Report of cases of empyema treated by irrigation : with remarks upon the operation of paracentesis thoracis / by Philip J. Hensley.

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REPORT

OF

CASES OF EMPYEMA TREATED BY IRRIGATION,

WITH REMARKS UPON THE OPERATION OF PARACENTESIS THORACIS.

BY

PHILIP J. HENSLEY, M.D.

Of the following cases, the first, in which the result of the treatment adopted was more or less disappointing, has a somewhat long history. That of the others, where the treatment was successful, is naturally short.

Case I.

J. W. L., a clerk, aged 52, was admitted to Matthew Ward, St. Bartholomew's Hospital, on March 18, 1880, under my care. He was a spare man, who had usually enjoyed good health, was of temperate habits, and could give no account of any special weakness of constitution among other members of his family.

There were the signs of a considerable effusion into the left pleura; dulness, absence of breathing sounds and of vocal vibrations over the base, displacement of the heart to the epigastrium, with some soft friction sounds and an impaired percussion note near the apex in front. The breathing on the right side was of a healthy character, but somewhat exaggerated. There was but little cough and no expectoration; the pulse was good, the temperature normal, and he complained only of shortness of breath upon attempting to move about.

On March 31 he was tapped in the ordinary manner, the aspirator being used, and about 48 oz. of clear serous fluid were withdrawn.

It did not appear at the time that a sufficiency of the fluid present was evacuated, and I suspected that the cessation of flow was due to the presence of subdivisions in the fluid-containing space, or to the blocking of the canula by a coagulum. There was, however, a return of the heart to nearly its natural position, and respiratory sounds were heard somewhat lower than they had been. Beneath the clavicle and towards the mammary region the freer entry of air brought out more distinct morbid sounds, and there were to be heard various irregular, creaky, and crepitant sounds; in fact, the physical signs here were in all respects such as would certainly, taken alone, have given rise to the diagnosis of phthisis.

The shortness of breath was relieved by the tapping, but there shortly began to be signs of an increase in the effusion, and a second tapping appeared to me to be called for, but was postponed on account of a slight attack of gout. The patient afterwards passed from my care to that of Dr. Southey, who, on account of the doubtful signs at the left apex, was indisposed to interfere with the effusion. He left the Hospital on May 24.

On July 14, 1880, he presented himself at the Chest Hospital, where he was admitted under my care. He complained then of extreme shortness of breath, and could lie only on the left side. He had recently been troubled with some pain over the left side of the chest, but had no night sweats, and had been able to sleep fairly, and had kept up a fair appetite. He presented no lividity, the pulse was of fair volume, the temperature slightly above 99° F., and the condition of the urine normal.

There was a bulged appearance over the base of the left side; absolute dulness over the whole left side of the thorax up to the clavicle, and extending to nearly the right border of the sternum at its upper part; tympanitic resonance in the left supraclavicular region. Complete absence of respiratory sound over the whole of the left side, with exception of faint tubular breathing near the root of the lung; absence of vocal vibrations, and marked transmitted pulsation from the heart over the lower part where the bulging was most noticeable. Breathing on the right side was harsh. The heart's impulse was to be felt in the fourth right interspace, two inches beyond the sternal border.

The day after admission he was tapped with a fine exploring trocar connected with a bottle aspirator, and six pints of laudable pus were slowly withdrawn, greatly to his relief.

The physical signs after this tapping were on the whole cer-

tainly better than they had been after the original tapping, as there were apparently breathing sounds heard much lower, and even at the base the percussion note was not absolutely dull; the heart also returned more completely to its natural position. The apex sounds were, however, of the same nature as they had then been, and there were some indistinct signs of pneumo-thorax. On this occasion the canula became blocked when about four pints of pus had been removed, but was cleared by passing through it a reverse stream of a dilute solution of Condy's fluid from a raised vessel. This blocking and clearing recurred several times before the end, and determined me in any future tapping to provide for a reversal of current without the need of disconnecting the tubes.

On August 7th, the signs of the presence of fluid having gradually increased until there was dulness up to the third rib, he was tapped by direction of Dr. Gabbett, who was in charge for me during my absence from town. On this occasion only 15 oz. of pus were withdrawn, aspiration being hindered by the stoppage of the canula by coagula.

On August 26th, 40 oz. of pus were withdrawn, but on account of the imperfections in the instruments used it was not possible satisfactorily to complete the operation.

