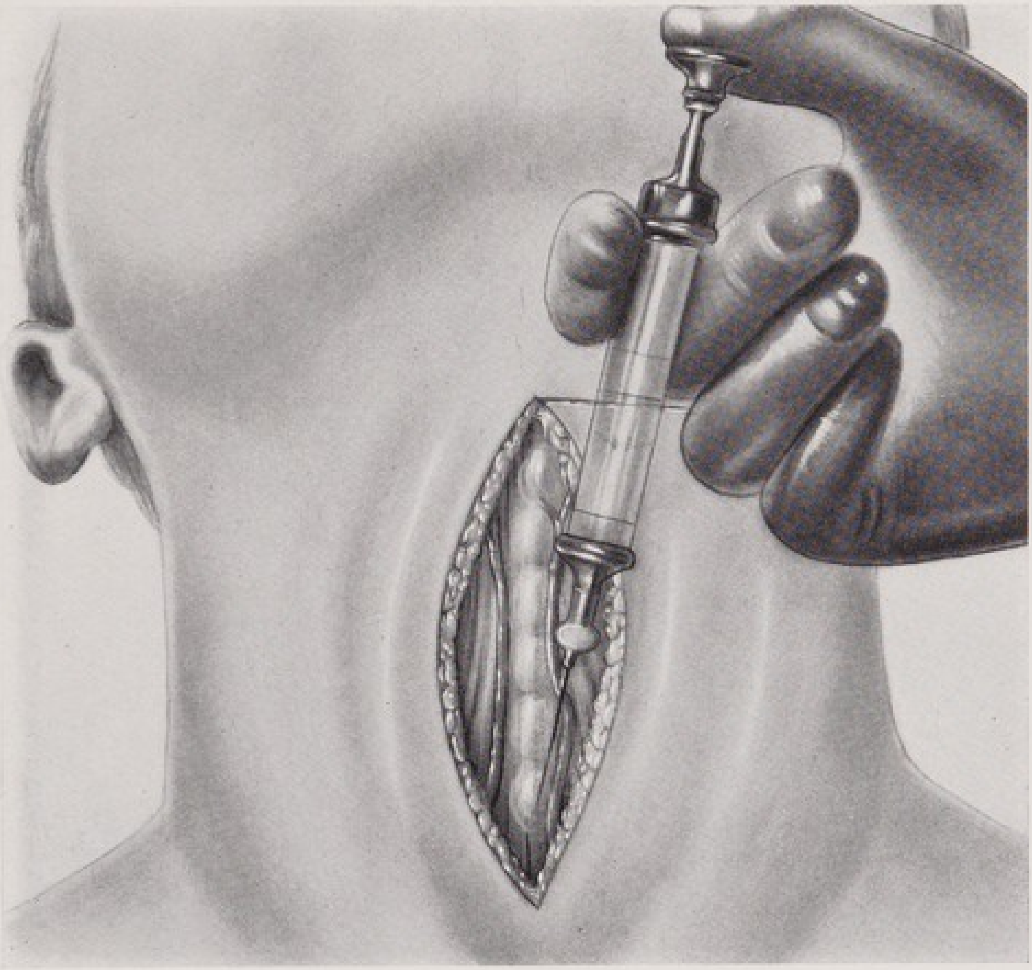


Fig. 43.—Laryngectomy. Infiltration of Fascia with Novocain.

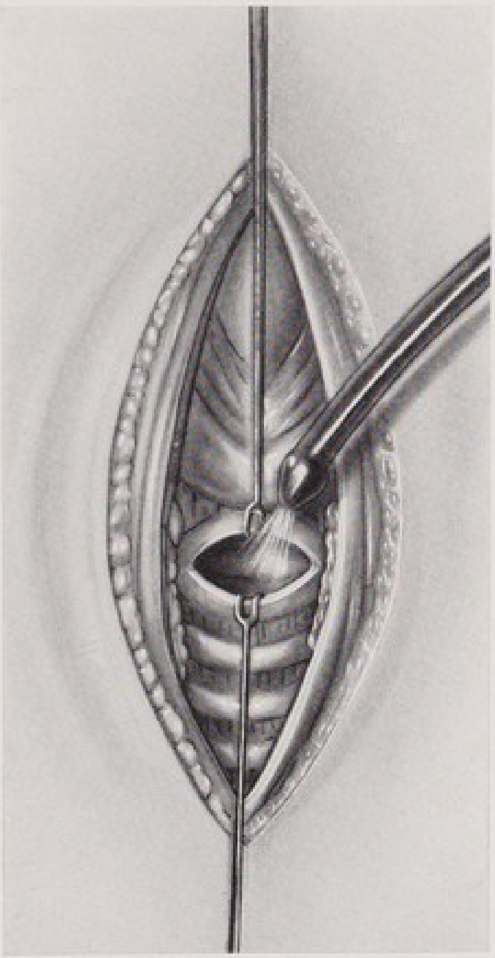


FIG. 44.—LARYNGECTOMY. NOVOCAINIZING THE NERVE-ENDINGS OF THE TRACHEA.

slaught of the vagi upon the heart will not be made by both vagi simultaneously. In the case in which one of us tried this plan it seemed to be completely effective (Fig. 41).

The second stage—the excision of the larynx—is safely and easily accomplished. Each division of skin, subcutaneous tissues, platysma, and mucosa is preceded by a thorough infiltration with novocain. Reflex inhibition of the heart and respiration through mechanical stimulation of the superior laryngeal nerves may be absolutely prevented by the hypodermic administration of $\frac{1}{100}$ gr. atropin (adult dose) before the operation and during the operation by the local use of novocain applied either by a spray or hypodermically. Laryngectomy is usually followed by a brisk local reaction; but since the mediastinum has been protected by the previous gauze packing, and the bronchopulmonary tract has been given a special defense by the preliminary tracheotomy, the patient is well equipped to meet the new condition (Figs. 42–45).

Of thirty-four laryngectomies, twenty-eight have been performed in two stages with but a single death.

CANCER OF THE TONGUE

In operations for cancer of the tongue two difficult problems must be met, the immediate surgical risk and the possibility of permanent cure. The principal immediate danger is pneumonia from inhalation of infection from the field of operation, while there is also danger from the exhaustion which is a result of the diminished ingestion of food and the prolonged endurance of the disease.

To ensure a permanent cure not only is the cancer to be removed but all of the glands of the neck must be completely excised whether they be enlarged or not. If both of these operations be performed at the same seance, then the patient may go to the ground because he is unable to bear the burden of the diminished nutrition and the soreness over so

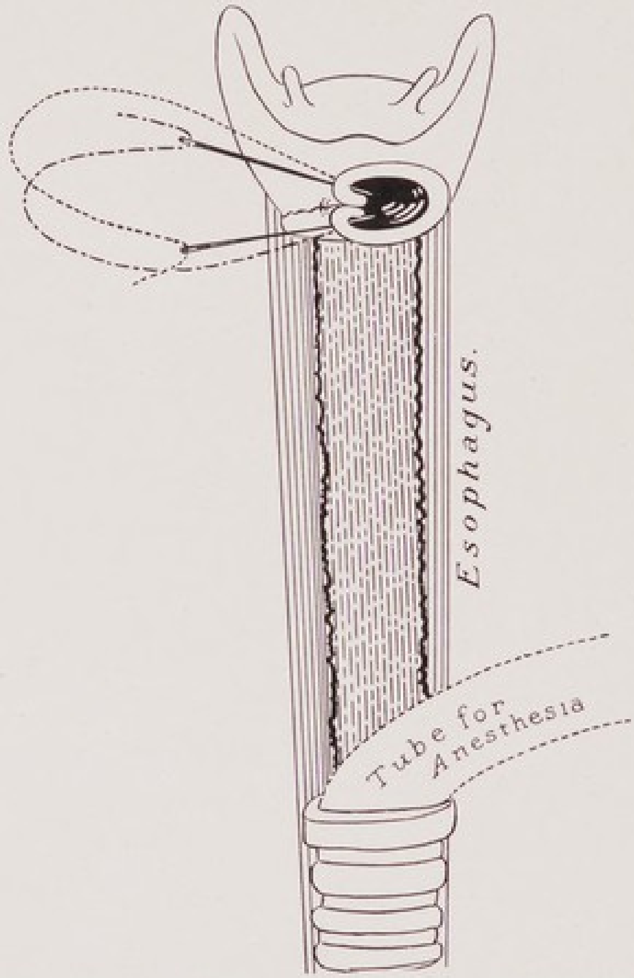


Fig. 45.—Laryngectomy. Schematic Drawing Showing Arrangement of Tube through which the Inhalation Anesthesia is Administered and also the Shoemaker's Stitch used in Closing Pharyngeal Opening.

large a field as the mouth and neck and the inevitable infection in the mouth. The possibility of a permanent cure depends also on the prevention of the immediate implantation of cancer cells in the mouth at the time of the operation. If the cancer be not large, no cutting operation whatever is made but with the cautery all of the disease in the mouth is destroyed. If, however, the growth be extensive, it is best on one day to cauterize the field of the disease and on the following day after the cancer cells have died of starvation, to excise the entire cancer field in the mouth. After the patient has well recovered from the mouth operation and is able to take nourishment satisfactorily, the final operation—the excision of the glands in the neck—can be performed without great inconvenience to the patient.

In addition to the lessened risk of the extension of the cancer, the two-stage operation lessens also the danger of infection, for when the whole operation is performed at one seance the neck is so sore that the patient is almost certain to inhale infection from the mouth directly, whereas if the neck be normal the patient is able to stand up, to move about, to spit out the inhalations and thus to protect his lungs against the infection.

SUMMARY

The two-stage operation under *anoci-association* gives the surgeon his maximum opportunity for lessening the operative mortality rate in many of the gravest surgical risks. Thus we may triumph over surgical difficulties by strategically dividing our forces. In our own personal experience in these formidable operations for cancer, the mortality rate has already been diminished one-half.

CHAPTER XIII

ANOCI-ASSOCIATION IN TREATMENT OF EXOPHTHALMIC GOITER

Every one will agree that a technique that can carry an advanced exophthalmic goiter case through an operation without increasing the pulse-rate can all the more readily do as much in any other operation. In fact, it was in large measure the study of the preoperative and postoperative course of cases of Graves' disease which led to the enunciation of the kinetic theory of shock and the development of the shockless operation.

Graves' disease is not a disease of a single organ, nor is it the result of some fleeting cause, but it is a disease of the motor mechanism of man, the mechanism by which physical action is being produced and the emotions expressed. Phylogeny as well as ontogeny must be called to account for its existence, though the *final* exciting cause may be a stimulating emotion, an infection, autointoxication, or any other stimulus of the kinetic system, as a result of which a pathological interaction is established between the brain and the thyroid. This pathologic interaction may be broken by diminishing the thyroid output, thus allowing the brain to regain its normal control of the mechanism; or by securing physical rest by which the brain will fast regain its normal control and which in time will cause the return of the thyroid to its normal activity.

A searching inquiry into the past history of a patient with Graves' disease will frequently elicit the fact that he has undergone some emotional experience, often so deeply disturbing in its nature that it has become a dominant emotional stimulant, absorbing attention during the day and disturbing sleep at night. The constant recurrence of this evil stimulus is attended by an increase of all the emotional phenomena, so that gradually a state is reached in which the effects of the constantly present stimulus remain unchanged—the eyes protrude, the body trembles, the facies of terror is present, the thyroid is permanently enlarged, the entire emotional (motor) mechanism being involved (Fig. 46).

In such a state any excitation which might produce slight apprehension in a normal individual becomes an overwhelming stimulus. In patients with Graves' disease, the mere proposal that an operation be performed becomes a pathological excitation which may so increase the disease that the patient is even less able than before to make up his mind to submit to adequate treatment. On all sides the patient is beset by vicious circles, by pathological interactions. The ideal plan of approach, therefore, is to assure the patient that his malady is curable, that treatment can best be administered in a hospital; that unoperative measures will first be tried, but that if they prove inadequate, a simple operation will be performed; that it will be best to leave the final decision as to the advisability of an operation to his medical adviser; and that, since even the discussion of an operation is both unpleasant and injurious, it will be best not to open the subject again.

If the patient, as is usually the case, consent to leave the whole matter to the judgment of the physician, the way is opened for the most effective treatment which in our judgment has ever been proposed for exophthalmic goiter; that is, ligation or excision under the protection of *anoci-association*.

For several days the anesthetist with the paraphernalia for the administration of nitrous-oxid-oxygen administers to the patient fictitious "inhalation treatments." On the morning of the operation, which is performed in one of the favorable phases of the many cycles of this disease, the hypodermic injection contains morphin and scopolamin; nitrous oxid is added to the oxygen "inhalation," and the patient falls asleep in bed without realizing that the first step in the operation is being taken. The anesthetized patient is transported to the operating room, where the operative field is prepared. In the operation itself each division of tissue is preceded by the infiltration of novocain, and sharp dissection and gentle manipulations are employed throughout. In grave cases quinin and urea hydrochlorid may be injected into every part of the operative field before the wound is closed, though the need for this protection may be neutralized by the employment of so gentle and strategic a technique, that a minimum amount of trauma is caused and the postoperative protection of quinin and urea may not be needed.

