FOREWORD

Persistent cavities (Resthoehle) in the chest have taxed the skill of surgeons since the early days of chest surgery. It is unusual for any one surgeon to have an extended series of these cases. Bernhard has reported here the results obtained by using HELLER's Lattice Plastic operation. 100 of the cases followed empyema and 24 of them followed hemothorax. They include cases of fairly recent origin and older cases, even one of 25 years duration.

It is unfortunate that all the original illustrations could not be reproduced. However, the loss of X-ray films by fire and water damage, hasty removals and temporary storage incident to developments during the war are completely understandable.

The experience recorded in these two articles has been enlarged since they were written with equally successful results.

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THE RESIDUAL CAVITY OF THE HEMOTHORAX

by
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With 4 Illustrations

Translation prepared by:

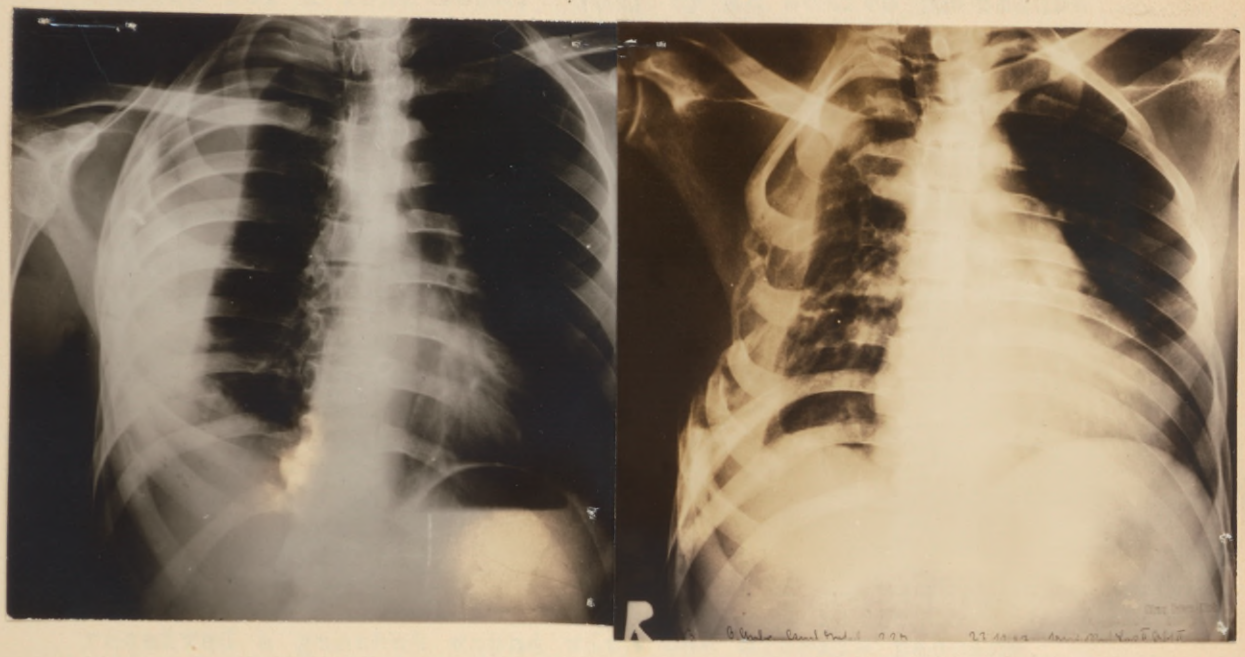
U. S. Naval Technical Unit, Europe, (Medical Section)
Office of Naval Adviser
Office of Military Government (U. S.)