On September 11th, 115 oz. of pus were removed. Two fine canulæ were inserted, each having connection with the receiving-bottle, and with a reservoir containing 1 per cent. solution of carbolic acid raised about three feet above the level of the bed. By means of taps the direction of the current in each canula could at any moment be reversed, so as to be either outwards or inwards.

Of the whole quantity, about 70 oz. was drained away without the admission of any of the solution, and the remainder was removed by repeated washings, between eight and nine pints of the solution being used, and the washing continued until the fluid was returned only slightly turbid. The amount of solution finally left in the chest was believed to be about 5 oz.

The patient was very greatly relieved, and upon examination of the chest the physical signs were found to be such as, whether deceptive or not, appeared to indicate a very considerable amount of re-expansion of the left lung.

Finding this to be the case, I determined to postpone for the present making any free opening, with the hope that the accumulation of fluid being prevented beyond a certain point by frequently repeated tappings, a certain amount of pleural adhesion might take place, and the prospect of closure of the remaining cavity might be the greater.

Unfortunately the accumulation of pus was at times so rapid that distension beyond what had been intended could not be prevented.

On September 27th, nearly 60 oz. of pus were removed, a large proportion of this being obtained by the washing process. Between 9 and 10 pints of carbolic acid solution were used, and for the final washing a solution containing two grains of iodine to the ounce, and made up with glycerine to a specific gravity of 1060.

After this tapping there were evidences of air in the pleura, and these continued to be noted with more or less distinctness afterwards until the time when a free incision was made, and rendered such signs as might be supposed to be given by the lung itself still more uncertain and puzzling.

On October 10th, 114 oz. of pus were withdrawn, that which was first obtained being discoloured from the presence of the iodine of the previous tapping. This time there was an extreme irregularity in the way in which the pus was obtained, the washing being continued for three successive times until the fluid returned was nearly clear, and then suddenly a large proportion of pus being obtained, as if the cavity were more or less separated into compartments by the presence of coagula or partial adhesions preventing the ready movement of fluid.

This irregularity led me to take special note of a defined patch of dulness which was left after the tapping at the base behind, and to surmise that this might be due to a separate collection of fluid.

It would appear that this was so, as upon tapping this part on October 13th, the pus obtained was of a different colour to that of the 10th, being free from the tinge due to the presence of iodine, which had been used both on October 10th and September 27th. The quantity of pus obtained on this day was 26 oz., which was washed out with about four times its volume of carbolic solution.

On October 21st, 44 oz. of pus were removed by the washing process, about 6 pints of carbolic lotion being used, and the final washing being with an iodine solution.

On October 27th, 32 oz. were withdrawn in a similar manner.

On November 3d, 6½ oz. were obtained by a carbolic acid washing, no iodine being used; the completion of the operation was prevented by an accident.

On November 5th, 49 oz. were removed by a carbolic acid washing.

On November 10th, about 25 oz. were withdrawn by washing: the two canulæ were afterwards retained in place for nearly

seventy hours, and for nearly the whole of that time a continuous stream was kept up through the pleural cavity of solutions of carbolic acid and sulphate of zinc.

The patient bore this with very little discomfort, such as there was being caused by the pressure and irritation of the canulæ: he was able to sleep well, had no nausea, and took food well; there was no cough, the pulse was uniformly good, and throughout the time the temperature was slightly above 97° F., having the day previously been 102° F.

The level of the reservoir of fluid was only a few inches above that of the chest, and altogether about 110 pints were transmitted, the temperature being generally between 60° F. and 70° F., but no very special pains were taken to maintain this uniformly, as it had been found on all previous occasions that the entry of fluid at the ordinary temperature of the air had been borne with perfect impunity.

The appearance of the chest after this was remarkably changed, the intercostal spaces of the left side being very markedly drawn in; the whole side from this cause, or even from actual further change, presenting a retracted look. The auscultatory signs, if these could in any degree be trusted, seemed to indicate that there was contact between the costal and pulmonary pleuræ behind to the base and at the apex in front; that there was breathing over these parts of the lung; and that a pleural cavity at the anterior base contained air and fluid. The heart was in its natural position.

It would probably have been the best course now to have made a free opening and kept in a drainage tube.

On November 24th, about 20 oz. of pus were removed, and a continuous irrigating stream of carbolic lotion kept up for nearly twelve hours. This was well borne, and was terminated before it was intended by the accidental displacement of the canulæ.

