resistance to stress and strain in such cases, a matter of clinical observation, not only in medicolegal cases but also in cases without a cause for legal action is probably due to relatively minor changes in the cerebrovascular system as compared to those here noted.

In the history of this case, it is shown that the patient apparently recovered from the cerebral injury after the operation. A succession of vascular accidents beginning with the cerebral injury and possibly influenced by the excessive use of alcohol took place, leading finally to his death. It is reasonable to suppose that these changes would not have taken place in the absence of any such injury. Certainly, the exact nature of the changes was determined by the extensive laceration of the brain tissue incidental to the original brain injury. Extravasating hemorrhage into the pia arachnoid is a relatively rare pathological phenomenon. I have seen it in one other case affecting approximately the same distribution in the brain in a case of locomotor ataxia.

The necrosis of the cortical and subcortical tissue is difficult to explain. It is possible that the inflammatory adhesions of the pia arachnoid to the dura produced partial or complete obstruction of the cortical capillary or both the capillary and the cortical venous circulation. The pyramidal shaped areas would be more in favor of a subcortical capillary destruction.

A PRACTICAL APPARATUS FOR THE PRODUCTION OF THERAPEUTIC PNEUMOTHORAX: WITH SOME NOTES ON THE MODUS OPERANDI, INDICATIONS, AND CONTRA-INDICATIONS.[1]

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In presenting this new apparatus, originally the Forlanini apparatus, which was modified by Saugman, again by Muralt and Nebel, and then upon my suggestion made by the Kny-Scheerer Company in a little more substantial form, more easy to transport, more clearly graduated, and with glass tubes inserted in the rubber hose connecting the apparatus with the thoracic cavity, I do not wish to claim any credit for bringing out what I believe to be a very superior apparatus. The credit is due to the original inventors, Professors Forlanini and Saugman, and also to the Kny-Scheerer Company, who, as above stated, have made the apparatus compact, safe, and transportable.

[1] Read by invitation before the meeting of the Association of Physicians attending the Tuberculosis Clinics of New York City, October 8, 1913.

Those who have had experience heretofore with the Forlanini apparatus now on the market, will appreciate the difference. Shipped from a distance, the apparatus usually arrived with the glass tube broken and the gas containers unsupported, and if not broken, liable to break at the slightest jar.

Among the modifications which I have incorporated in this new apparatus, besides the better support of the gas receptacles and stop-cocks, is a manometric scale. In the older apparatus it consisted of a narrow strip of paper, with no light background, which made the reading of the oscillation exceedingly difficult. The scale in the new apparatus is made of a broad strip of milk glass, which at the same time serves as a background to make the reading indicated by the colored liquid more easy.

The manometric scale is divided into 50 cm., 25 cm. above and 24 cm. below zero, indicating respectively negative and positive pressure. To make the reading as easy as possible, every division has a number, and the 5, 10, 15, 20, and 25 are cut in larger and heavier figures. The old apparatus does not indicate all numbers, only 5, 10, 15, etc.

To increase the pressure, the rubber bulb in this apparatus is smaller than in the one heretofore on the market; this is for the purpose of better control when it is desired to use a little more pressure in the flow of nitrogen. The reason for having two intervening glass tubes in the rubber hose connecting the pleural cavity with the apparatus is to enable the operator to see at once if the needle is drawing fluid serum, pus, or blood. It was a peculiar accident which made me see the necessity of this modification in the connecting hose. Prior to practising the pneumothorax operation myself, I decided to see as many experts operate as possible. For this purpose I had visited a colleague in a neighboring State, who operated on a case in my presence. When the needle was inserted, the manometer rose and fell to a considerable degree. My colleague, who has had a large experience in artificial pneumothorax, stated that he could not account for the behavior of the manometer. He turned on the gas-cock, but no gas would flow. He finally gave up the operation and withdrew the needle, and the patient left the table neither better nor worse for the experiment. When the doctor tried to clean the apparatus and needle, he discovered the connecting tube to be full of pus. This explained the peculiar behavior of the manometer, and gave me the inspiration for the employment of the intervening glass tube.