The patient is kept under anesthesia until he has returned to his room, which has been restored to its condition when the administration of the anesthetic was started. In the course of the cycle from his room to the operating room and to his return, the patient's brain has received no activating stimuli and no record of the operation has been written upon either the conscious or the subconscious brain.

FIG. 46.—TYPICAL CASE OF EXOPHTHALMIC GOITER SHOWING CHARACTERISTIC FACIES.

By this technique the scope of the operation is greatly increased, and the lobe can be safely removed from any pa-

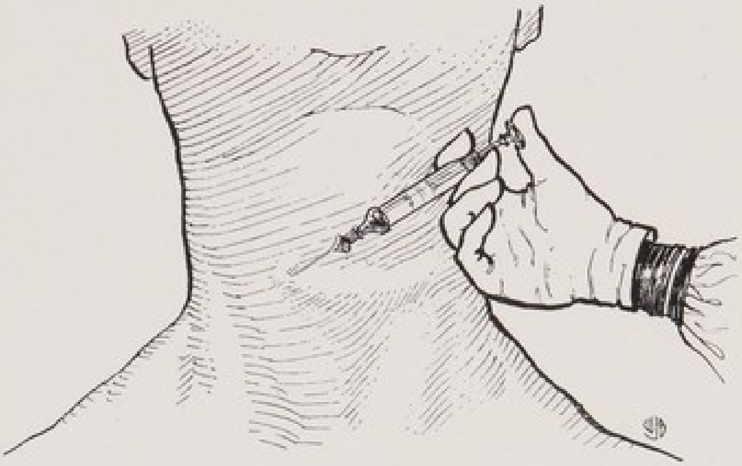


Fig. 47.—Thyroidectomy. Infiltration of Skin.

tient whose condition can endure the metabolic influence of the withdrawal of so much active gland tissue. In cases in which the excision of a lobe is contraindicated, it is best

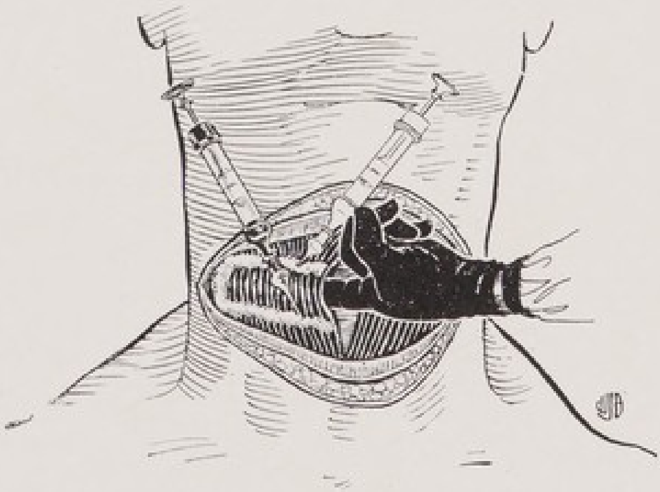


Fig. 48.—Thyroidectomy. Infiltration of Muscle before Division.

to ligate one or both poles, excising the lobe later, if it be necessary. Ligation is performed without removing the patient from his bed. Nitrous-oxid-oxygen may or may not be administered, but the brain is always protected by a complete novocain infiltration.

As for the technique of the excision itself; the transverse incision should be sufficiently ample to expose the gland to its lateral border (Fig. 47). The important part of the dissection may thus be in full view without more than nominal retraction of the muscle. The operation should be so bloodless throughout that the lymphatic vessels can be everywhere seen and identified. This may be accomplished

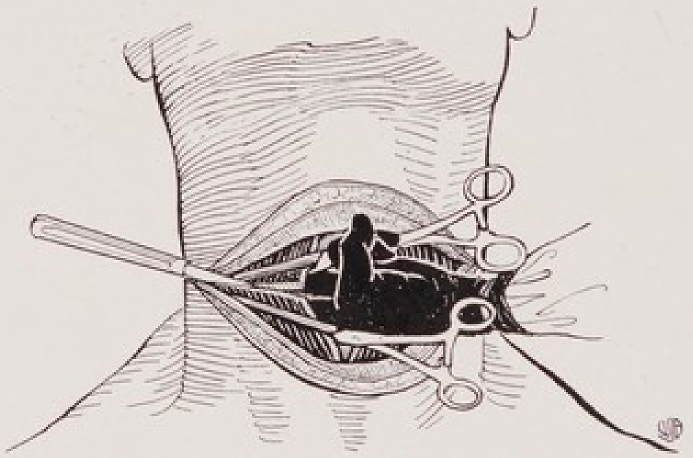
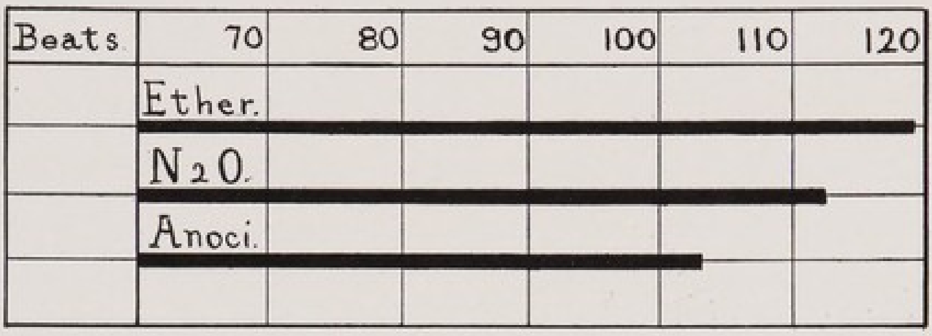


Fig. 49.—Thyroidectomy. Bloodless Division of Muscles Between Clamps.

if *every blood-vessel is clamped twice and divided between the forceps* (Figs. 48 and 49). The field will then always be translucent, and being thus controlled, the dissection is carried entirely *on the capsule itself*. The hoarse voice which used to be a frequent sequel to thyroidectomy has been largely eliminated by *always picking up tissue parallel to the larynx and trachea, and never at right angles to them.* If, in the translucent field, the Halsted forceps are applied always parallel with and closely against the capsule of the gently retracted gland, no paralysis of the vocal cord will follow, while the parathyroid will rarely if ever be endangered nor will its blood supply be disturbed.

The surgeon also must protect *himself* from a certain psychic phase which is apt to develop in difficult goiter operations and which corresponds to the "break" of the pointer dog when he "rushes the covey." As the surgeon follows a trying and teasing path around a baffling lower



The Pulse.
Each heavy line represents the average 5 P. M. pulse-rate of ten patients during the first four days after operation.

FIG. 50.—COMPARATIVE CLINICAL RESULTS OF CONSECUTIVE THYROIDECTOMIES PERFORMED UNDER ETHER, UNDER NITROUS-OXID-OXYGEN ALONE, AND UNDER COMPLETE *Anoci-association*.

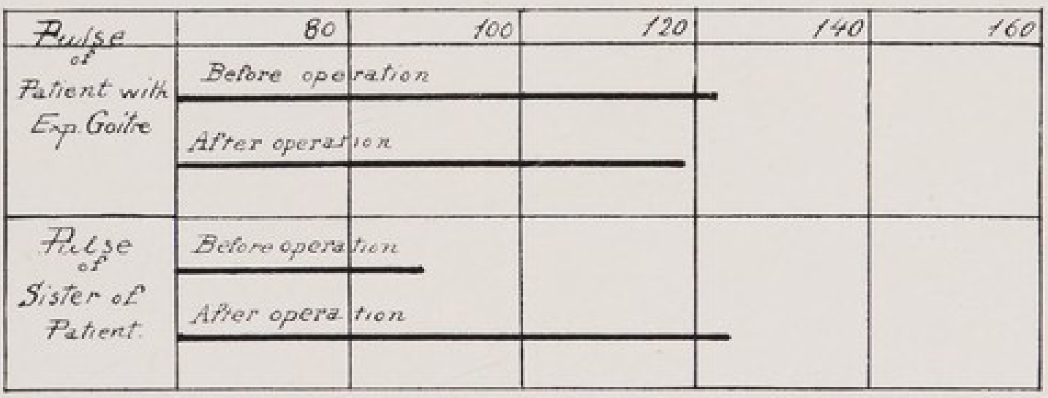


FIG. 51.—CHART ILLUSTRATING PROTECTION AFFORDED BY USE OF *Anoci-association* IN THYROIDECTOMY.

The patient's brain received neither traumatic nor psychic stimuli from the time she was anesthetized in bed until she returned again from the operating-room. Her pulse-rate *fell* slightly during the operation. On the other hand, the psychic strain undergone by the patient's sister while the operation was being performed caused her pulse-rate to rise to 124.

border where now and then a small vein breaks and momentarily veils the field, he will again and again be tempted to rush the operation, thus losing his technical control of the field. To succumb to this temptation is to court disaster.

By the control of a translucent field, by rigidly making all tension parallel and close to the gland and by sharp knife dissection throughout, every drop of the patient's blood is conserved; the parathyroids are left unimpaired; the voice is unaffected; the wound may be closed without drainage; the local field is but slightly injured and the trachea and larynx are deprived of none of their protective tissue covering (Figs. 50 and 51).

The benefits of the operation do not end with the immediate results. *The postoperative hyperthyroidism is prevented or minimized* and the later clinical results are as much improved as is the immediate postoperative condition.

When a case of Graves' disease, which is not under surgical treatment, is subjected to a severe psychic shock, to a heavy nervous strain, or to intense worry, the disease may be aggravated for weeks or months and not infrequently death results. The evil effects of facing the ordeal of operation are not only seen immediately but are perpetuated for days, weeks or months by their frequent recall. From this handicap the *anociated* patient is free and by so much is his convalescence speeded on its way.

A comparison of the records of the cases of exophthalmic goiter operated upon at Lakeside Hospital shows in 28 consecutive *ether* cases an average increase of 25 beats in the pulse-rate in the first twenty-four hours after operation and of 29.9 beats during the operation; while 28 consecutive *anociated* cases showed an average rise of but 3.03 beats in the first twenty-four hours after operation and a *fall* of *6.39 beats during the operation.*

CHAPTER XIV

ANOCI-ASSOCIATION IN OPERATIONS ON THE BRAIN

The work of Horsley, Cushing and Frazier amply confirms the conclusion from our laboratory experiments that there are in the brain no nociceptors, the adequate stimulation of which can produce exhaustion of the brain-cells. Local anesthesia therefore is not needed in operations on the brain, although, as in all other operations, the environment of the patient both before and after the operation should be kept free from nocuous influences.

It is true that injury of the brain may interfere with the vasomotor or respiratory centers and cause collapse—but this collapse is not surgical shock. A certain class of gravely handicapped patients may well be considered in this connection, however. These are the patients with a pathologic intracranial tension which most commonly results from intracranial hemorrhage or depressed fractures. Our researches have shown that the brain cannot endure total anemia for more than from six and one-half to eight minutes. Our first duty therefore is to maintain a high pressure until the pathologic intracranial tension is relieved. If the patient be comatose, or nearly so, no general anesthetic should be used, but under local anesthesia an osteoplastic flap may be turned down, or the skull at least may be opened. Should a general anesthetic be required, a momentary nitrous-oxid-oxygen anesthesia may be given as that will not lower the blood-pressure. In these cases, however, pain is an advantage as by its primary stimulation of the brain-cells it will cause a rise in blood-pressure. The slight resultant exhaustion can be well borne later after the pathologic intracranial pressure is relieved.

Many of these head cases have been killed by an unintelligent technique intended for relief, but ineffective because of the lack of appreciation on the part of the surgeon of the disastrous result of anemia of the brain of even a few minutes duration.

In operations for the relief of trifacial neuralgia Frazier's method is of great value. As soon as the Gasserian ganglion is exposed he injects alcohol into it, thus blocking nerve conduction. He then dispenses with general anesthesia as all the rest of the operation can be carried on in the field which has been completely anesthetized by this blocking of the entire trifacial nerve.

CHAPTER XV

ANOCI-ASSOCIATION IN OPERATIONS FOR CANCER OF THE BREAST

Very few large operations produce less shock than does an excision of the breast. Every *anoci* precaution must be taken in this operation, however, because patients with cancer of the breast may be heavily handicapped by long illness, by overwork and worry, by age—by all the noci-associations which accompany this disease, not the least of which is the crushing fear of the cancer itself.

There are very few nociceptors in the area of operation beneath the skin, so but little local anesthetization is needed in addition to that produced by the infiltration of the skin along the line of incision. If the patient be not too feeble, the entire operation may be shocklessly performed under local anesthesia alone. One of the authors was once greatly impressed by seeing Dr. Bloodgood perform a breast amputation under local anesthesia alone upon a feeble, aged patient. There was no shock and the patient made an easy and good recovery.