On December 3d, about 30 ounces were evacuated, and irrigation afterwards continued with carbolic acid and sulphate of zinc solutions for about sixty-four hours. The canulæ on this occasion were probably finally displaced by the action of the patient, as towards the latter part of the time considerable local irritation was set up.

On December 13th, an incision was made in the seventh interspace in the axillary line, and about 20 oz. of pus let out, a drainage tube inserted, and the cavity from that time washed out two or three times daily with solutions of carbolic acid.

On December 16th, the patient presented a very anxious and

distressed appearance; breathing was short and catchy, the pulse rapid and hard, the temperature above 103° F., and loud pericardial friction sound was heard. He was treated with aconite, and a small blister was applied over the pericardial region, and on the following day was much relieved, and the heart's action had become quiet: friction sound remaining loud for some days. From this time until December 26th the oscillations of temperature were greater than ever previously: after the 26th there was no rise higher than 99° F., and the patient began gradually to gain strength.

At the end of January 1881, the cavity would contain about 10 oz., and the amount of discharge was usually about 3 oz. daily.

On the 24th of February, the patient left the Hospital, the cavity at that time admitting between 6 and 7 oz. of fluid.

As the cavity gradually diminished a more and more marked constriction became formed about 1½ inches from the external opening. If the drainage tube was not passed beyond this, accumulation of pus immediately took place behind it, and it became a constantly increasing difficulty to get the tube through this constriction.

To obviate this difficulty, I got Messrs. Arnold to make for me some fine drainage tubes with closed rounded ends like catheters, and these were found to answer well, being readily inserted by means of a stylet; they are kept in position by being passed through a short length of elastic tube tight enough to hold them firmly without constricting them, one end of which short piece of tubing is expanded into a flat shield or button-like plate, which lies on the chest wall. No holes are made in the part of the tube outside the chest, and the end is kept in a small bottle suspended to the waist; the patient is in this way enabled to keep the skin and clothing dry, and to get about with much greater comfort than would otherwise be possible.

The patient continued to wash the cavity out twice or three times daily, and by the end of May it had diminished, so as to hold a little above an ounce, but was a long narrow sinus extending for about six inches from the external orifice in a direction behind the pericardium.

Since then there has been but little change in the condition of this sinus, but the general condition of the patient has remained good.

There is at present (October 1881) a considerably impaired, but by no means absolutely dull, percussion note posteriorly

below the root of the lung; anteriorly dulness, with a cracked-pot sound under the clavicle. There is a very good imitation of feeble vesicular breathing to near the base behind; amphoric breathing and pectoriloquy under the clavicle, with some creaky sounds lower down.

It thus remains a question whether there has been destructive disease at the apex of the left lung and the formation of a cavity there, or whether these physical signs are to be otherwise explained.

The tolerably extended trial made in this case would seem to indicate that when an empyema of this magnitude occurs in a person so far advanced in life, a free opening cannot with benefit be long delayed. On the other hand, the course of the case would seem to indicate that it must be a more or less mistaken idea to believe that final healing is prevented by the difficulty of getting the space filled up. Here somehow or other all is filled up to the last ounce, and it is difficult to believe that this could not have been provided for if only it had been distributed in a different form.

If there had been the opportunity, the first serous effusion should, I think, have been tapped earlier. The first tapping was unsatisfactory, and on this occasion air probably entered the pleura.

The sequel showed that delay on account of the signs indicating disease at the apex was a mistake. In two cases in which, with a serous effusion, there have been similar signs at the apex I have not been deterred from tapping; have found the result good, and have come to the conclusion that either these signs were misleading or that rapid repair took place.

Case II.

C. D., a boy aged 10, was admitted to Matthew Ward, St. Bartholomew's Hospital, on August 30, 1881.

He had attended a school-treat on August 6th, on which occasion, according to his own account, he had been supplied with a superabundance of beer, and had lain for some time upon damp grass; this was followed by a rigor, and from this time until his admission he had complained of shortness of breath, some cough without expectoration, and occasional pains about the chest.

The patient was a delicate-looking boy of dark complexion; there was said to be phthisis on the father's side.

At the right base, below the level of the nipple, there was complete dulness in front and laterally, with absence of breath

sounds and vocal vibration; the resonance was more or less impaired up to the clavicle, with feeble irregular breathing sounds and indistinct friction; behind, the resonance was impaired in the interscapular region, with feeble tubular breathing, and lower down there was complete dulness and absence of sound.