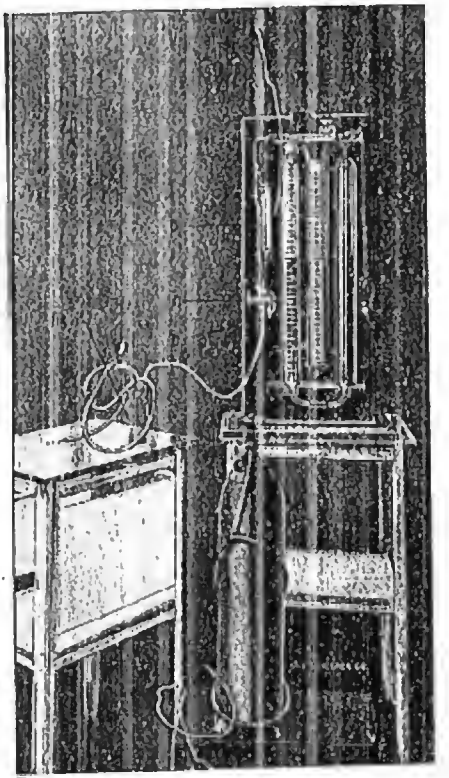
For the benefit of those not familiar with the apparatus, the following is a summary of its workings: (See illustration.)

The apparatus, in a general way, consists of two glass tubes 24½ inches high and about 2 inches in diameter. These two tubes are joined by means of a rubber hose under the base *A*.

The tube at the left is graduated to 1000 c.c.

The two receptacles are filled with water up to 500 c.c.

The graduated tube to the left hand is filled from the tank with the gas to be introduced into the pleural cavity by the weight of the water in the tube, or by additional pressure, the latter being obtained from a double rubber bulb. The flow of gas into the



intra-pleural space is slow but steady. The graduated tube is connected with a glass tube containing sterilized gauze *B*, serving as a filter. It has a ground-glass stopper, which can be removed for the renewal of gauze or cotton.

The filter communicates with a two-way diagonal-passage

glass stopcock *C*. Stop-cock *C*, when turned with the arrow downward, connects the instrument to the gas supply tank (nitrogen or oxygen) by means of a rubber tube. The stop-cock, in the same position, serves for the introduction of the gas into the intrapleural cavity.

When stop-cock *C* is reversed, that is, with the arrow pointing upward, it is connected to the manometer by a thinner glass tube, mounted between the large glass tubes, thus showing the oscillation when the needle is in the intrapleural cavity.

When the arrow of the by-pass stop-cock *D* is pointing horizontally it permits the manometric reading, showing the degree of oscillation while the gas is still flowing provided, of course, that the arrow of stop-cock *C* is turned downward.

When filling the instrument with gas, the rubber hose from the tank should be connected to the outlet below stop-cock *C*. Stop-cock *D* should stand vertically; the arrow on stop-cock *C* should point downward; stop-cock *E*, on the top of the non-graduated tube, should be turned horizontally to the left. When the flow of gas is no longer desired, stop-cock *C* should be turned so that the arrow points upward. If additional pressure is desired, stop-cock *E* must be turned with arrow pointing upward.

Funnel *F* connected with the manometer serves for the filling of the manometer tube to zero with an alcoholic solution of methylene blue.

The illustration shows a transportable tank of nitrogen containing 25 cubic feet, which is equal to 175 gallons, or 700 liters, under the pressure of 1800 lbs., per square inch. The same size tank, containing oxygen under similar pressure, can also be procured. While nitrogen may be obtained more cheaply from the air or with the aid of pyrogallic acid, the use of the tank will be found more convenient and simple.

Owing to the high pressure under which nitrogen or oxygen is held in the tank, great care should be exercised that the liquid is not blown out of the glass tube when filling the apparatus. The surest way is to have an intervening rubber bag into which the gas flows first, and from which it can gradually be pressed into the receptacle of the apparatus; but with care the flow of gas from the tank can be regulated so as to avoid accidents. The flow should always be regulated prior to attaching the receptacle to the apparatus.

In addition to this new apparatus, the illustration shows a device which will eliminate at least one of the unpleasant features which occasionally attend primary as well as subsequent operations for artificial pneumothorax. The distress which the patient sometimes feels, manifesting itself in anxiety, intense dyspnea or cardiac pains, and which is due to the expansion of the nitrogen which has been injected at the temperature of the room. The much higher

temperature of the thoracic cavity causes the gas to expand and thus increase considerably in volume. To eliminate the possibility of this accident, a coil of metal tubing is suspended over an alcohol lamp (see illustration), through which tubing the nitrogen gas is passed before it enters the pleuritic cavity. Pneumonia has been said to have been produced by the inhalation of cold oxygen, hence it is suggested that when oxygen is chosen as the gas to be injected for the production of artificial pneumothorax, it should be passed through a heated coil of metal tubing, after the alcohol flame has been extinguished, to avoid any possibility of explosion.