The important point in these operations is not the anesthetic but the operative technique itself. The pernicious habit of sponging with rough gauze should be avoided, as should the forcible extraction of the lymphatic glands, and the violent separation of the mammary glands. Sharp knife dissection is not only less damaging to the tissues, thus favoring wound repair, but it makes it easier to maintain a dry, clear field.

To minimize postoperative pain and to prevent infection from necrosis of the tissues, the skin surfaces should not be pulled together with tight sutures, but to avoid tension the field should either remain open, skin grafts being made to close the surface, or the Rodman technique for making skin flaps should be employed.

CHAPTER XVI

ANOCI-ASSOCIATION IN OPERATIONS ON THE EXTREMITIES—ACCIDENTS

Amputations. Osteotomy. General Considerations in Accident Cases.

AMPUTATIONS

Amputations are nearly always performed upon patients seriously handicapped either by the acute shock which results from crushing injuries, or by general debility as in cases of senile or diabetic gangrene. Amputations for sarcomata of the bones are less frequently performed than formerly.

The general technique of *anoci-association* in these cases includes nitrous-oxid-oxygen anesthesia; the progressive infiltration with novocain of the skin and subcutaneous tissues; the intraneural anesthetization of nerve trunks; the sharp division of the soft parts to the bone; and the division of the bone with a Gigli saw. *No tourniquet is used*, but all blood-vessels are secured *en route* so that a dry, clear field is maintained throughout. The crushed tissues should be handled most gently, in fact, *all handling should be on the distal side of the field.* In short, we should employ a feather edge division of tissue without the contusion of handling or sponging so as to leave a clean incised wound surface only.

By avoiding retraction, by sharp dissection and by thoroughly blocking the operative field, an amputation may be carried through without a change in the pulse-rate, no matter what may be the size of the limb.

In cases of acute shock from crushed limbs, deep morphinization is imperative.

On account of the danger of infection in these emergency cases, the use of quinin and urea hydrochlorid is contra-indicated *unless the risk be grave*, when a deep infiltration should be made beyond the immediate field of operation, as in such a case the choice is between death from shock and delayed healing.

If recovery be doubtful in a case of acute shock, then an immediate transfusion of blood should be given. This will prove a saving measure unless the brain-cells have become so extensively disrupted by anemia that their restoration is impossible.

On this plan we have performed sixteen amputations for gangrene resulting from diabetes or thrombosis, without a fatality.

OSTEOTOMY

In extensive operations for chronic infections of the bones with necrosis and caries the risk is considerable, especially in children reduced by long suffering and by suppuration. In these cases, on account of local conditions, nerve blocking is not practicable, but the surgeon should minimize the loss of blood by the use of the tourniquet; and he should minimize the trauma by gentle manipulations, and by the use of as few movements as possible. By following the brilliant technique of Murphy in these cases, the resultant shock will be minimized.

GENERAL CONSIDERATIONS IN ACCIDENT CASES

The principle of *anoci-association* is a splendid guide in the care of patients who have sustained fractures or dislocations, who have been mangled by machinery or in railway accidents, or have been pierced by bullets or knives. These patients are suffering not only from the actual trauma and consequent hemorrhage, but in most instances from such overpowering fear that by that fear itself their bodies would still be damaged, even if there were no obvious physical injury.

If there be no contraindication to its use, solacing doses of morphin should be given—not text-book doses, but repeated physiologic doses until quiescence is established. Should an operation be required, complete *anoci-association* is urgently indicated to protect the already depleted brain-cells. If amputation be necessary, sacral anesthesia, spinal anesthesia, or local nerve blocking should without fail be employed in addition to nitrous-oxid-oxygen. Should the brain be dangerously anemic as a result of hemorrhage or shock, or both, then a timely direct transfusion of blood should be made. By the combination of these methods the dangerous phase may be safely tided over.

In open, crushed wounds, quinin and urea hydrochlorid would be an ideal protection against postoperative depression were it not for the irritating effects of this drug. In a close risk in which there are extensive lacerations, however, "safety first" demands that the first two critical days be tided over by the aid of ample infiltration *at a distance*, even though the later wound repair be delayed. In penetrating wounds the surgeon should have definitely planned, concise, short-cut, efficient methods—such, for example, as have been formulated by Dr. John Young Brown as the result of his unexcelled experience with this class of patients in civil practice.

CHAPTER XVII

THE IMPORTANCE OF ANOCI-ASSOCIATION TO PATIENTS HANDICAPPED BY TOO HIGH OR TOO LOW BLOOD-PRESSURE

A good heart and normal blood-vessels with active innervation and with the capability of maintaining an average blood-pressure give a patient a strong defense against a surgical operation. With almost human ingenuity, however, disease processes strike at the strongest defenses of their intended victim, and, as a consequence, all too seldom does a patient come to the surgeon with this protective mechanism unimpaired. It is essential, then, that we understand well the causes which may produce menacing deviations in blood-pressure, that we may be able successfully to combat these conditions by preliminary and coincident measures.

HYPERTENSION

Hypertension may be but a temporary condition induced by a continued and intense emotion—worry, grief or anger; it may be due to acute or chronic infection, to exophthalmic goiter, or to increased intracranial pressure, as well as to such more immediate causes as cardiovascular disease and physical changes in the blood-vessel walls. From this enumeration it is obvious at once that while some of the causes of hypertension are temporary and remediable, others are permanent and irremediable.

In considering the advisability of operation upon a patient with hypertension, therefore, we shall find that while at times the hazard must be taken at once, at times also, operation may be delayed until the hypertension hazard has been eliminated or, to some extent at least, diminished. If a patient with a benign tumor be in the throes of an overwhelming grief, or if he be passing through a psychic strain—the result of intense worry or anxiety—the operation may well be delayed until the emotional stress has passed. A benign tumor in a patient with Graves' disease may safely await a lobectomy or ligation, and the after-cure of the dominant trouble. If the hypertension be due to a pyogenic infection, the operation for a chronic disease may be delayed until the focus has been eradicated. Again, operation for benign tumors or chronic diseases may await the most favorable phase of that form of hypertension which can be partially controlled by nitroglycerin, meat-free diet, rest and diversion. In these controllable cases, however, we do not meet the great problems which are: (1) to discover just what are the special risks when operation in hypertension cases cannot be postponed; and (2) to evolve means by which these risks may be minimized or obviated.

The natural sequelæ in hypertension cases are embolism, thrombosis, renal insufficiency, angina, pneumonia, cardiac failure. Why are these dangers precipitated by operation? We know that some of these results are to be expected when a person whose blood-pressure is high is subjected to undue mental or physical exertion; to sudden shock, either physical or psychic; or to heavy nervous strain. From such cases a heavy toll of life is levied at seasons of great stress, such as financial panics, the San Francisco earthquake, etc.

Since hypertension cases meet the same dangers in times of physical and in times of psychic stress, may we not find that the underlying causes in both instances are identical? An explanation which fits all cases may be based on the principle of biologic adaptation. To make clear the argument here it is necessary to restate briefly that emotional excitation will drive the whole motor mechanism, even though no muscular act be performed. The brain, the thyroid, the suprarenals, the liver, the muscles—all the parts of the body that contribute to fight or to flight—are activated. The reason is clear. In our phylogenetic history those causes which produced fear or anger or any form of emotional excitement at once led to great bodily activity. The individual put his entire motor mechanism into use by either running away from danger or by aggressively fighting against it. As the human race developed and civilization advanced, man learned to control the outward expression of his emotions, but it is still impossible for him to control the activities of the mechanism itself. By his very repression he increases the danger of too great activity, for the energy which formerly would have been expended in motion, accumulates within the mechanism itself. Right here we find the key to the cause of damage in cases of hypertension, for among the energizing substances thrown into the blood stream to increase the power of motion are adrenalin and glycogen. As there is no muscular action, these agents are not entirely consumed, while the body is shaken and damaged as is the stationary automobile whose engine is running at full speed. Besides causing needless activation, all these energizing substances must be eliminated and so an unusual strain is put upon the organs of elimination.

As was fully enunciated in Chapters II and III this reasoning is based, not only upon clinical observations, but also upon laboratory experimentation, by means of which (1) we have proved conclusively that the emotions cause as great activations of the brain as does physical injury or physical exertion, and (2) we not only have confirmed Cannon's observation that emotion in cats causes an increased output of adrenalin, but we have added the significant fact that if the nerve supply of the suprarenals be divided, there is no increase in their output.

The significance of these two conclusions becomes obvious at once when we recall the rich nerve supply of the ductless glands, the physical evidence of brain stimulation, and the definite proof that the brain controls the adrenalin output.

The significance of the increased adrenalin output is obvious when we remember that adrenalin specifically stimulates the blood-vessel walls, raises the blood-pressure, and increases the output of glycogen by the liver.

And in turn the significance of the increased glycogen output is obvious when we recall the physiologic fact that glycogen bears the same relation to the running of the human motor that gasoline bears to the running of an automobile.

From these studies, clinical observations, and laboratory experiments, therefore, we have arrived at a simple explanation of the disastrous effects of emotional stimulation upon a patient with hypertension. We see that the emotional factor assumes an increasingly important rôle in the performance of surgical operations. The elimination of the emotional factor—important always—is essential to the successful outcome of operations upon these cases whose margin of safety is narrow at the best.

In addition to the psychic and traumatic factors, one other operative factor has a most important bearing upon our thesis, and that is the anesthetic. Ether, however skillfully it may be administered, induces a stage of psychic stress in the earlier stages of its administration. As we have stated previously, ether immediately impairs the immunity of the patient; it increases the coagulation time of the blood; as a fat solvent it dissolves many of the body lipoids—in the brain, the renal epithelium, the liver, etc.—and, as a consequence, there is an increased amount of waste products to be eliminated and a resultant increased tax upon the organs of elimination. The strain of ether nausea and vomiting, always a dangerous factor, is especially so in cases of hypertension. Therefore, the mere administration of ether in these cases is a distinct risk *per se*, because it injures and taxes the kidneys, predisposes to embolism and pneumonia, and increases the traumatic and psychic dangers.

We see then that hypertension increases the gravity of the prognosis in operative cases unless in some way these adverse factors can be controlled.

HYPOTENSION

It may at first seem unwarranted to state that we can often give a more favorable prognosis in the case of a patient with hypotension than in one with hypertension. That we can do so is due to the fact that for hypotension we have a definite and efficient remedy. As the principal causes of hypotension are hemorrhage and anemia, the condition is logically to be met by the direct transfusion of blood, which, as occasion demands, may be done several days before, just before or during the operation, or immediately thereafter.

It may be argued that this remedy, even though efficient, is too difficult to be practised generally. It is true that the technique is difficult and that special instruments and special training are required, but this objection is ethical rather than scientific, and the only answer can be the ethical question:—Is the saving of human life worth the pains of the surgeon to train himself in the technique of any procedure which will subserve that supreme end?

In a case of pathologic hypotension the margin of safety is much reduced and the prognosis is grave; for in such cases the brain-cells are deteriorated or destroyed, and consequently the vitality is low and complications are facilitated. In both hypotension and hypertension, therefore, the operation should be performed under nitrous-oxid-oxygen anesthesia and with complete *anoci-association*, so that every damaging factor, whether psychic or traumatic, may be excluded and the narrow margin of safety may be preserved.

CHAPTER XVIII

THE RELATION OF ANOCI-ASSOCIATION TO POSTOPERATIVE MORBIDITY AND MORTALITY

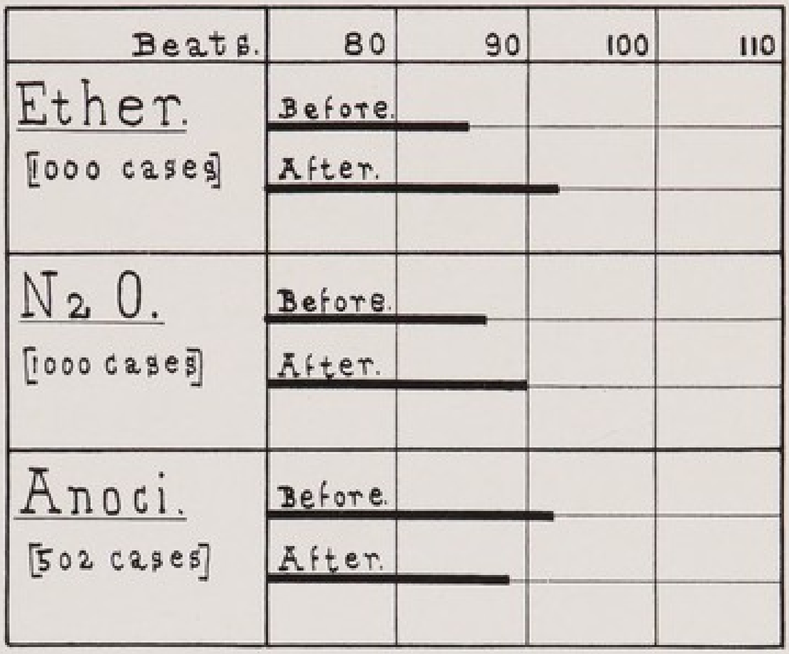
Gas Pain. Painful Scar. Nervousness. Aseptic Wound Fever and Postoperative Hyperthyroidism. Nausea and Vomiting—Digestive Disturbances. Backache. Infection. Nephritis. Pneumonia. Mortality.