The breathing over the left lung was exaggerated, with slight catarrhal sounds. The heart's apex was slightly to the left of its normal position; the sounds were natural.

The circumference of the right side at the level of the ensiform cartilage was 13 inches; of the left, 12¼ inches.

On September 1st, the pulse was 124, and of small volume. Respirations, 38. Temperature, 101° F.

On September 3d, the patient being under chloroform, two fine canulæ were inserted in the sixth and eighth interspaces in the axillary line, and about 18 oz. of pus withdrawn. Of this quantity, only a small proportion (between 6 and 7 oz.) was obtained at first, the whole of the remainder being brought out by repeated washings. The solution used was a saturated one of salicylic acid at the temperature of about 75° F., and this was continued until it was returned nearly clear; and altogether about nine pints, or ten times the volume of the pus evacuated, were used. So far as could be judged, but little of this was ultimately left in the pleura. The operation was concluded by the injection of about ¼ oz. of tincture of iodine.

There were evidences of fair expansion of the lung immediately after the operation, the resonance in the infraclavicular region being much improved and towards the base, dulness being also much less marked than it had been. Feeble breathing sounds, somewhat tubular in character, were heard to near the base in front and behind, with some irregular friction sounds.

On September 5th, the circumference of the chest at the level of the ensiform cartilage was 12½ inches on each side.

The patient did well in every way, and there was no return of effusion; the apparent contraction of the right side compared with the left became more marked, and *pari passu* with this change the breathing became better.

On September 26th, the measurement of the right side of the chest was 12½ inches; of the left, 13 inches. The temperature had been normal for several days, and there was gain of flesh and strength.

He was able to go to the Convalescent Home on October 14th.

Case III.

G. A., aged 3, a rickety, unhealthy-looking child; was brought as an out-patient to the Chest Hospital on April 6, 1881.

He had been exposed to cold about three weeks before, after which the mother noticed that he was feverish, that he cried when moved, complained of pain about the chest, became more and more short of breath, and had an occasional catchy cough.

The expression of the patient was anxious, the respiration very rapid, the lips slightly livid, the veins of the neck somewhat distended; the left side of the chest was found to be completely dull in front to above the clavicle, behind there was a faint resonance above; no respiratory sounds were audible over this side, and the heart's impulse was to be felt just below the right nipple.

The patient was at once admitted, and by means of a fine canula and syringe 8 oz. of pus were withdrawn, but no attempt was made on that day to evacuate the whole.

On April 8th, the respirations were above 60, the pulse about 160; measurement of chest at level of ensiform cartilage, 9¾ inches right side, 10½ inches left.

In front there was dulness below the nipple; behind the interscapular region was impaired, the base quite dull; breathing sounds absent at the base, tubular above; heart's impulse to be felt in the epigastrium.

Two fine canulæ were this day inserted in the sixth and seventh interspaces in the axillary line; but one of these being accidentally displaced, the operation was almost entirely through one, and for this reason the washing out was not so complete as had been intended.

About 11 oz. of pus were removed, and of this rather more than half was by successive washings, first with about 2½ pints of warm water, afterwards with a warm 1 per cent. solution of carbolic acid, of which about a pint was used.

After the operation vesicular breathing appeared to be heard all over, feeble in character near the base; resonance was impaired at the base, elsewhere good. The number of respirations fell to 32.

Two days afterwards there were the signs of commencing reaccumulation of fluid, and these became more and more manifest until April 16th. On that night the patient was extremely restless, had profuse sweating, and the respirations had risen to 64.

On April 17th, two canulæ were inserted in the axillary line, and about 18½ oz. of pus withdrawn, the first 7 or 8 directly, the remainder by successive washings. The fluid was a warm saturated solution of salicylic acid, of which nearly nine pints were used.

During the latter part of the washing, quantities of about 10 oz. were alternately admitted and withdrawn; and as this was done there could be traced gradually increasing dulness and gradual loss of respiratory sound, and then again the gradual return of breathing sounds and fair resonance.

After the operation the respirations were found to be 32.

There was no sign of return of effusion after this, and fair breathing and resonance were established on that side as it began to show retraction compared with the other. On April 23d, the measurement of the right side was 10½ inches; of the left, 10 inches.