T18 July 1948

During the first World War, special interest was paid to penetrating gunshot wounds of the chest. Based on the fundamental works of SAUERBRUCH concerning thoracic surgery, considerable improvement in the treatment of this serious injury was obtained, and general instructions for the treatment were established which are still correct. This is also the case with the hemothorax which is rather regularly associated therewith in various degrees. Concerning this clinical picture, in the first years of the World War I, the necessity of removing each accumulation of blood in the thorax by repeated punctures in order to avoid serious complications, even when it did not cause any immediate threat to life by displacement phenomina, was observed too infrequently. The earlier apprehension concerning this treatment proved to be unfounded. Hitherto, the treatment of the hemothorax was improperly considered to be concluded with the relief of the immediate danger and no longer to be the subject of medical treatment or surgical action. As a consequence the possible formation of thick callus in the pleural space has been observed. During World War I, it was established by MORITZ, when he summarized numerous gunshot wounds of the chest, that the final result of the hemorrhage into the pleural cavity were unsatisfactory, and that scars and wheals could be the cause of considerable and manifold pains with a great number of soldiers. By careful examination he came to the astonishing conclusion that pleuraempyemas show a better prognosis after the surgical drainage of the pus than the non-treated and non-infected hemothoraces. With this statement one was content. An explanation of this contradictory circumstance did not occur. Therefore, the way could not be found by which better results could be obtained with the hemothorax.

From my exoeriences, the cause of the unsatisfactory results is to be seen with the subsequent conditions of numerous penetrating injuries of the chest in a hitherto unobserved clinical picture, the causes of which have been known for a long time. With more than 20 wounded soldiers I was able to prove by X-rays as well as by operative findings, that in spite of previous repeated puncture, astonishingly large cavities are often hidden in the so called "callosities" following an effusion of blood into the thoracic cavity. (Ill. 1).

This residual cavity following a hemothorax is almost regularly filled with thick clumps of old remnants of fibrin. It contains only a little brownish liquid and consequently escapes diagnosis by the simple test puncture. The wall consists of wheals of several centimeters of thickness, and is covered with old and decaying layers of fibrin. Theclinical picture can be considered as a result of the pleuritis which occurs after hemorrhages into the pleural cavity. On account of the chronic processes of inflammation and the phenomena of disintegration (decay) in the old fibrin clumps, toxic albuminous substances enter the circulatory system and cause noticeable abnormal variations which continue for a long time. They cannot be



a b

Illustration 1

Big, coatlike callus, one year after injury through shell splinter, with additional hemothorax. A big hemothorax residual cavity has been found and closed by thoracoplasty.

a) Condition before the plastic.

b) X-ray after plastic gives an imagination of the extension of the cavity.

removed by medical hospital treatment even this extended for a long time. Only by an active procedure or surgical treatment was success achieved in saving such soldiers from a chronic disability and to obtain either a healing or a complete fitness for military service.

I therefore consider it my duty to call attention to this aspect of disease and to point out its symptoms. For this purpose I will not give a detailed reproduction of the numerous hospital reports since the observations correspond to each other with a certain monotony. I consider it most impressive to describe only the first observation with which I found, by chance a great cavity in the pleura after an earlier hemothorax, in order to give in connection therewith a survey of my clinical experiences with the residual cavity of the hemothorax.

The 23 year old soldier had been wounded by a small arms projectile on September 21, 1942, and received a gunshot wound with the missile passing through the right lung. A hemothorax developed which was aspirated several times. At first there were great quantities of a sanguinous fluid. The punctures undertaken later on were negative. On January 15, 1943 he was received in a specail hospital for patients suffering from injuries of the lungs. Contrary to similary wounded men, he did not recover in spite of the same treatment. His general condition left much to be desired. His appetite was moderate. He always felt faint and physically weak. He was not even able to tolerate light physical exertions. In addition to a shift to the left, the blood cell count showed a slight anemia. The sedimentation rate was always slightly accelerated. The right half of the thorax showed a distinct shrinking, and the intercostal spaces showed considerable limitation. Clinically and radiographically an extensive thickening of the pleura was found. Repeated punctures again showed negative results. However, based on my other experiences with sequelae of gunshot wounds in the lungs, I supposed a focal inflammation in the thickened pleura was to be considered the source of infection. The general condition was similar to that of focal infection. With regard to this I recommend a diagnostic thoracotomy which the attending physician agreed to since he was not successful with medical treatment, and the patient also consented because of feeling sick without any recognizable cause and wishing to get rid of it all.