The best clue to the comparative value of different operative methods is found in a study of the postoperative morbidity.

After operations performed under ether anesthesia alone, surgeons are confronted constantly with a familiar train of disastrous sequelæ, painful to the patient and discouraging to the physician. The immediate sequelæ include gas pain, nausea, and aseptic wound fever while the later results range all the way from painful scar alone to the long train of symptoms accompanying "postoperative neurasthenia."

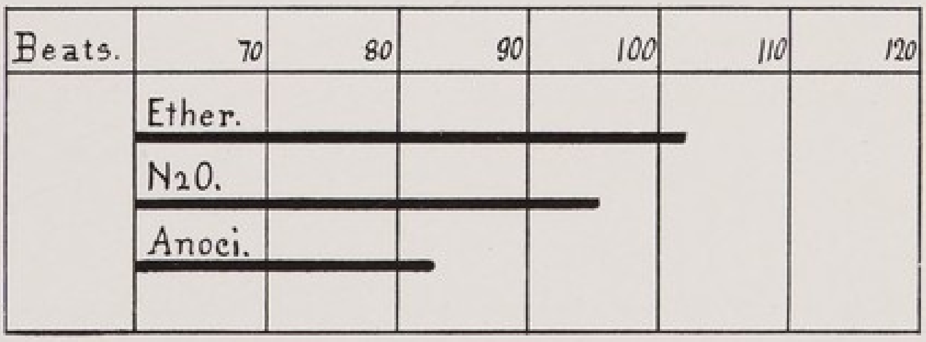
Here again biologic considerations teach us the cause of each of these disturbances and show how and why they may be obviated by the strategical maneuvers of *anoci-association*.

It has already been stated that a study of the pulse during and after the operation perhaps gives us our best clue to the value of the protective technique of *anoci-association* and explains the strikingly decreased postoperative morbidity after *anoci* operations. A comparison of 500 consecutive cases operated upon under ether with 500 consecutive cases operated upon under *anoci-association* showed in the ether cases an increase of 21.6 beats during operation, while the *anoci* cases showed a *fall* of .83 during the operation.



The horizontal lines represent the averages derived from 1000 cases operated upon under ether, 1000 under nitrous-oxid-oxygen, and 502 under complete *anoci-association*.

Fig. 52.—The Pulse-rate Immediately Before and Immediately After Operation.



The Pulse.

Each heavy line represents the average 5 P. M. pulse-rate of ten consecutive miscellaneous cases during the first four days after operation.

Fig. 53.—Comparative Clinical Results of Consecutive Operations Performed under Ether, under Nitrous-oxid-oxygen, and under Complete *Anoci-association*.

GAS PAIN

Postoperative gas pain can be explained as a biologic adaptation to overcome infection. In the course of evolution, all abdominal penetrations were infected, and, therefore, as a natural sequence, a protective mechanism within the abdomen was evolved as a means of protection. Most infections may be overcome if they can be localized. To accomplish such a localization of an infection in the abdomen, the intestines and the abdominal wall must be kept fixed against each other. To this end the intestine must be distended with gas, the abdominal wall must be rigid. If the intestine be distended with gas and fixed, then digestion must cease. If digestion be arrested, then there is anorexia, or even vomiting to expel food from the stomach. These facts show us how postoperative gas pains are due to a biologic adaptation to overcome infection, and explain their resemblance to incipient peritonitis. Nature does not depend upon the surgeon, or perhaps she knows the surgeon too well. The test of this hypothesis is easily made. If the brain through which this adaptive response is made be kept in ignorance of the incision into the peritoneum (a) by progressive novocain blocking throughout the operation, and (b) by postoperative quinin and urea blocking to break later communication with the brain through stitch tension, then there should be no gas pains. Clinical experience has abundantly confirmed this hypothesis. It must be remembered that if a single nerve filament escape the block, there will be gas pains.

PAINFUL SCAR

The lesion which produces a painful scar is in the brain, not at the site of the wound. It is explained by a fundamental principle of nerve conduction; that is, that a strong traumatic or psychic stimulus produces some change in conductivity somewhere in its cerebral arc, the effect of which is to lower the threshold of that arc.

The following clinical case well illustrates this point:

A physician, when about to leave his office one evening, was confronted by a man who pointed a pistol at him and ordered him to throw up his hands. The assailant was so nervous that the hand holding the pistol trembled constantly, thereby increasing the fear of the threatened physician who was in terror lest the nervousness of the man should cause an accidental discharge of the pistol. The burglar made the doctor turn round, pushed him face against the wall and pressed the pistol close between his shoulders, this position being maintained while with his free hand the burglar ransacked desk and pockets. The physician stated that for weeks, even months, after this occurrence he felt in his back the actual sensation of the pressure from the pistol, *as real a sensation as if the pistol were actually there.* A year after the event, even, the impression could be vividly recalled.

After the stimulus of physical trauma, the result is similar. The arc receiving the stimulus suffers a lowered threshold and hence from that time on mere trifles become adequate stimuli. Most familiar examples of this result are the sensitiveness of limbs after fractures and the painful stumps of crushed limbs. Now if an operation be so performed that no strong stimulus reaches the brain, either during or after the operation, then the threshold of the cerebral arc from the wound will not be lowered. Since the threshold is not lowered, contact with the scar or any injury to that part will have little more effect than will contact with any other part of the body. Hence we see how painful scars may be minimized or prevented by complete *anoci-association.* Our clinical data seem to support this hypothesis, although these have not as yet been fully worked out.

NERVOUSNESS

The explanation of "painful scar" applies also to postoperative "nervousness." When in the night one is threatened with an unknown danger the brain threshold is always lowered, apparently as an adaptation to the more swift and accurate detection of danger. As stated above, when one has received a crushing physical injury, there is a universal lowering of the threshold. During these states of tenseness minor stimuli have major effects, or, in other words, one is "nervous."

The subconscious brain being tortured directly during unblocked operations under inhalation anesthesia, the resultant general effect on the brain thresholds is demonstrably the same as if the injury had been inflicted without anesthesia,—that is, after the ordeal of punishment of the subconscious mind during an operation the patient emerges "nervous," "exhausted"; and, since a low threshold is lavish in its waste of nervous energy, recuperation is slow. Hence there results a period of postoperative nervousness, of postoperative loss of efficiency. It is obvious—and clinical experience abundantly proves—that the brain threshold is preserved by complete *anoci-association,* hence the unpleasant damaging postoperative phenomena are minimized.

ASEPTIC WOUND FEVER AND POSTOPERATIVE HYPERTHYROIDISM

Since it is a physical law that any form of force may be converted into heat, and that heat thus produced, if not at once transformed into motion, must increase the temperature of the body affected, we see readily why any stimulus, mechanical or physical, which normally would cause increased motor activity, must cause a rise in temperature if complete motor expression is impossible. Anything, therefore, that drives the motor mechanism of the body beyond the point of normal expression will cause fever. Anger, athletic contests, fear, physical injuries, all produce a rapid oxidation of certain body compounds too great for complete translation into motion.

In operations under general anesthesia only, we expected routinely to see some postoperative rise of temperature as a result of the suppressed power of motor response to the physical and psychical injury; but by the use of *anoci-association,* both during and after the operation, we discovered a change of postoperative temperature and pulse-rate. We were, therefore, forced to the conclusion that, barring infection and the absorption of hemoglobin, postoperative fever is the result of increased oxidation, this being in turn the result of the psychic and traumatic stimuli of the operation to which natural response has been denied.

These observations led us to a further knowledge of the phenomena accompanying Graves' disease. This disease being due to a disarrangement of the general motor mechanism whereby the threshold of the brain to both psychical and traumatic stimuli has been lowered in varying degree, the stimulus which in the normal individual would cause no appreciable change in pulse or temperature, will, in a case of Graves' disease, drive the brain and body so fast that greatly increased motor activity and a rise in temperature are caused. Anything, therefore, that raises the threshold of the brain to stimuli must diminish the susceptibility to pulse and temperature changes in the patient suffering from Graves' disease as well as in the normal individual. This explains why patients under morphin or in a stupor show little change after excitation, and why an operation performed under *anoci-association* is followed by diminished or no aseptic fever and in Graves' disease by greatly diminished or no so-called "hyperthyroidism."

NAUSEA AND VOMITING—DIGESTIVE DISTURBANCES

The intensity of these postoperative symptoms depends upon the location of the operation; on the kind of general anesthetic which is used; on the amount of postoperative pain; and on the gentleness or roughness of the operator. Appetite may be driven away and digestion may be broken down by even a simple operation on any part of the body if it be crudely and roughly performed under nauseating ether anesthesia, or if the tension of the stitches be too great and the dressings too tightly applied.

On the other hand, nausea and vomiting may be obviated and the digestive impairment will be minimized by the employment of nitrous-oxid-oxygen anesthesia, sharp knife dissection, the gentle manipulation of tissues, cautious despatch in operating, complete nerve blocking during the operation, and for several days thereafter; the careful insertion of stitches and application of bandages. No matter how extensive or what the location of the operation, if it be performed under complete *anoci-association*, a nursing mother will be able to give each regular feeding, and the babe will give no token of digestive disturbance. There may be morphin nausea, however, to the degree ordinarily caused by that drug.

BACKACHE

In *anociated* operations the patient rests on the operating table on a water-bed. For this reason, and since the muscles are not relaxed under the mild nitrous-oxid-oxygen anesthesia, heavy strain on the ligaments and joints is eliminated, and backache is averted, excepting that backache which is produced by the technique of certain abdominal operations, such as supravaginal hysterectomy. This too may be avoided by the complete infiltration of the stumps with the nerve-blocking anesthetic. In our comparative study we found that in the postoperative bedside notes of 500 cases operated upon under ether anesthesia, backache is mentioned in 91 cases, while in 500 cases under *anoci-association* it is mentioned but 30 times.

INFECTION

As we have stated in Chapter IX, ether anesthetizes the phagocytes as well as the man, and so places the patient in the position of a citadel when, at the hour of assault by the enemy, the defenders are asleep in the trenches. If nitrous-oxid-oxygen be used, however, the phagocytes remain ready for action and the danger of infection is therefore lessened.

NEPHRITIS

The lipoid-solvent action of ether is sufficient reason for the ether nephritis, as the renal epithelium contains much lipoid substance. Moreover, other products of ether solution in various parts of the body are thrown on the kidneys for elimination. The use of nitrous-oxid-oxygen relieves the kidneys from this strain and the danger of nephritis from this cause is eliminated.

PNEUMONIA

Many theories have been advanced to account for the more frequent occurrence of pneumonia after operations in the upper abdomen than after operations in the lower abdomen, on the back, or on the extremities. That pneumonia is not due to ether alone is proved by its occurrence after operations under local anesthesia; that it is not due to infection alone is shown by the fact that it occurs as frequently in connection with uninfected as with infected wounds; that it is not due to emboli or thrombosis alone is evident since superficial wounds are rarely followed by pneumonia.

The clue to the real cause was found in a comparison of the postoperative behavior of patients operated upon under the old nocuous technique with that of patients operated upon under *anoci-association*. After the nocuous operation the wound is tender. Now the upper abdominal muscles have especially important respiratory functions. In each respiratory movement these powerful muscles pull on the stitches which hold together the divided wall. The exquisite pain produced by this respiratory pull causes an inhibition of the muscular contraction on the side of the incision, or on both sides of the incision if it be median. As a result, the excursion of the lower chest wall is diminished so that the lower lobes of the lungs cannot be filled completely. That a lessened exchange of air in the lower lobes predisposes to pneumonia is proved by noting the predisposition to pneumonia in cases of localized pleurisy, in which the pain causes an inhibition of free excursion in the part of the chest which is involved. The resultant pneumonia occurs in that portion of the lung whose free action is inhibited. After gall-bladder operations pneumonia begins not in the left but in the right lobe, whereas, were the pneumonia embolic in its origin, the lobes would fare alike.