On April 24th, the temperature, which had been gradually falling towards normal, suddenly rose to 104° F., and on the 25th he was found to have a well-marked scarlatina rash. On the 26th, he was removed to the London Fever Hospital.

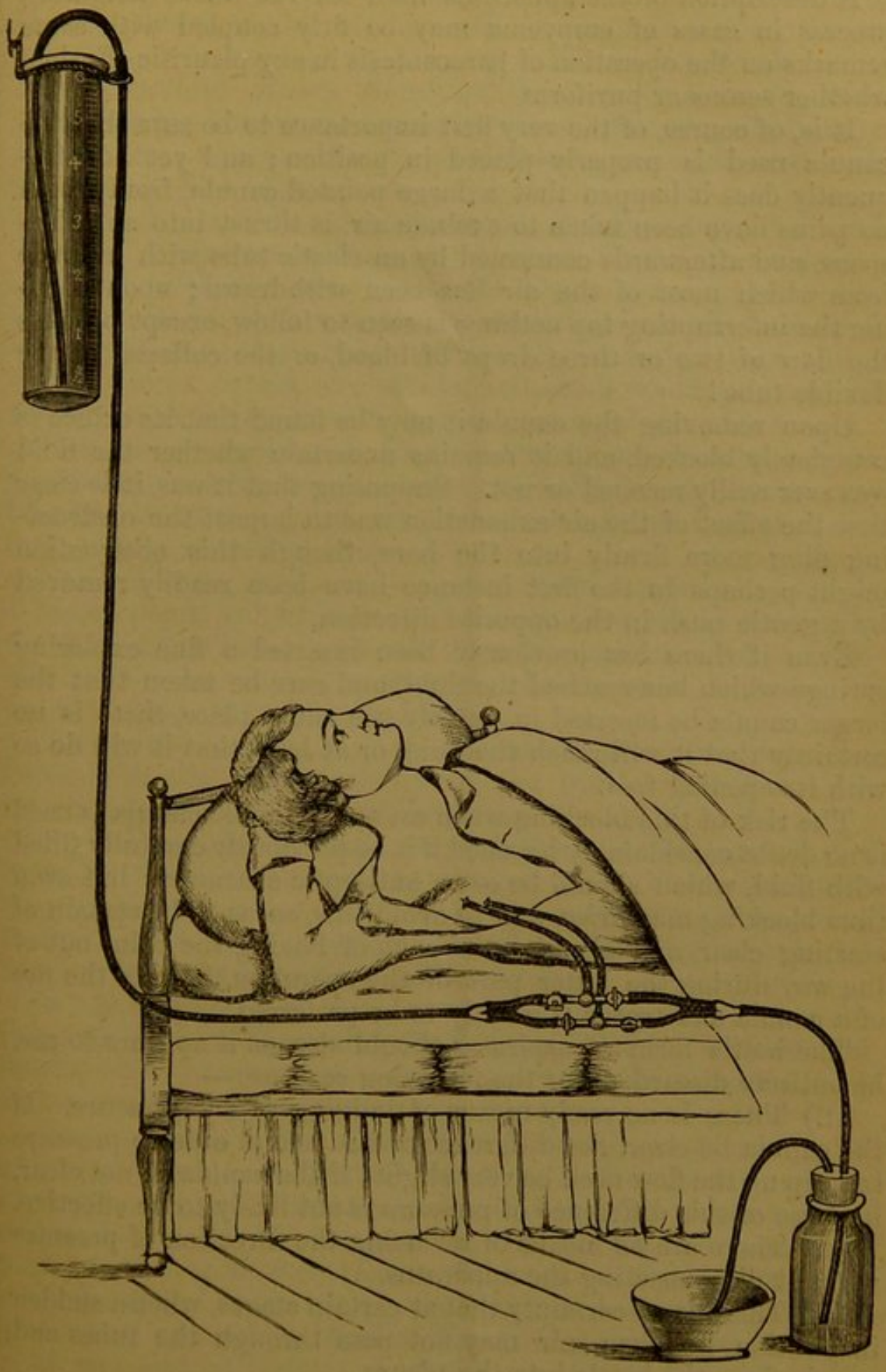
In July the child was again brought by the mother to see me, and was then in the most miserable plight. The belly was swollen, the limbs wasted; there was an abnormally large appetite and constant diarrhœa; there were various irregular râles over both lungs, but, allowing for the retraction of the left, the general character of the breathing was the same on both sides.