On August 9, 1943, I operated above the middle of the thickened pleura under local anaesthesia performing an extended subperiosteal resection of the right sixth rib. The exposed periosteum and the considerably thickened pleura, lying below it, was split along the course of the rib. After separating a callus of more than 3 centimeter thickness I opened into a cavity which circumscribed nearly the entire right half of the pleural cavity. It contained air and only a small quantity of a turbid, slightly bloody fluid in which a non hemolyzing

accumulation cocci could be demonstrated bacteriologically. Besides there were decaying, bad smelling clots of fibrin larger than a fist. Residuals of the earlier hemorrhage were indicated by their yellowish color as well as the pleural callus. The wall of the cavity was covered by similar, not very adherent layers which were curretted away. After the cleaning of the cavity, it was closed according to the principle of the lattice plastic operation by HELLER. (The lattice plastic is a method of thoracoplasty which was described by HELLER in 1934.) Therewith in the thorax above the cavity, which must be closed, the ribs are subperiosteally excised and then the periosteum is split in the middle along the course of the ribs and likewise the thickening of the pleura lying underneath the ribs. By this way the intercostal nerves and vessels remain intact. Strong ligaments of soft parts develop from the intercostal muscular apparatus and the thickening of the pleura. They can be made movable and when the technique is correct, they hang down slackly so that astonishingly large and deep cavities can easily be eliminated. I applied this method in nearly 150 cases of empyema residual cavities and was successful in closing each cavity by this excellent operation, no matter how difficult the situation of the cavity may have been. The lattice plastic operation required an extended subperiosteal resection of the second to ninth rib. The postoperative course was smooth, and 4 weeks later the discharge to the special hospital for after treatment of the gunshot wounds of the lungs could take place for convalescence.

The result of the operation was astonishing. After removing the residual cavity of the hemothorax with its decomposing mass of albuminous matter, all the phenomena of disease, previously present, disappeared. The appetite returned and caused a considerable increase of weight which previously had not been obtained in spite of all efforts. The general weakness and fatigue disappeared. The wounded man again felt like a healthy man. The functional capability improved. The blood picture and the sedimentation rate returned to normal. The impairment of the respiration which was caused by the elimination of the entire right lobe of the lung, naturally could not be avoided. The general condition progressed so satisfactorily that, after a short time of convalescence, the patient could be released from the hospital whereas before the operation the disease could not be influenced by any means, not even by excellent medical management for a period of 7 months.

The course of this observation described in detail gave a very imporessive idea of the clinical importance of the residaul cavity of the hemothorax. After this description, the most important viewpoints brought along with the aspect of disease and the questions started by it can be discussed more easily and understood with a further 23 cases on the basis of this experience.

First of all we have to consider the cause. Without doubt this is to be seen in the so called post-hemorrhagic pleuritis. The residual cavity of the hemothorax represents an aftermath of this condition. This explanation is not sufficient in regard to the evaluation of this aspect of the disease. On the contrary we must consider in detail the question - why the presence of blood in the pleural space causes a serous exudate of the pleura which sometimes requires frequent aspiration and discharges considerable quantities of fluid after what primarily was not too severe a hemothorax.

Concerning this there exist two different conseptions. MORITZ considers the cause for the post-hemorrhagic pleuritis to be a simultaneously occuring infection. SAUERBRUCH doubts the correctness of this opinion with the justified objection that the hemorrhage generally is found to be sterile. His opinion is that the entire process is based on an aseptic inflammation and formation of exudate. With this interpretation the question is left undecided as to why with some people only the pleura is susceptible to the irritation of the extravasation and causes an abundant exudation of fibirn and a marked pleural thickening.

A short consideration of this problem is not to be avoided since the cause of the posthemorrhagic pleuritis is of decisive importance for the treatment of the residual cavity of the hemothorax. From the last World War there are some investigations on the behaviour of the hemorrhage with penetrating gunshot wounds in the chest (REHN, COBET, TORNISSEN, GERHARDT and others). According to experiments on animals, an accumulation of blood in the pleural space should not leave behind any sequelae. With horses, TROUSSEAU has brought into the pleural space great quantities of blood, This was absorbed with astonishing speed and completely without consequences. MORITZ, repeated these experiments with dogs and found the same result. From these observations and his clinical experiences he concluded that hemothorax in man was a harmless matter which did not lead to a posthemorrhagic pleuritis if it is truely sterile. He points out to the numerous hemorrhages which were so frequent during the war with wounded soldiers and which were rapdily absorbed without leaving behind bad sequelae, as there are thickenings and callus. Now this would be the normal course with a sterile hemothorax. The frequently negative bacteriological examination in the hemorrhages which are not absorbed represents an important objection. MORITZ opposes the same with the following evidence: The question concerns attenuated agents or the consequences of their toxins. The presence of highly virulent germs on the contrary should lead to a pleural empyema.