The diminution of the number of cases of postoperative pneumonia since the adoption of the technique of *anoci-association* is the final proof of this reasoning as to its cause. Because of the lack of local tenderness in the field of operation produced by the technique of the operation itself and by the postoperative nerve blocking, there is diminished or no inhibition of the respiratory excursions. This also with-

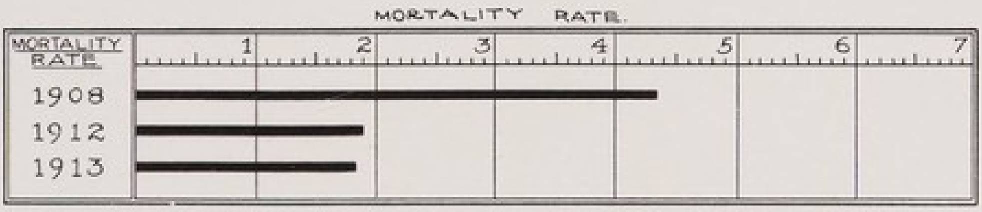


FIG. 54.—COMPARISON OF THE MORTALITY RATE OF ALL OPERATIONS PERFORMED AT LAKESIDE HOSPITAL BY THE AUTHORS AND THEIR RESIDENT STAFF DURING 1908—THE YEAR BEFORE *Anoci-association* WAS INTRODUCED—WITH THE MORTALITY RATE OF THE LAST TWO YEARS, 1912 AND 1913.

out doubt explains the reduced mortality of operations for umbilical hernia performed with the transverse incision (Mayo).

The clinical observations here reported have been confirmed by the personal experiences of Bloodgood, Cabot, Codman, and a number of other American surgeons; by Moynihan and others in England.

MORTALITY

Not only the lessened postoperative morbidity, but a reduced mortality rate also bears witness to the value of the technique by means of which *anoci-association* is attained. A study of the statistics of the Lakeside Hospital shows that in 1908, the year before the adoption of the principle of *anoci-association*, the mortality rate of all operations performed by the authors and their resident staff was 4.4 per cent.; in 1912 the mortality rate had fallen to 1.9 per cent.; and last year, 1913, to 1.8. (See Fig. 54.)

CHAPTER XIX

SUMMARY

The development of the principle of *anoci-association* and the application of that principle to the operations described in this monograph are the result of prolonged laboratory experimentation; of a critical comparative study of the clinical data of operations performed at the Lakeside Hospital under ether alone, under nitrous-oxid-oxygen alone, and under complete *anoci-association;* and of the practical experience gained by the authors in the treatment of over 26,000 surgical cases.

In this monograph we have endeavored to show that shock may be produced by physical trauma with or without inhalation anesthesia; that in the distribution of the defending nociceptors we have a brief epitome of our phylogenetic struggle for existence, as a result of which those parts of the body having the greatest number of nociceptors and those which defend the most important regions by muscular action are the most shock-producing on receiving trauma. We have shown that nitrous-oxid-oxygen anesthesia as compared to ether anesthesia is a protective agent against shock—protective through its interference with the use of oxygen by the brain-cells. We have shown that the physical exhaustion is the result of demonstrable changes in certain kinetic organs—notably the brain, the suprarenals, and the liver, and that these changes are due to an adaptive response of the organism to the injury—a silent, motionless effort to escape from the physical injury of the operation, and that therefore if the field of operation be blocked by local anesthesia, or if the nerve connection between the brain and the injury be blocked, physical injury alone can cause no shock. We have shown that the motor mechanism may be powerfully driven by psychic stimuli—perhaps as powerfully as by traumatism and physical exhaustion—and that corresponding changes are produced in the organs of the kinetic system. We have seen that when both the traumatic and the psychic stimuli are excluded shock cannot be produced. We have found that the essential pathology of shock is identical whatever its cause. That is, when the kinetic system is driven at an overwhelming rate of speed—as by severe physical injury; by intense emotional excitation; by perforation of the intestines; by the sudden onset of an infectious disease; by an overdose of strychnia; by a Marathon race; by foreign proteids; by anaphylaxis—the result of these overwhelming activations of the kinetic system is a condition which is identical however it may be clinically designated, whether as surgical or traumatic shock, toxic shock, anaphylactic shock, drug shock, etc.

As a result of the acceptance of this theory an operative method has been evolved by means of which shock is minimized or eliminated according as the principle of *anoci-association* is partially or completely applied.

The practical value of *anoci-association* is attested by the fact that in the authors' clinic both the mortality rate and the postoperative morbidity have been reduced by the application of this principle.

Were it possible to add to the surgeon's experience an expression of the subjective symptoms of the patient, the proof of the value of *anoci-association* would be even more striking. There is no longer any need of the postoperative recovery room; the work of the nurses is lessened; and the clinical aspect, both in and out of the operating room, is altered.

To achieve these results means a thorough understanding of the principle on which the technique is founded; it necessitates the intelligent and special training of assistants, interns, anesthetists, hospital officials, and nurses; it means a careful hand and a sharp scalpel; it presupposes a mind free from dogma and tradition; it means that no detail is too petty for the careful attention of the surgeon himself. Above all it means that from the patient's first appearance in the surgeon's consulting room throughout the entire cycle of hospital entrance, operation, and exit from the hospital there must be no sharp points of contact, either psychic or physical.

If performed perfunctorily, as a dull ritual, the technique of *anoci-association* will fail; it can accomplish its purpose only when each detail, however minute, is considered from the viewpoint of the individual patient.

APPENDIX

THE TECHNIQUE OF ADMINISTERING NITROUS-OXID-OXYGEN ANESTHESIA

BY AGATHA HODGINS
Chief Anesthetist, Lakeside Hospital

PRELIMINARY

The apparatus must be one that will give *constantly* an even mixture of nitrous oxid and oxygen in whatever proportions are required, and it should also provide means for adding ether-vapor in any required amount to the nitrous-oxid-oxygen mixture. This important point will be referred to later.

Our patients usually come to the operating room in a calm and comfortable frame of mind. This tranquillity is partly due to the preliminary hypodermic medication, but even more to the special management of the patient. The usual preoperative hypodermic medication is $\frac{1}{6}$ gr. morphin and $\frac{1}{150}$ gr. scopolamin. In alcoholics or for particularly large muscular men this dose may be increased to $\frac{1}{4}$ gr. morphin and $\frac{1}{100}$ gr. scopolamin. This is the maximum dose, however, and is seldom used. Frequently less than the usual dose is given, while to children under ten years of age, to the aged, and to patients enfeebled from any cause no preliminary medication is given.

The reassuring attitude of the surgeons and nurses before the operation is a factor which contributes greatly to the mental comfort of the patient and to the efficiency of the anesthetic. It is our rule that the operating room be kept absolutely quiet—no talking, rattling of instruments or other noise is allowed, and no ostentatious preparation is seen. The patient is never touched or restrained until he is quite asleep.

INDUCTION OF ANESTHESIA—FIRST STAGE

The pulse, respiration, color and physical characteristics of the patient are first noted. The induction of anesthesia is gradual, slow and comfortably reassuring. The mask is not finally adjusted until the patient is oblivious of his surroundings.

The total exclusion of air and an adequate mechanical adjustment of the neck and jaw are necessary. The position of the head should be comfortable,—neither flexed nor extended. Attention to these points will assure free respiratory exchange and will overcome the tendency of the tongue to drop back.

Beginners are taught to work with the patient's head on its side as a safeguard in case of vomiting, for as the limits of nitrous-oxid-oxygen anesthesia are narrow it requires experience to enable one to recognize the warning before nausea occurs. Nausea may result from too much nitrous oxid as well as from an uneven light anesthesia. It is important, therefore, to establish anesthesia satisfactorily by a careful and gradual administration before the operation is commenced. The proper mixture of gas and oxygen must be empirically ascertained for each patient.

The average patient takes nitrous-oxid-oxygen without trouble, but the anesthetist should never assume that trouble may not occur.

In the management of a difficult case, good judgment, careful adjustment of the anesthetic, and time are the important factors. *An anesthetist should never feel hurried.* The gradual induction and even adjustment of the anesthetic prevent the jactitation and clonic spasm which were formerly associated with nitrous-oxid anesthesia.

The mental control of the patient is of the greatest importance. No mention should be made of fear or hurt, but it should be impressed upon the patient that he will be well cared for and that the operation will soon be over. The anesthetist should watch the patient's eyes that he may know when to tell him to "let go."

Patients most commonly fear that the operation may be started before they are asleep, this being especially true of women of a certain nervous type and of foreigners. Foreigners especially are apt to fear that they will never wake up. Reassurance on this point is always a comfort to them. We try to divert the minds of little children from their surroundings, and to make them feel that the operation is the first step toward getting well and going home. Personally I prefer to have the child entirely under my own management, for a child quickly notices the anxiety which is almost invariably betrayed by the expression of the parents, however sensible they may be. From the anesthetist's point of view a temporary "Peter Pan" type of child is desirable.

INDUCTION OF ANESTHESIA—SECOND STAGE

The second stage of anesthesia is the most difficult to manage. As the patient is now unconscious, he can no longer be controlled by suggestion, and the anesthetist must depend entirely upon his management of the anesthetic for the control of the further psychical and physiological phenomena. In some cases unpleasant dreams or sensations occur which cause increased resistance to the anesthetic.

The most difficult patients to deal with in this stage are heavily built muscular men. Patients of the resistant neurotic type, those under deep fear of the anesthetic, and alcoholics form a separate class. These patients often show muscular rigidity and difficult respiration which prevent the much-desired even anesthesia, and, as a consequence of the uneven anesthesia, nausea is produced. With alcoholics the addition of ether-vapor is usually necessary to secure good anesthesia without cyanosis. Ether-vapor should be added gradually so that coughing and spasm of the respiratory muscles may be avoided. In these difficult cases, nitrous-oxid-oxygen anesthesia is more easily induced than is straight ether anesthesia. Rigidity and resistance in the plethoric and the alcoholic must be overcome early, as otherwise even anesthesia cannot be maintained.

With the neurotic resistant patient *time* and a *gradual adjustment* of the anesthetic mixture are essential. In these cases it is often difficult to secure a tranquil anesthesia, but this must be attained before the operation is begun. After the patient is tranquilly asleep, the initial trauma, however slight—the first prick of the novocain needle even—will give the clue to the further mixture of the anesthetic.

In anemic, cachectic and feeble patients, the proper amount of oxygen is most important. These frail patients do not tolerate even slight asphyxia. After an even induction of the anesthetic it is best to give a mixture containing a higher percentage of oxygen.

In cases of acute intestinal obstruction the head should be kept well on the side, that in case vomiting occur the anesthetist may be prepared to prevent the vomitus from being inhaled. Since vomiting may come on quickly without perceptible warning the anesthetist must be strictly on guard. This rule applies to any case with a history of preoperative vomiting, especially if for any reason it demands a light anesthetic. Any case which has not received preparation for operation must also be closely guarded against vomiting.

As compared with ether anesthesia, however, the patient under nitrous-oxid-oxygen is much less likely to inhale the vomitus, as, the anesthesia being lighter, there is less relaxation of the muscle guards of the larynx.

In children the second stage of anesthesia is most important. Children are more susceptible to the action of nitrous oxid than they are to ether and many pass directly from the first stage to profound anesthesia. A child should never be restrained during the induction of nitrous-oxid-oxygen anesthesia. The anesthesia should be started with a mixture containing a large percentage of oxygen, not enough to produce excitement, however, the percentage of nitrous oxid being gradually increased until anesthesia is secured.

In very young children a small percentage of ether is given with a light mixture of the nitrous oxid and oxygen, unless the child takes the latter without the slightest trace of cyanosis or disturbance of respiration. Instead of placing a mask over a child's face he may be given the free end of the gas-tube to play with. If the tube be gently directed towards his nose, he will soon become sleepy and will doze off, when the mask may be applied without any protest.

While in all cases restraining and struggling are carefully avoided, especial care is exercised in cases with serious cardiac lesions—especially fatty degeneration. In these cases the anesthetist should be strictly on his guard to prevent strained respiration or cyanosis.

In any case, after proper induction the patient's face should be that of a person asleep, not of one under profound anesthesia, or that so often seen in a dentist's chair when nitrous oxid has been administered.

THE MAINTENANCE OF ANESTHESIA DURING OPERATION

At the completion of the second stage of induction the eyes are quiet and the upper lid may be raised without restraint. *The conjunctiva is never touched.* The swallowing reflex is absent. The respiration should be tranquil and regular, the rate being higher than normal, ranging usually from 20 to 32, and being highest in the early stages of the anesthesia. If the inspiratory rate increases in response to the operative trauma more nitrous oxid is added to the mixture. *A high respiratory rate is never permitted*—it is kept low by changing the mixture of nitrous oxid and oxygen or by adding some ether-vapor.

An increase in the respiratory rate with a return of facial expression and eye reflex means that the patient is coming out of the anesthetic. These signs may be followed quickly by the return of the swallowing reflex and signs of nausea.

Transient cyanosis during induction cannot always be avoided—but *should never be allowed* after anesthesia is established. If the supply of oxygen be sufficient, cyanosis means respiratory obstruction and must be remedied quickly. If it does not yield to a mechanical readjustment of the jaw and to pure oxygen, then the mask should be removed, a wooden mouth gag inserted between the teeth, the tongue pulled forward and respiration re-established. The experienced anesthetist however will rarely encounter this emergency.