So far, then, as the empyema was concerned, the treatment adopted in this case may be regarded as satisfactory in its results.

In Case II., although the patient was an unpromising subject, the result was eminently satisfactory.

In each of these cases it may be noted that success followed the use of a solution of salicylic acid. Whether there be any special virtue in this I do not pretend to say; it was used in preference to carbolic acid from a fear of the dangers to which the latter might give rise.

For the care with which I have been aided in the treatment and observation of these patients I am much indebted to Mr. Dingley and Mr. Barnes, house physicians, and Mr. Irvine, clinical clerk, at St. Bartholomew's Hospital, and to Mr. Jessop, Mr. Batterham, and Mr. Harper, house physicians at the Chest Hospital.



A description of the apparatus used for the above irrigating process in cases of empyema may be fitly coupled with some remarks on the operation of paracentesis in any pleuritic effusion, whether serous or puriform.

It is, of course, of the very first importance to be sure that the canula used is properly placed in position; and yet how frequently does it happen that a large pointed canula, from which no pains have been taken to exclude air, is thrust into an interspace, and afterwards connected by an elastic tube with a bottle from which most of the air has been withdrawn; upon opening the interrupting tap nothing is seen to follow, except perhaps the flow of two or three drops of blood, or the collapse of the flexible tube!

Upon removing the canula it may be found that its orifice is completely blocked, and it remains uncertain whether the fluid was ever really reached or not. Supposing that it was, it is clear that the effect of the air exhaustion was to impact the obstructing plug more firmly into the bore, though this obstruction might perhaps in the first instance have been readily removed by a gentle push in the opposite direction.

Even if there has previously been inserted a fine exploring syringe which has reached the fluid, and care be taken that the larger canula be inserted in exactly the same place, there is no certainty that it will reach the fluid, or at least that it will do so with its opening free.

The risk of this blocking when an open pointed canula is used is no doubt considerably lessened if it be previously carefully filled with fluid, which should be of an antiseptic character; but even thus blocking may arise, and to avoid this, so as to be certain of starting clear, and also for the sake of having the point out of the way during the latter part of the operation, I think the use of a canula and trocar is greatly to be preferred.

The bottle form of aspirator should also, as it appears to me, be entirely discarded, for the following reasons:—

(1.) There is no ready means of judging of the pressure. If the canula be clear, the difference of inside and outside pressure to keep up the flow need be very slight; if the canula be not clear, increase of this difference of pressure is not likely to be effective.

(2.) There are no means of reversing the direction of pressure without disconnecting the apparatus.

(3.) There is no certainty that at certain stages, when a sudden inspiration is taken, air may not pass through the tubes and canula from the bottle into the pleura.

(4.) There is always the temptation towards the end of the operation, as the flow ceases, to attempt to obtain more fluid by

continuing the exhaustion, with a view of thereby, as it were, forcibly causing further expansion of the lung. The effect of such attempt, as it appears to me, can never be beneficial, and is usually harmful. Either the end of the canula may be suddenly jerked against the lung, causing in this way bleeding or injury to the surface; or rupture of the blood-vessels, or of the lung itself, may be caused by the tension.

If in any special case a different arrangement from that described farther on seems to be called for, I much prefer to use a syringe with a double-tap nozzle like a stomach-pump, the tube connecting this with the canula being from the first filled with fluid; with this a coagulum entering and blocking the end of the canula would at once be felt, and would probably be washed back simply by reversing the action of the piston.

It would seem desirable that whatever instrument is used for exploration should be such as may be available for the completion of the operation, so that, when once in good position, no fresh puncture need be necessary.

For exploring only, as in some cases successive trials at different points might have to be made, it would be natural to use quite a fine instrument. On the other hand, for the continuance of the tapping it is necessary that it be of a calibre to transmit fluid with sufficient freedom.

The canulæ I prefer to use are of about $\frac{1}{30}$th inch bore, and these, with the ordinary fall from the bed-level to floor, will transmit from 1 to 4 oz. of fluid per minute.

A small syringe is combined with the trocar and canula, the barrel of the syringe being continuous with the canula, which thus forms its nozzle, and the trocar being screwed to the piston in the direction of the piston-rod prolonged, so that it is drawn backwards at the same time as the piston.