Robinson and Floyd state that the warming of the nitrogen will materially aid in preventing a "pleural reflex."

As to the manner of producing artificial or therapeutic pneumothorax, all antiseptic precautions, sterilizing of hands, needles, and field of operation, should be rigorously adhered to. While the operation is seemingly slight and many times accomplished without any accident whatsoever, serious and even fatal accidents have happened. Therefore, the operation should be performed either in the home of the patient or in the hospital, but never in the physician's office.

Furthermore, one should not undertake to treat a patient by compression of the lungs unless the latter is informed that it will take a long time and probably many inflations before a successful compression is obtained. He should also be told that the operation is not always successful.

To avoid accidents from shock, infection, or even temporary discomfort, the patient should be prepared by having his bowels moved. Prior to the inflation a quarter of a grain of morphine should be injected. The skin should be rendered aseptic by tincture of iodine. A local anesthesia of the skin should be produced by ethyl chloride, prior to the insertion of the needle for the injection of novocain, to anesthize the muscular layers of the thorax.

Before beginning, the apparatus should be tested to see that it is working properly. Since it is not always possible to locate a point free from pleuritic adhesion, several punctures may be necessary before the manometer indicates free oscillation, which means that the needle is in the interpleural space. Large needles which require a preliminary incision into the skin and thoracic muscles may lead to septic infection, particularly when several incisions become necessary. A finer needle is not likely to do serious damage, even if it does enter the lung. The regions which are apt to be more frequently free from pleuritic adhesions are along the axillary lines. The Kny-Scheerer Company have manufactured for me a moderately fine needle, which by means of a cap can be easily attached to the rubber hose connecting with the manometer or gas receptacle.

The patient should be placed on his side, with the arms up,

so as to widen the intercostal space. The needle is then slowly inserted through the skin and muscular layer in such place as percussion and auscultation had showed a seeming freedom from adhesion. When the needle penetrates the parietal pleura, free from adhesion, a peculiar resistance is felt, which might be likened to the passing of a needle through stretched parchment. When the manometer indicates a negative pressure, with free oscillation the gas is allowed to flow.

As an initial inflation, perhaps not more than 500 c.c. should be injected, except when the injection is made for uncontrollable hemorrhage, then larger quantities may be indicated.

To avoid gas embolism, it is advisable to begin with an inflation of 50 to 100 c.c. of oxygen. In cases of uncontrollable hemorrhages the more oxygen injected the better the patient feels from the operation. Dr. Mary E. Lapham,[2] who has had a large experience with artificial pneumothorax, recommends the substitution of oxygen for nitrogen whenever the introduction of the latter gas causes dyspnea and cardiac distress.

As stated above, it is best to inject small quantities of gas at the beginning (about 500 c.c.) This, as a rule, suffices to give the desired relief, reduces temperature, and influences cough and expectoration favorably. Robinson and Floyd, however, give as a maximum for the first injection 1000 c.c., and Bonniger[3] as much as 2000 c.c. in a strong man and 1600 c.c. in a woman. Concerning this, King and Mills[4] say: "These larger quantities seem to us unnecessarily heroic, and not altogether devoid of embarrassing sequela if not of danger." In regard to the subsequent injections, the latter say: "Subsequent inflations had best be made at intervals of not more than a few days, until the manometer readings are neutral or slightly positive and the *x*-rays show as complete a lung compression as is possible. After this is accomplished, the intervals between the injections are governed by symptoms, especially the amount and character of the sputum, temperature, etc., and by the *x*-ray. If atmospheric air is used, the intervals will necessarily be shorter than when nitrogen is employed."

Atmospheric air should never be used unless it is passed through the filter referred to in the above description of the apparatus and rendered sterile.