Sometimes with normal respiration there may be a persistently slow response to oxygen—a condition which is always a serious matter. If increasing the oxygen in the mixture does not clear up the color it is well to stop nitrous oxid and give ether and oxygen for a few minutes. The color should always be carefully watched. Too much nitrous oxid may cause paleness. It is therefore a matter of routine with us to diminish the amount of the nitrous oxid during the operation—and towards the end to give the lightest possible mixture.

When it is necessary to give ether during nitrous-oxid-oxygen anesthesia, it should be given gradually so that coughing and respiratory spasm may be avoided. In children the mucous membrane is very susceptible to ether, as it is in heavy smokers. Coughing and irritation of the mucous membranes delay the operation and tire the patient.

During the harder phases of difficult operations on the biliary passages and deep in the pelvis, in rigid, fat, or resistant patients, nitrous-oxid-oxygen may not give sufficient relaxation. In such cases ether-vapor is added until sufficient relaxation has been secured, when the ether is discontinued and the patient carried through the remainder of the operation on nitrous-oxid-oxygen alone. At the end of the operation these patients will experience neither the odor nor the taste of ether. In all cases the surgeon should co-operate with the anesthetist by warning her in advance

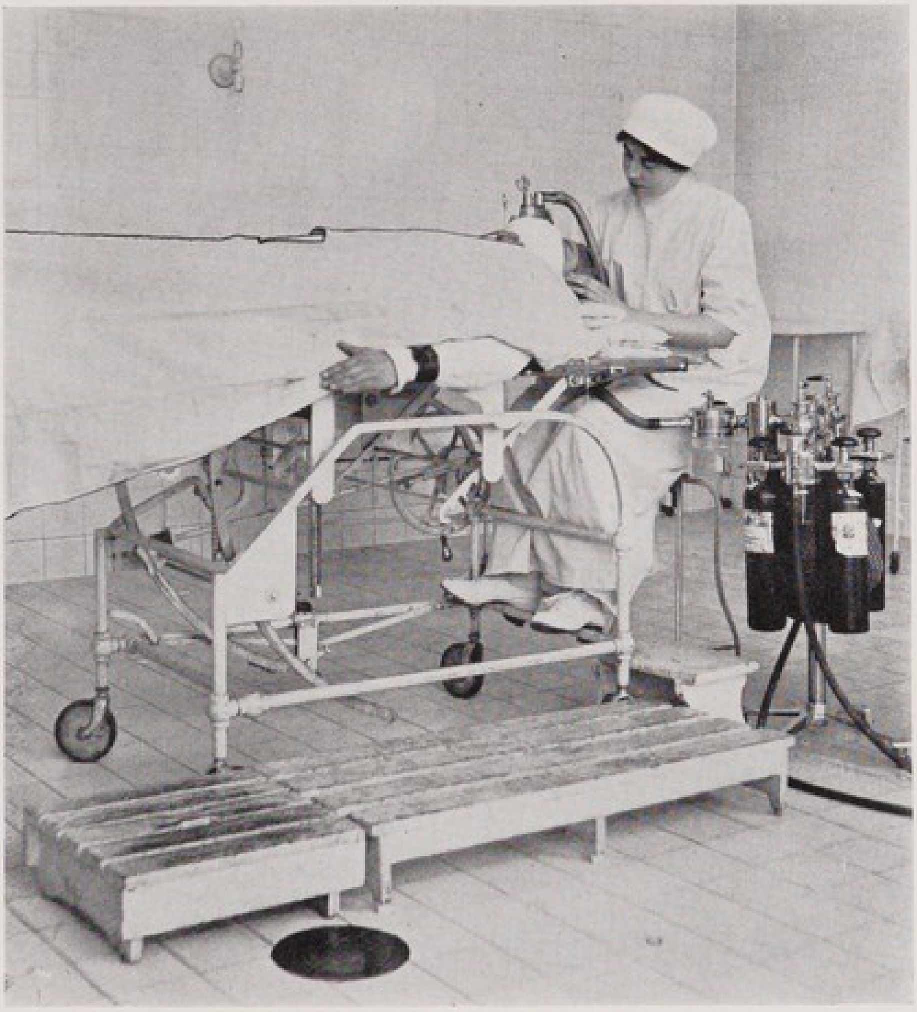


Fig. 55.—Nitrous-Oxid-Oxygen Anesthesia. Patient in Dorsal Position.

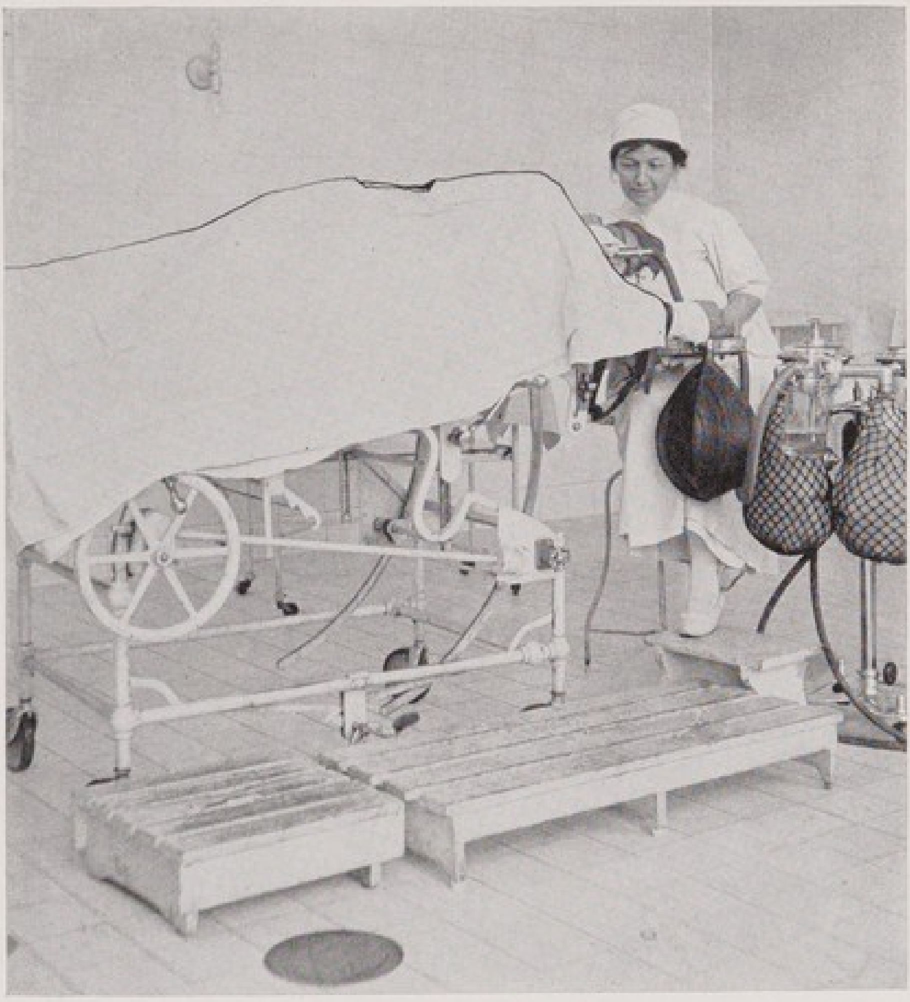


Fig. 56.—Nitrous-Oxid-Oxygen Anesthesia. Patient in Lateral Position. Mask Held in Place by Linen Cloth.

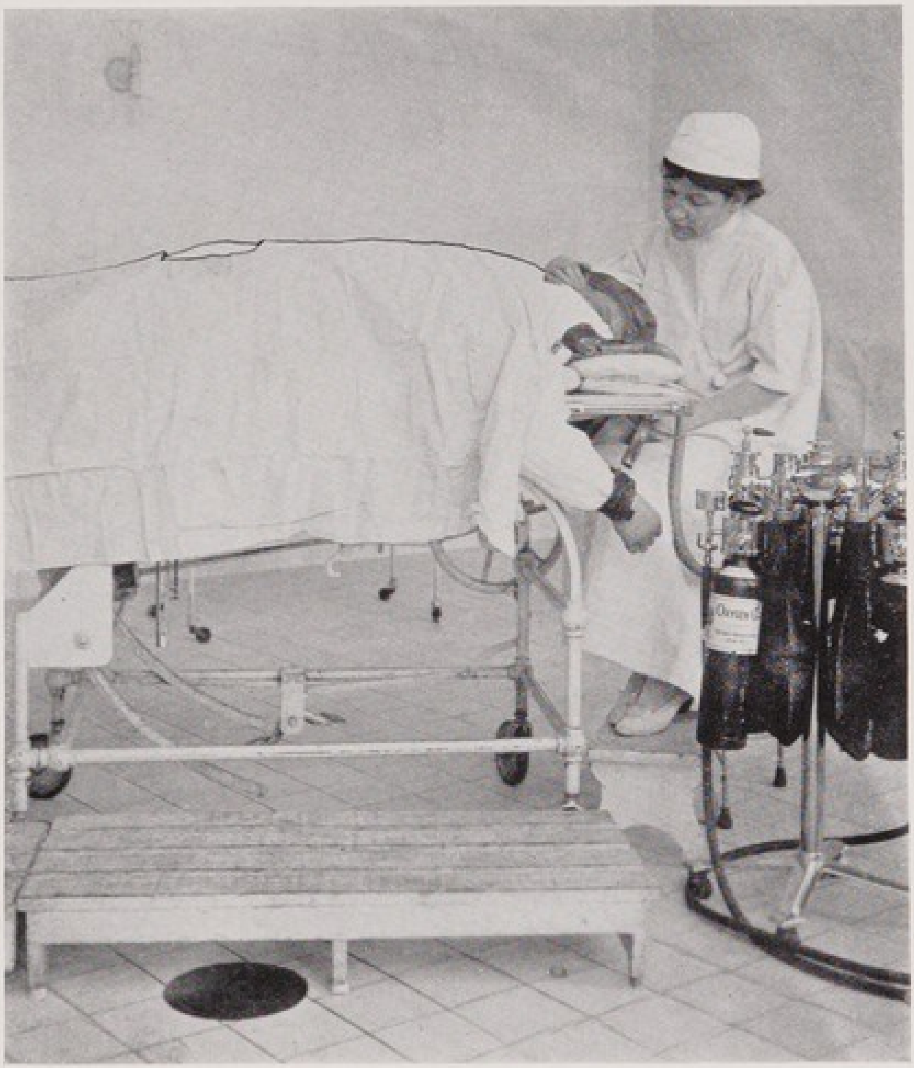


FIG. 57.—NITROUS-OXID-OXYGEN ANESTHESIA. PATIENT IN PRONE POSITION, MASK HELD IN PLACE BY LINEN CLOTH.

when he is ready to dislodge a tumor or about to perform any other especially stimulating manipulation.

POSITION OF THE PATIENT DURING ANESTHESIA

It is our rule to anesthetize all patients in the dorsal position (Fig. 55), the change to any position demanded by the operation being made after the patient is asleep. As in ether anesthesia, especially if the patient be fat or have any cardiac lesion, the change to the Trendelenburg position should be made gradually and not until even respiration and good color have been established.

The lateral, lateral prone and prone positions are always difficult for the anesthetist, especially with nitrous oxid and oxygen. The difficulty of holding the mask securely enough to exclude air and of maintaining a proper position of the hand may be a great strain. The first of these difficulties may be largely overcome by passing a linen cloth behind the mask and securing it in position with hemostats (Figs. 56 and 57). When properly adjusted this will hold the mask securely and will completely exclude outside air. It requires practice however to adjust it properly. The arms are supported by Bevan's cuffs.

The loss of bodily heat is negligible in nitrous-oxid-oxygen anesthesia, being much less than in ether anesthesia, and sweating is rarely seen in the *anociated* operation. The patient, however, is well protected during the operation when he lies on a warm water-bed, and on his return trip to the ward, before which fresh warm clothes are put on.

Transitory nausea and sometimes vomiting may occur immediately after the operation.

TECHNIQUE FOR SPECIAL OPERATIONS

EXOPHTHALMIC GOITER

Nitrous-oxid-oxygen anesthesia is especially advantageous for patients with exophthalmic goiter, for the quick loss of consciousness is an important factor in these cases and the dangerous excitement experienced when going under and coming out from ether anesthesia is avoided. Our method is to give the patient daily "inhalation treatments" for several days before the operation. From a few whiffs of oxygen and a little conversation we gradually increase the amount of nitrous oxid in the mixture until the day before the operation, when the patient is put to sleep without any difficulty. To test the heart in especially bad risks a trial anesthesia of about ten minutes is given. The patient does not realize that he has been anesthetized but believes that he has fallen asleep during his "treatment."

On the morning of the operation the "inhalation treatment" is given once more, and when completely anesthetized the patient is carefully lifted from his bed to the operating-room cart. One orderly takes charge of the cart, another of the gas machine. A physician and a nurse accompany the anesthetist, so the patient is safeguarded on all sides. When the operating room is reached the patient is gently lifted to the operating table and the anesthetic apparatus is changed for the permanent one belonging to the operating-room equipment. The patient is then prepared for the operation. As every step is taken with deliberation and gentleness there is little disturbance of the anesthesia.