In the first form of this, as made for me by Messrs. Arnold, the glass barrel of the syringe was of considerable diameter, and the connection between it and the canula was by a screw fitting with a tap, through which the trocar passed.

A much simpler form is to make this barrel consist merely of a piece of glass tube ground smooth at both ends, and of the same diameter as those used as inspection tubes inserted in the course of the india-rubber tubing. A short length of india-rubber tubing is tied or fixed by means of a small enveloping cap on to the bulbous end of the canula, and connects it air-tight with the glass tube, over which it slips for a length of about an inch or an inch and a quarter. A steel stylet forms the piston-rod, and a small disc of oiled leather cut from a glove, where this stylet and the trocar are screwed together, forms an efficient piston.

All parts of the instrument as thus made are separable, and easily kept in order. In using it, as the piston is drawn back there is of course no entry of fluid into the glass tube until the trocar leaves the canula, when fluid suddenly makes its appearance. The glass may then be carefully drawn nearly out of the short piece of india-rubber tubing, leaving a sufficient length of this free to be compressed between the finger and thumb or by a clip. While there is this compression, the glass tube may be removed without the danger of the entry of any air.

Supposing that it be found that the fluid is serous, the next step is to insert into the open extremity of this india-rubber tube one end of a short piece of glass tube, the other end of which is slipped into a flexible tube long enough to reach to the floor, taking care that the whole length from where the compression is made is filled with water or some antiseptic fluid.

A convenient way of doing this with certainty is by the bottle arrangement, shown to the right of the figure.

The longer flexible tube has a short length of glass at one end, and the other end passes air-tight through a cork in the neck of a small bottle, to the bottom of which it reaches; a short length of flexible tube, passing also through the cork, opens into the top of the bottle.

The bottle and flexible tubes are completely filled with liquid, and kept ready for use with the open ends of the two tubes held at the same level, and it is then easy to insert the end of the glass tube into the india-rubber tubing attached to the canula without the entrance of even a bubble of air. There is thus a continuity of fluid from the pleura through the canula and tubes to the bottle, interrupted only where compression is made; the bottle being then lowered and the compression removed, flow begins from the end of the tube coming out through the cork.

The advantages of this method are:—

(1.) There is no danger of air-entry at first, and from the first, and uniformly afterwards, the current through the canula is kept up by the weight of a column of liquid from the level of the chest to that of the floor.

(2.) It can always be seen at a glance whether the flow continues; this is especially valuable towards the close of the operation. If there be simply a flexible tube from the canula down to the receiving vessel, and the end of this tube be raised above the surface of the fluid therein in order that it may be seen whether the flow continues, there is always a danger that by a sudden inspiration air may be drawn up through the tube and canula into the pleura.

(3.) If there should at any time be a cessation of flow in consequence of the blocking of the orifice of the canula by the entry into it of coagulum, this can probably be washed back and cleared by raising the bottle above the level of the chest.

I have tapped many cases of serous effusion in this manner, and have found that if the canula be well placed in the first instance, there is never any difficulty in evacuating a quantity of fluid which, if at all less, cannot be very much less than the quantity which would be obtained if more forcible exhaustion were attempted.

No bleeding is ever caused, and the fineness of the canula and the comparative slowness with which the fluid drains away makes the operation one which is borne with but little discomfort. Some that have been treated in this way in the out-patient room have walked home afterwards and done well in every way.

In but few cases of pleuritic effusion—probably in none except those of mere passive dropsical effusion—is it to be supposed that the condition of the lung and pleura is such that it is possible immediately for expansion to take place so completely as to displace all fluid from the pleural cavity; and were this possible, the position of the canula would hardly ever be so exactly right that all would be actually displaced.

No forcible attempt to remove the residual fluid can, I believe, succeed; nor in the case of a serous effusion would there seem anything to be gained by the replacement of this fluid by some other. The absorption of serum is probably a very simple process, scarcely one of pathological repair, and not likely to delay the other necessary reparative changes in the lung, pleura, and chest walls.

It is quite otherwise, however, if the fluid be pus. If pus be left, there is a considerable probability that fresh pus will be formed. Even if absorption commence, this must be a process causing a great amount of constitutional strain, and convalescence must be considerably delayed and impeded beyond what it would be if there were relief from the necessity of this absorption.

Now, although the residual fluid cannot be removed by any forcible exhaustion, it may, as in the above cases, be more or less completely replaced by some other fluid, which it may be hoped may be easily and harmlessly absorbed as the reparative changes go on around it.