Our own observations contain several viewpoints which are important in reply to this formulation of the question. First of all, the result of the <u>bacteriological investigations</u> is interesting. With the large number of the patients who had passed through many hands, the ab-

sence of a systematic bacteriological examination is not surprising. Consequently, a tabular summary cannot be given. Therefore, I wish to restrict this discussion to a short summary of the results. From the 24 residual cavities of hemothorax which I have seen until now, I have operated 18. Before the operation a search for pus forming germs took place only in the fluids obtained by puncturing 7 wounded men. With more than half of them (4), staphylococci and streptococci were, sometimes repeatedly, demonstrated. With the thoracoplasties we searched for bacteria in the fluid of most of the cases. Among 14 specimen, bacteria were found in 7 cases, which had been established with some wounded men even before the operation. Success was achieved in healing six further residual cavities of the hemothorax without operation, but only by the negative pressure treatment. In all these cases the search for pus forming bacteria was negative though it was repeated several times. For this there are two possible explanations. Since this aspect of disease could be healed without operation, the disease was probably less severe than with the cases treated by a thoracoplasty. Furthermore, the possibility must be considered that during the existence of the residual cavity of the hemothorax for months and years the germs have been destroyed. In this sense the negative bacteriological findings in fluid obtained by aspiration from wounded men can be explained in whom at an earlier date, when the hemothorax was not so old, bacteria might have been found. Admittedly, these findings do not permit a definite conclusion on the cause of the hemorrhagic pleuritis, but on the other hand, there is no doubt, after these bacteriological results, that the infection has a decisive influence on the development of the residual cavity of the hemothorax following a penetrating gunshot wound in the chest.

Further important observations can be cited to support this interpretation. With the microscopic examination of the fluid obtained by puncture. The presence of many leucocytes was astonishing. With some residual cavities there were even fluid transitions to the pleural empyema. As to the surgical findings, three wounded men showed a closed empyema residual cavity, when the clinical course and the development of a hemothorax existing for many months would not have suggested placing them in the group having a residual cavity of the hemothorax. Also the thick clumps which were regularly found in these cavities at the thoracoplasty, are worth mentioning for they showed rather the same structure as those of the same sort which can be found after a short time with every infected pleural empyema.

Finally the symptoms of disease, which are to be described in detail, have to be taken into consideration. They can be explained in the most convincing manner by the presence of a bacterial infection. Their disappearance after removing the focus of the disease is to be considered as a direct proof. All these view points, however, suggest making the penetration of germs responsible for the development of the residual cavity of

the hemothorax with a probability that is nearly certain. How far this consequence can be applied to the posthemorrhagic pleuritis, can be passed over here. On the other hand, from this knowledge and the principles of general surgery the postulate can be formulated indicating the surgical treatment of each residual cavity of the hemothorax as soon as it causes pains and its healing cannot be obtained by other methods, in order to remove the focus of inflammation and its sequelae from the body.

A reproduction in detail of our pathologico-anatomical findings is not necessary. But some short remarks for the better understanding of the whole explanation cannot be avoided. Similar to residual cavities follwoing empyema, the cavity after a preceding hemothorax can occupy an entire half of the thorax or only a part of the same. The first form occurs rarely. The second appears nearly always in the posterior lower part of the pleural cavity and has the shape of a cloak. Therefore, it is most practical to distinguish between a partial and a total residual cavity of the hemothorax. The wall of the hollow space is formed by a thick callus which may be as thick as 5 centimeters. Usually it has a gray-white color, but sometimes it has a brownish-yellow tinge, and can contain residuals of the preceeding absorption of blood. The callus shows concentric layers. On their inside there are often layers like the layers of an onion. The content chiefly consists of air and gelatinous, fibrinous clumps of fibrin. There cause a comprehensible astonishment. Sometimes they are on the point of decomposition and have a corresponding color. Small quantities of fluid may be present which can easily be overlooked during the puncture. Usually it has a brownish, sometimes a chocolate colored appearance.