After the conclusion of the operation the patient is kept asleep until he has been taken back to his room,—the arrangement of which is exactly as it was before he fell asleep. When the patient awakes only the anesthetist and attending nurse are present. The amount of information given him depends entirely on the case. Usually however he is reassuringly told that the operation is over.

The management of a bad case of exophthalmic goiter is usually difficult. In addition to the unstable nervous system there is often an impaired heart. These patients

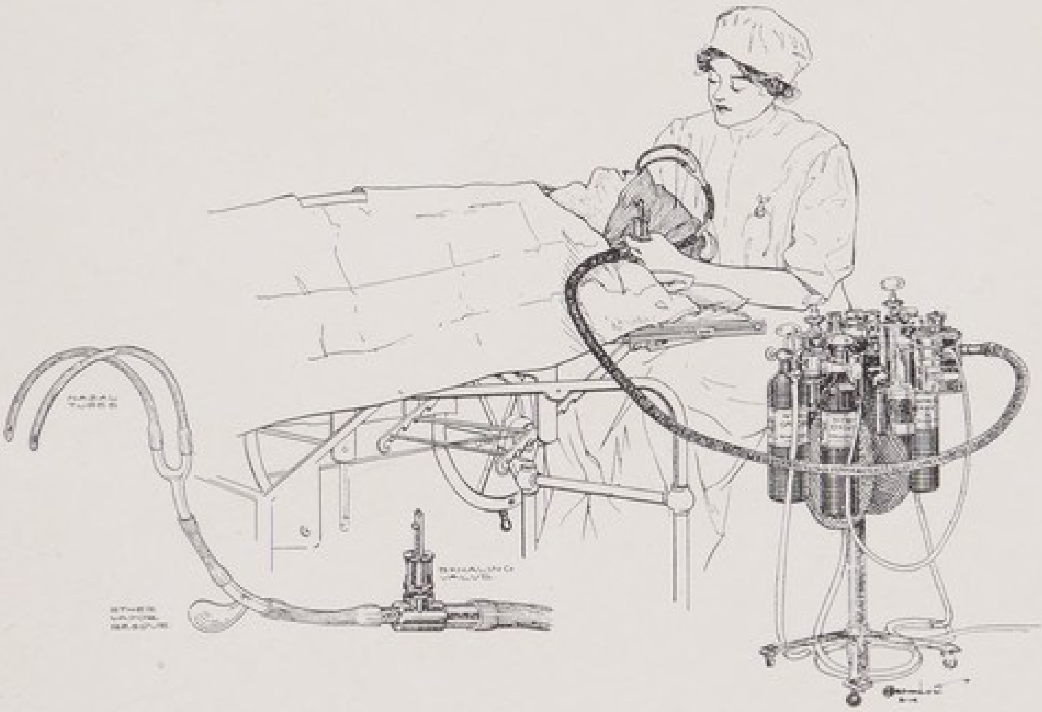


Fig. 58.—Nitrous-Oxid-Oxygen Anesthesia, Showing Use of Nasal Tubes in Face, Mouth and Neck Operations.

are sometimes erratic in their response to the anesthetic and may show marked resistance in the second stage. In those cases of exophthalmic goiter in which there are degenerative changes in the heart muscle it is vitally essential to keep the respiration free from strain and to maintain the lightest possible anesthesia.

SURGICAL SHOCK AND COLLAPSE

In patients suffering from shock and collapse, as in accident cases, the very gradual adjustment of the anesthetic is most important and the utmost care must be taken to establish a comfortable *free* respiration. Here also the lightest possible anesthesia is maintained, as the surgeon uses local anesthesia and wishes to be aware of any response that the patient may make to the trauma that he may extend the local anesthetic protection.

FACE, MOUTH AND NECK OPERATIONS

In operations on the face, mouth or neck in which the mask interferes with the operation, nasal tubes are used (Fig. 58). The patient is first put to sleep with nitrous-oxid-oxygen and then enough ether-vapor is added to secure the necessary relaxation for the insertion of the nasal tubes. By means of a glass tube these are connected with the rubber tubing which extends to the gas machine. An expiratory valve is of course a necessary adjunct. The mouth is carefully packed and watchful care is exercised to prevent kinking in the tube. After the insertion of the nasal tubes, the patient can usually be carried through the operation without the addition of ether-vapor.

LARYNGECTOMY

The patient is anesthetized in the usual way until the trachea is opened. A long rubber tube attached to the gas apparatus is then inserted into the trachea. The tracheal connection is made air-tight by means of gauze packing, which also prevents the entrance of blood and mucus.

BRAIN OPERATIONS

In brain operations a calm and free respiration is maintained by the use of nitrous-oxid-oxygen. As little pressure as possible is used to prevent venous congestion and increased bleeding. A light administration of nitrous-oxid-oxygen is usually sufficient to maintain the above conditions, but it may be necessary in some cases to diminish the nitrous oxid and add ether-vapor.

TONSILS AND ADENOIDS

In the removal of tonsils and adenoids we still use ether or ether-vapor.

ACUTE INFECTIONS

In these cases we try to avoid the use of any ether-vapor—even if the time needed to establish anesthesia is prolonged. These patients are prone to vomit in any case, a tendency which is increased by the lack of preoperative preparation as these are emergency cases. Some excitement may occur in the second stage—but as a rule these patients do well under nitrous-oxid-oxygen.

OPERATIONS ON THE THORAX

Clinical judgment is necessarily required in the use of positive pressure in a machine which is not equipped with a manometer, whereby the pressure may be accurately recorded. In one of the machines in use in our clinic (the Teter) positive pressure to from 4 mm. to 8 mm. may be obtained by the use of the expiratory valve. Dr. Teter considers that from 8 mm. to 10 mm. is sufficient for cases requiring positive pressure, while 4 mm. is sufficient to maintain the depth of anesthesia in an ordinary case.

In our other machine (the Monovalve) the technique by which the pressure is governed depends almost entirely upon clinical experience. The breathing bag is as near the face mask as is convenient and the pressure in the bag is regulated by means of a light expiratory valve. In ordinary work the bag is evenly and lightly distended but is not taut at the end of an ordinary expiration. The pressure in the bag may vary from one mm. to four or five. Whatever pressure gives a free unembarrassed respiration is clinically the best pressure for that case. The respiration will quickly show the effect of too much pressure.

When positive pressure is required within the thoracic cavity, we endeavor to increase the pressure by closing the expiratory valve, thus holding the bag taut. The amount of pressure secured in this way cannot at present be accurately given. It has been sufficient, however, to prevent collapse of the lung in the cases in which we have used it.

ANALGESIA

We have used nitrous-oxid-oxygen to produce analgesia in minor operations on patients who desired to return home immediately after the operation, and who would resist the anesthesia if entirely unconscious, so that increased anesthesia would be required to overcome the resistance. These patients were talked to throughout the operation, and at the slightest evidence of pain were told if they would draw a long breath the pain would disappear. Deep breathing and the consequent resistance indicate that the anesthesia is becoming too deep. This is overcome promptly by discontinuing the gas for a moment and by increasing the percentage of oxygen. The amount of oxygen should be governed carefully, as too much may excite the patient.

SUMMARY

Dr. Teter, my associates at Lakeside Hospital, and I have administered nitrous-oxid-oxygen for general anesthesia 34,964 times without an anesthetic fatality. We consider the use of nitrous-oxid-oxygen, with the addition of ether-vapor when necessary, a practical and safe anesthetic for the work of a large surgical clinic.

In this clinic there is no prejudice against the use of ether-vapor, but we endeavor to use it only when it adds to the efficiency of the anesthetic. In other words, we advocate that combination of anesthetics which will produce the safest and best anesthesia possible for each particular case.

In the clinic we work under ideal conditions. The surgeons by their careful and gentle manipulations during the operation, help the anesthetist to secure a tranquil, quiet anesthesia and to keep the general tone of the patient up to our standard.

The fundamental necessity is for the anesthetic to cover the hurt. The greater the hurt, therefore, the greater is the amount of anesthetic required.

In this clinic, nitrous-oxid-oxygen is given only by anesthetists who have had a good preliminary training and experience in the administration of ether anesthesia, and who are also specially trained in the use of nitrous-oxid-oxygen.

The ideal method by which the nitrous oxid and oxygen are supplied to the operating pavilion in Lakeside Hospital, is another factor which contributes greatly to the efficiency of the anesthetist.

ANOCI-ASSOCIATION IN ITS RELATION TO THE PREOPERATIVE AND POSTOPERATIVE CARE OF PATIENTS

BY SAMUEL L. LEDBETTER, JR., M.D.
Resident Surgeon, Lakeside Hospital

PREOPERATIVE CARE

The principle of *anoci-association* is carried out not only in the operating room, but is applied from the moment that the patient enters the hospital. As fear diminishes the patient's power of resistance, he should be received on his entrance into the hospital with cheerfulness and kindness, for a quiet and cheerful atmosphere will do more to dispel his fears than will all the verbal encouragement that can be given. In a few words, the patient should be made to feel that he is to be well cared for and that he will suffer no unpleasant experiences. This duty belongs for the most part to the nurses and the house-officers, who while taking the history and making the routine physical examination can do much to obtain the confidence of the patient.

In our practice here in the Surgical Service of the Lakeside Hospital, it is our endeavor always to exalt the patient's viewpoint.

The preoperative preparation should be flexible. If the patient be sleepless during the night before operation, he should be given a sedative. We all know from our own experiences the depressed physical state produced by a sleepless night, surely an unfavorable state for an operation.

On the day of operation it is our custom to administer to strong adult patients a hypodermic dose of morphia, gr. $\frac{1}{6}$, and scopolamin, gr. $\frac{1}{150}$, about one hour before the patient goes to the operating room. The aged, the young, and the debilitated receive very little if any sedative.

The preliminary medication serves two purposes: First, it helps to do away with fear on the part of the patient, so that he goes to the operating room quietly; and, secondly, he relaxes into anesthesia much more easily. We have yet to see an unfavorable result following this preliminary medication.

On entering the operating room the patient should be gently placed upon the table and absolute quiet should prevail until he is under the influence of the anesthetic.

POSTOPERATIVE MANAGEMENT OF CASES IN GENERAL

Patients are taken back to their rooms quietly, and, as a rule, unless contraindicated, are made comfortable on four or five pillows in a semi-sitting posture.

We encourage our patients to move about in bed, to turn frequently, and as a rule allow them to sit up fairly early. This increases the general tone of the patient and helps to prevent pulmonary complications and phlebitis.

Very elderly individuals on account of the senile changes in their circulation are usually placed flat in bed for a few hours after operation, as the sitting posture immediately after operation may cause sufficient anemia of the brain to produce an increase of the pulse-rate. After a few hours, however, they are encouraged to sit up, to move about frequently and within two or three days are usually allowed to sit up in a chair. Cases of inoperable cancer, particularly those with cancer of the abdominal viscera, are often out of bed the second day after operation.

After major operations it is our rule to give to all cases rectal tap water containing glucose and sodium bicarbonate, one ounce of each to the quart. We usually administer the solution by the Murphy drop method, but in case it is not retained it is given in bulk, 200 c.c. every two hours.

SEDATIVES

After the anociated operations there is very little post-operative pain. The prognosis may depend largely, however, upon the comfort of the patient after the operation. If there be pain or restlessness we use morphia, usually in gr. $\frac{1}{6}$ or $\frac{1}{4}$ doses. Everything is done to give the patient a good rest on the night after the operation.

Morphia is rarely required routinely for more than from twelve to twenty-four hours. An enema is usually given on the second morning and at any time should there be flatulence.

NOURISHMENT

As nausea very rarely occurs, most patients except gastric cases begin to take water very soon after the operation. Even if there be nausea water in large amounts may be given. After simple laparotomies, not involving resections or anastomoses, when there is no nausea, the patient is usually given liquids without milk even on the day of operation. On the following day the patient is encouraged to take a little soft food, the amount being increased rapidly until the third or fourth day, when he receives a fairly liberal diet.

STIMULATION

Stimulants are not administered excepting in certain cardiac cases when the patient may be given camphorated oil or digitalis.

PREOPERATIVE AND POSTOPERATIVE CARE IN SPECIAL CASES

ACUTE INFECTIONS

Patients with acute infections are prepared as are other cases, excepting those with infections of the peritoneal cavity, when all catharses and enemata are withheld.

After an operation for acute appendicitis, for peritonitis, etc., the patient is placed in an exaggerated Fowler position and is given rectal tap water. Large, hot flannel packs are placed over the entire abdomen, going well up on to the chest and around the sides to the bed line. These are changed every two hours. The patient is allowed to drink all the water that he wishes, and is given by mouth sodium bicarbonate solution, one dram to the glass. At regular intervals morphia is given in sufficient doses to control the pulse and respiration.