To effect this it is only necessary to add to the above-described arrangement a branch leading to the canula from a reservoir of fluid raised above the level of the chest, and to have the means by taps or compressing clips of interrupting the communication of the canula with this reservoir above, or with the reservoir below, as may be required.

I should prefer, instead of thus using one canula, generally to make use of two, for the following reasons:—

(1.) The time of the operation is thereby diminished.

(2.) If the canulæ be inserted so far apart as may be justified by the physical signs, the direction and points of entry of the fluid currents are different, and a more intimate mixing, and hence a more complete washing effect, is produced.

(3.) It is possible, should it seem desirable, to keep up a continuous current through the pleura.

The figure shows the disposition of the tubes when two canulæ are thus used.

The reservoir above is a glass jar, narrow and graduated, so that the downward flow and the quantity of fluid introduced into the chest is readily shown. From the bottom of this a flexible tube passes over the edge down to the level of the bed; it here bifurcates into two short tubes, which again join into one to pass to the bottle on the floor, as already described. In each part of the tube where it is double there are two taps, and from the interval between each of these pairs of taps a branch of flexible tubing, terminating in a short length of glass tube, passes to join the canula.

To prepare this for use, the orifices of the glass tubes must be for the moment closed, and then (the taps being open) suction must be made at the open end of the tube coming from the bottle. Liquid is thus drawn up the flexible tube arching over the edge of the reservoir, and sufficient must then be allowed to flow to completely fill the whole system and displace all air from it,—the branch tubes to the ends of the glasses, and the bottle to the opening of its delivery tube.

All the taps being then closed, all is ready to make connection with the canulæ in the manner already described. To make perfectly sure that there is no air, it is best, at the moment as each glass tube is inserted into the india-rubber on the canula, slightly to turn the tap leading from the reservoir, so that the glass is full to overflowing.

When connection is thus made, there is, except at the four taps, no break in the continuity of fluid throughout the tubes, bottle, reservoir, canulæ, and pleural cavity.

The two taps leading downwards are now opened, and as much fluid as will is allowed to drain out of the chest. When the flow ceases these two taps are closed and the quantity discharged is noted. The two taps leading from the reservoir are then opened and the irrigating fluid allowed to flow in. I have not held it prudent usually to admit more than about two-thirds of the volume of that which has been discharged.

This alternate change of outward and inward current must be continued until it be judged that the pus is washed out as completely as possible. The observation of the appearance and the specific gravity of the discharged fluid gives the means of judging when enough has been done.

Care must be taken that the level of the liquid in the reservoir never falls below the end of the flexible tube. Supposing that a continuous irrigating current is passed through the pleura, in at one canula and out at the other, it would be inconvenient that it should be necessary constantly to watch and refill this reservoir, and a much wider one must therefore be added. But in order to be able at any time readily to observe the rate of influx, it is well to retain the small reservoir and to connect it with the larger one by means of a syphon of flexible tubing; then, if the connection at any time be interrupted by pinching this syphon, the rate of downward flow is easily seen.

For such a continuous irrigation it is sufficient that the surface of the fluid in the reservoir be at a level eight or ten inches above that of the canulæ.

To estimate the quantity of pus which is removed, it is not enough to know the total quantity of fluid which has been delivered at the receiver and the quantity which has been transmitted from the reservoir, since the difference between these two gives the volume of pus less the volume of fluid which is ultimately left in the pleural cavity; observation must also be made of the specific gravity of the solution used, of that of the discharged mixture, and also of that of an unmixed specimen of pus.

It is clear from the method employed this last cannot with certainty be obtained; but since the fluid from the chest enters the bottle at the bottom, it displaces the lighter fluid above it without much mixing, so that if the bottle contains, say two ounces, and after the passage of some three ounces there be the flow of a further volume sufficient for a determination of specific gravity, this must be, without much error, that of unmixed pus.

A pretty accurate estimate of the proportion of pus in the mixture may also be obtained by allowing it, or some of it, to settle in a cylindrical glass jar, provided the diameter of this be not less than about two inches. When the total quantity of pus is known, the quantity of fluid left in the pleura is also known.

It may be noted that in the figure the taps are shown as they would be while a continuous stream is being transmitted. If the two which are shown open were closed and the two shown closed were open, the direction of the current within the pleura would be reversed.