Before referring to the indications and contra-indications, it may be stated that sometimes the most careful injection is followed by an immediate surgical emphysema. When the beginning of such a complication arises, the emphysematous area should be encircled by a rubber bandage, which usually suffices to control

[2] Artificial Pneumothorax, New York Med. Journ., March 22, 1913.
[3] Berl. klin. Woch., August 26, 1912.
[4] Therapeutic Artificial Pneumothorax, Amer. Jour. Med. Sci., September, 1913.

the condition. Pleuritic effusion may occur later on and should be treated in the usual way. Collapse caused by pleural reflex, intense dyspnea, or hemorrhage, should be treated with injections of morphine, caffein, nitroglycerin, and locally with spirits of ammonia, whisky, hot-water bags, and ice-bags.

The cases which justify the operation of therapeutic pneumothorax although discussed before[6] may bear repeating. (1) Artificial pneumothorax is indicated first in all such cases as have not improved under ordinary hygienic, dietetic, climatic, and symptomatic treatment Such cases are, as a rule, moderately or far advanced.

(2) It is indicated also in those earlier cases in which there is no improvement because of mixed infection or lack of recuperating powers, or when for other often inexplicable causes the condition remains stationary or the progress toward improvement is particularly slow.

(3) In all rapidly progressing cases, whether they are treated in institutions or at home, and in whatever climate.

(4) It is indicated for all patients of the moderately or far advanced type, within or outside of institutions, who are discontented, feel that not enough has been done for them, and who are desirous to have artificial pneumothorax tried.

(5) It is indicated in uncontrollable hemorrhage or chronic sanguineous expectoration.

(6) In that group of cases, which King describes as uncomplicated unilateral phthisis, with slow or subacute course, regardless of the degree of lesion, but with such pleuritic adhesion as may be removed by artificial pneumothorax.

(7) In cases of bronchiectasis, when climatic, hygienic, and the ordinary symptomatic treatment fails, it is justifiable to try the injection of nitrogen gas, with a view of producing artificial pneumothorax. There are a few cases on record where this means has been successful.

Bilateral involvement, if one lung is more involved than the other, is not a contra-indication to the production of artificial pneumothorax. Those who see many tuberculous cases, both in private and hospital practice, will admit that tuberculosis limited to one side is rare in patients who have had the disease for any length of time. In my service at the Riverside Hospital Sanatorium, where from 300 to 400 cases are treated in the second and third stages of the disease, it is doubtful if there is one in whom the tuberculous lesion is confined to one side. Most of the cases operated on in sanatoria and hospitals have had bilateral lesions, and a fair number have shown gratifying results.

Interesting and paradoxical as it may seem, all clinicians doing artificial pneumothorax work have frequently noticed that in spite of the increased activity of the less involved portion of the

[6] Knopf and Lapham, Artificial Pneumothorax, New York, Med. Journ., March 22, 1913.

lung, as a result of compression of the other side a concomitant improvement has resulted in this non-treated part of the pulmonary lesion.

Casts and albuminuria are not necessarily a contra-indication, but, of course, one must be guided by the general condition of the patient. When the lesion of the less affected side is a basal one, some authorities consider this a contra-indication. In the opinion of Dr. Lapham, this condition is not an absolute contra-indication, and the production of artificial pneumothroax is permissible because of the relief which it gives to the patient.

There are of course decided contra-indications to the production of artificial pneumothorax:

1. An extensive involvement of both lungs.
2. When there is so much cavitation in the affected lung that there is danger of the needle entering a cavity.
3. Dry pleurisy or pleurisy with effusion.
4. Myocarditis, other serious cardiac complications, or serious renal complications.
5. Pulmonary tuberculosis complicated by any constitutional disease which in itself is sufficient to inhibit all possible chances of recovery.
6. When there is an ascites or a distention of the abdominal cavity due to gases in the stomach or intestines, artificial pneumothorax must not be produced until this condition is remedied, otherwise a serious dyspneic condition and heart complications might ensue.
7. When the patient, in no matter what stage of the disease, is too apprehensive and strongly objects to the performance of the operation, it should not be resorted to.
8. Finally I would wish to say artificial pneumothorax is contra-indicated in early and favorable cases.

There are a few clinicians who, because of their success in advanced cases, recommend its use in early unilateral lesions. My experience and knowledge up to this date make me consider an early lesion of pulmonary tuberculosis a contra-indication and not an indication for the performance of artificial pneumothorax. Such early uncomplicated cases, with relatively little envolvement, should be treated by the well-tried sanatorium methods in special institutions or at home. Artificial pneumothorax can as yet only be classified as a valuable therapeutic means in a limited number of cases of pulmonary tuberculosis, but it cannot be considered the treatment of this disease in all stages.