The histological structure depends somewhat on the age of the callus. Sometimes the pleural thickening is composed of hyalinizing connective tissue, rich in vessels, with fibrinous layers. On the other hand, it can also be permeated by chronic inflamatory infiltrations and may contain cells containing hemosidering. Occasionally the wall next to the cavity is covered by granulation tissue or is infiltreated by "pus corpuscles" so that it could be considered as the wall of an empyema residual cavity. The microscopic findings therefore point to a bacterial origin of the hemothorax cavity.

The greatest interest is claimed by the clinical course. When reviewing the hospital reports, it was striking that most of the soldiers must have given the impression of a more severe illness than is usually the case with a hemothorax. Yet more important, however, is the consequent behaviour. Generally the wounded men recover well from the consequences of a penetrating gunshot wound in the chest with subsequent hemothorax after some punctures. The thickening which remains at first, has the tendency to involution so that later on the pleura again becomes soft and pliable. This course is missed with soldiers who have a residual cavity of a hemothorax. Also under the most favorable conditions and

with the best care the convalescence takes place rather slowly or is even unsuccessful.

The clinical picture is marked by the chronic intoxication from the focus of inflammation in the thorax. The thick indurated wall hinders a quick absorption and represents a mighty barrier against the bacteria, their toxins, and the decomposition products of the protein. This view point is important for the understanding of some peculiarities. For a great part it is to be made responsible for the relatively vague general symptoms. The patients complain of faintness, weariness and feebleness. Particularly younger wounded men are most impressed by their decreased physical efficiency as well as by the weakness occurring after a short walk. Most of them suffer from anorexia. The pains caused by local changes are few. The shortness of breath seems to be considerably greater than after the usual penetrating gunshot wound in the chest. Its disappearance or its improvement after the successful treatment of the residual cavity removes every doubt of the causal connection.

The examination also offers so few obvious findings that overlooking the cavity is very well understood. The involved side always lags noticeably. The shrinkage of the same is the most pronounced sign and is best recognized by a comparison with the sound side. The extremely narrowed intercostal spaces and the ribs tightly pressed together signify the seriousness of the intra-thoracic shrinkage process. I was nearly always able to explain the fundamental complaints from the simple consideration with regard to the course.

For the exact <u>diagnosis,</u> a greater number of auxiliary means are available. Part of them belong properly to the clinical course. Diagnosis is discussed, however, in this section in order to avoid repetitions. The main point for the recognition seems to be that one is thinking of the presence of a residual cavity of the hemothorax with the pains after a penetrating gunshot wound in the chest. It is suitable for the systematic discussion to separate the general and the local symptoms. The first one has partly been mentioned with the discussion of the clinical picture. However, the behaviour of the body temperature has to be pointed out. When examining the temperature curves it is striking that the temperature is often at the upper limit of the norm and sometimes may show transient considerable increases.