CHOLECYSTITIS

In cases of gangrene and rupture of the gall-bladder, the postoperative care is the same as in acute, suppurative appendicitis cases, *i. e.*, hot packs and morphia, excepting that instead of placing these patients in the Fowler position we keep them in a recumbent position on the right side.

EXOPHTHALMIC GOITER—PREOPERATIVE CARE

The utmost tact and skill are required in the treatment of a patient with exophthalmic goiter. He is made as comfortable as possible, great pains being taken to insure absolute quiet, and he is kept in the open air as much as possible. To allay nervousness and improve the general condition of the patient, sponge baths are given frequently. A sedative—usually sodium bromid, from 30 to 50 grains, three times a day—helps to secure repose. It is our rule never to tell the patient the exact date of the operation. At about 8.30 each morning one of our anesthetists visits him and gives him an "inhalation treatment." At first the anesthetist may give just a little oxygen, with possibly a whiff or two of nitrous oxid. This is kept up for several days, the patient being given a little more nitrous oxid each day, until once or twice he may become completely anesthetized. After his "inhalation treatment" the patient usually feels much better and relaxes into a sleep. About nine o'clock, or after receiving the "inhalation," the patient is given his breakfast. After several days in the hospital, when the patient has become quiet and is considered a favorable operative risk, morphia, gr. $\frac{1}{6}$, scopolamin, gr. $\frac{1}{300}$, is given hypodermically, the dose being repeated in one-half hour. The patient is then anesthetized in his room without his knowledge, thinking that he is receiving only the usual "inhalation treatment." If the patient is still restless after being anesthetized, another hypodermic dose of morphia, gr. $\frac{1}{6}$, is given. In the rare cases in which this does not quiet him sufficiently the operation is postponed. If the patient is quiet he is conveyed to the operating room while under the anesthetic and the usual anociated operation is carried out. In some cases we give morphia on the table, repeating the dose until the patient becomes absolutely quiet with even and regular respirations. In cases with the nausea and vomiting, which we sometimes see with acidosis, the patients are given a glucose and sodium bicarbonate solution per rectum and infusions before the operation, which is deferred until the acetone and diacetic acid have disappeared from the urine.

EXOPHTHALMIC GOITER—POSTOPERATIVE CARE

The patient is taken back to his room while under the anesthetic and is allowed to wake up slowly. The management of the anesthetic has been described minutely in the chapter on Anesthesia. The patient is put in a comfortable position, an ice pack is placed over the heart, and tepid sponge baths are given every four hours. If the patient be very restless his hands and face are constantly sponged with ice water. Sodium bicarbonate and glucose solution is given per rectum. Morphia is given frequently enough and in sufficient doses to keep the patient quiet. If a reaction occur,—rarely in less than twenty-four hours after the operation,—the restlessness is again controlled by sponging with ice water and by morphia. After the first two or three days morphia is rarely necessary. We then give other sedatives, usually bromid of sodium, 30 grains, three times a day.

The patient is allowed from the first to have as much nourishment as he will take. He is kept quiet and out of doors as much as possible. The outcome of these cases depends upon the exclusion of traumatic and psychic stimuli at the time of operation, and on keeping the patient quiet after operation. Even if the pulse-rate should increase after the operation the prognosis is good in any case if the patient be quiet and if there be no acidosis. If acidosis occur it is combated by glucose and sodium bicarbonate solution per rectum, carbonates by mouth, and as much nourishment as can be taken.

A HOSPITAL PLANT FOR THE MANUFACTURE OF NITROUS OXID

BY A. R. WARNER, M.D.
Superintendent, Lakeside Hospital

Lakeside Hospital has manufactured most of the nitrous oxid used in the hospital for about four years, and during this time gas has been purchased only on days of unusual consumption and during breakdowns in the manufacturing plant.

Through the generosity of Mr. H. M. Hanna, one of the trustees of Lakeside Hospital, it has been possible to run the hospital plant experimentally for the past year (1) to find how the safest possible nitrous oxid for anesthetic use can be made and (2) to develop a mechanical plant by which nitrous oxid may be surely and safely manufactured under usual hospital conditions and limitations. During this experimentation there have been frequent changes in the form of apparatus and in the materials used in the generation and purification of the gas. This experimental work is not finished and the plant is changed in some particular very frequently. The accompanying diagram, therefore (Fig. 59), can give but a general idea of the process of manufacture. In the actual plant the apparatus is arranged around three sides of a room in the basement; but to make the diagram as simple as possible it is shown here in a straight line. The diagram indicates that but one washing is done in a tower, but it is probable that we shall soon substitute a stoneware tower for one of the washing jars. However, plants of small capacity will probably always use these or other special jars for certain washings.

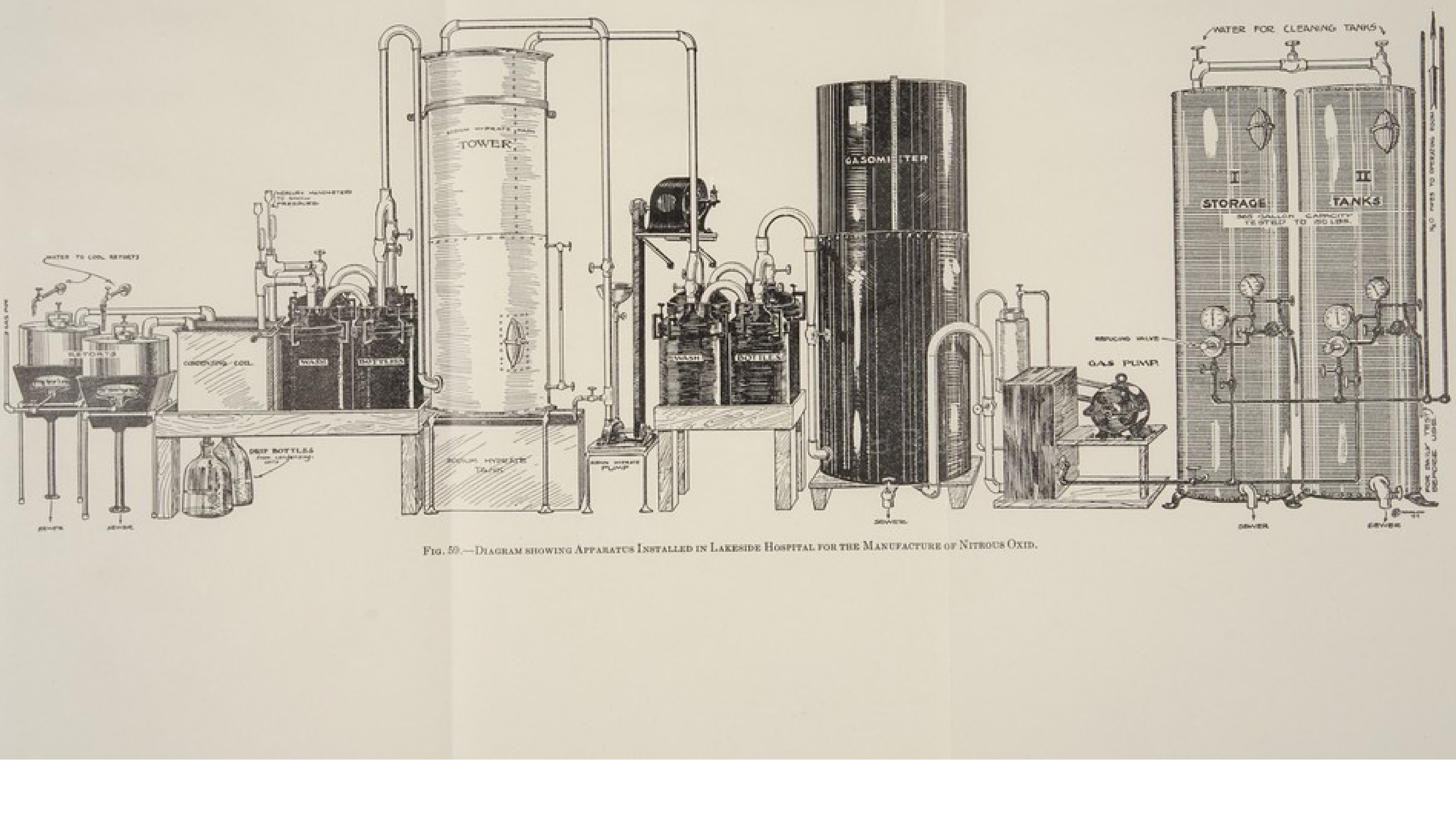


Fig. 59.—Diagram showing Apparatus Installed in Lakeside Hospital for the Manufacture of Nitrous Oxid.

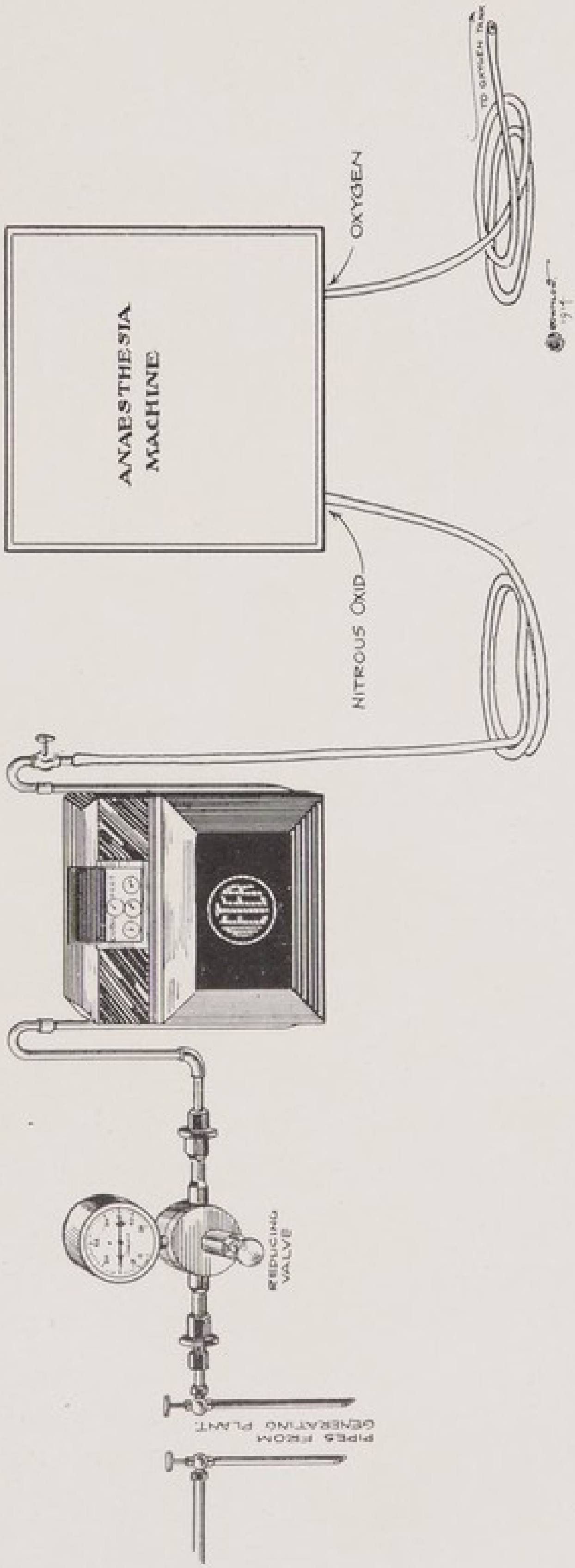


FIG. 60.—DIAGRAM SHOWING OPERATING-ROOM ARRANGEMENT OF NITROUS-OXID-OXYGEN APPARATUS AS INSTALLED AT LAKESIDE HOSPITAL.

The storage tanks have proved just as useful whenever we have purchased gas as when we have made it. To avoid interruptions from freezing or from the varying pressures and rates of flow from the cylinders we arranged an inlet to our tanks at which we connect the cylinders of purchased gas. The lowest price can be secured on the large (3,200 gal.) cylinders, so we have always purchased these. A reducing valve set at a safe pressure for the tank is inserted between the cylinder and the tank and protects the latter from high pressures and makes it possible to leave the cylinder attached all day or over night. When the tank is full, the flow is automatically cut off. A reducing valve on the tank controls the pressure delivered through the main line to the operating rooms. Another reducing valve at the outlet in the operating room gives the anesthetist control of the pressure needed in the machine which is in use (Fig. 60).

The advantages of this system of tanks, valves, and pipes to the operating rooms are briefly as follows: the gas is delivered to the mixing machine and to the patient at any desired pressure and with a uniform rate of flow; there are no interruptions in the flow of gas; the large cylinders can be used, thus saving a third of the cost of the gas; the gas reaches the patient at room temperature, not at the very low temperature of gas direct from cylinders; the time of attendants is not required to change small cylinders and the need for keeping large or small cylinders in the operating room is avoided. All these advantages are secured by the manufacture of the gas in the hospital and the tanks were originally considered a part of the manufacturing plant, but attention is directed to the advantage of these storage tanks in overcoming the objections to the use of cylinders in the operating room.

INDEX