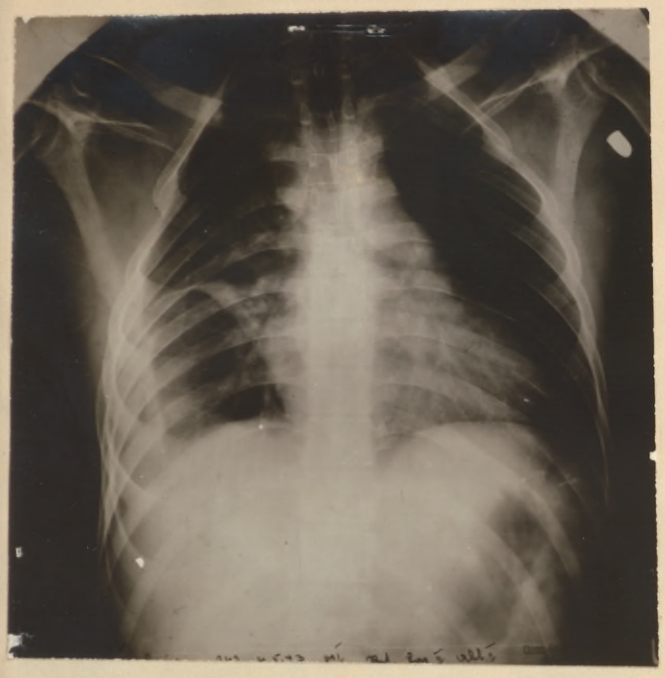
Since the abnormal changes are caused by inflammatory processes, the behaviour of the blood picture has to be taken in consideration. The number of the white blood corpuscles is generally normal. With a repeated examination, however, slightly increased values are found. Occasionally transitory pronounced leukocytosis appears. The sedimentation rate is not reliable. Even with transitions to the pleura empyema, the acceleration of the sedimentation rate is occasionally absent. Such a discrepancy can easily be the source of a faulty inter-

pretation. Generally, however, a slightly increased acceleration of sedimentation rate can be observed. As with the white cell blood count a frequent repetition of the test is highly recommended here also. The occasional slight anemia is not useful since it is not only a consequence of the chronic intoxication, but is a frequent finding in the first months after gunshot wounds in the lung.

Even when all points of view indicate the presence of a residual cavity of the hemothorax, one has to endeavour to explain the diagnosis absolutely. The physical examination leads regularly to the assumption of a callus formation. This is confirmed by the result of the survey X-ray of the lung. Still greater errors occur when a large cavity contains much air and has no particularly thick wall. Only the presence of a sufficient quantity of liquid makes possible an accurate interpretation of the circumstances, but this often does not occur. Consequently the clinical and the X-ray examination scarcely surpass the easy diagnosis based on thickened pleura formed after hemothorax.

Also the test puncture fails in consequence of the peculiar aspects of disease. Its negative result is for the most part responsible for the overlooking of the residual cavity following hemothorax. By the observation of certain directions, however, success is achieved in reforming this method of examination to the most infallible diagnostic auxiliary means. According to our experiences the proceeding is simple and without danger. By means of a not too thin puncturing needle one pierces the region of the greatest thickening and also at the favorite location of the residual cavity following hemothorax. If there is a hollow space below the callus , it can easily be recognized. For, after overcoming the resistance in the thickening, the needle at once can be moved relatively easily. There one has the feeling of having reached an empty space. Now is the piston of the syringe can easily be moved (to and fro) without the aspiration of fresh or old blood, first of all some sterile sodium chloride solution is cautiously injected. If this is very easy and can be followed with a larger quantity and without the occurrence of any phenomena of irritation, the presence of a relatively large hollow space can be assumed, and the experiment of a contrast demonstration may be undertaken. Greatest conscientiousness naturally is supposed. In proceeding so we have easily fixed the size of the residual cavity of the hemothorax on the X-ray picture.

Of course it must not be concealed that this reliable and unobjectionable method leads us once into error. Probably the unusually numerous and thick fibrin coagula led to an obstruction of the puncturing needle. Since numerous phenomena of disease were present and all the other evidence indicated the presence of a residual cavity following hemothorax, I believed the undertaking of a thoracotomy to be in order. After the subperiosteal resection of a rib, I split the posterior



a

General radiography with callus.

Illustration # 2b could not be reproduced with the facilities available.

b

Contrast filling of the cavity, front view.

Illustration 2 a,b,c,d,e,f,

Apparently unimportant formation of callus 1 year after a machine pistol shot with subsequent hemothorax. The contrast medium proves the presence of a large residual cavity which was closed very successfully by an operation.

Ill. 2 c

Side-view picture of the cavity filled with the contrast medium.

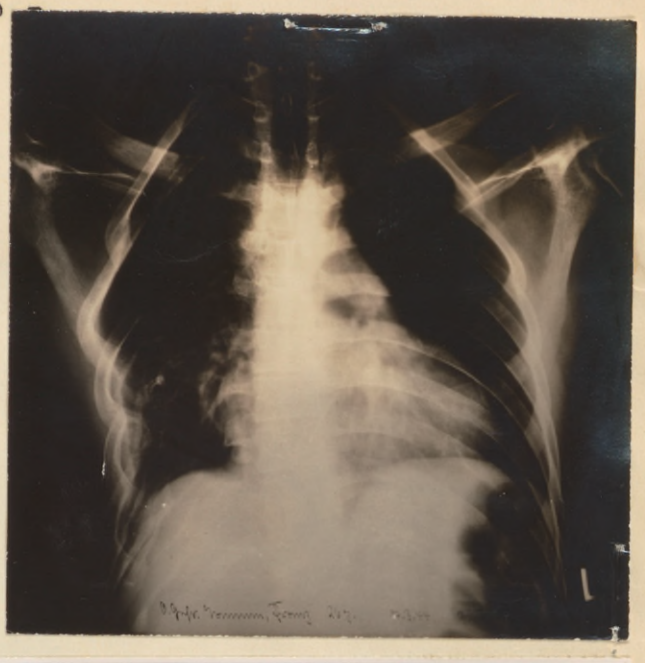


Illustration 2_d

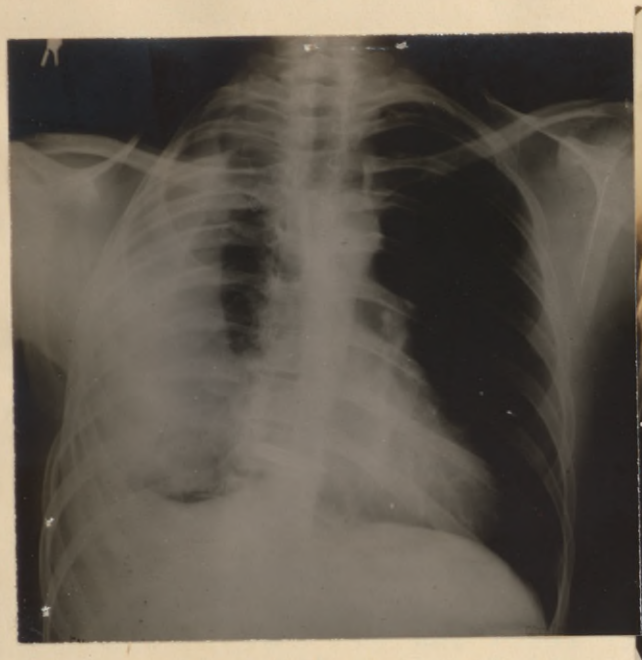
General X-ray view after thoracoplasty.

e

Picture of the thorax after the operation, front view.

f

Side-view of the same.



a

General radiography of the lungs.

b

Picture of the cavity after the injection of the contrast agent.

Illustration 3

Extensive formation of callus after a small arm gunshot passing through the left half of the chest with hemothorax residual cavity which can be proved by the injection of a contrast medium and can be removed by thoracoplasty.

Illustration 4

Radiography of a hemothorax residual cavity within a so-called callus after a gunshot wound with the missile in the chest. The light areas in the shadow are caused by fibrin clumps.

ribperiosteum in its longitudinal direction and subsecuently I cautiously opened the thick pleural callus. I reached into a typical residual cavity in which many old fibrinous clumps were found. With a cautious proceeding there is no danger of a pleural opening or of other complications. With doubtful but suggestive clinical pictures, therefore, and considering the experience with the exploratory laparotomy in the case of vague abdominal diseases, the indication for a diagnostic thoracotomy should be justified since not only the return of the fitness for military service, but also the health is endangered when the residual cavity following hemothorax is not removed.

Thus we have to come to the treatment. It would be of some importance to know what the chances are of a spontaneous healing of such cavities. WEINER who, on the basis of postmortem appearances, saw the clinical picture for the first time in the year 1915 and believed it worth a description on account of its peculiarity doubted this possibility with a cavity the size only of a man's fist and existing for nine months on the basis of his macroscopic and microscopic observations. I myself would not deny it entirely. If, however, an inflammatory focus is present in the cavity which causes general phenomena of disease, I consider it must be closed in order to regain the health and also the fitness for military service. Naturally this should be obtained preferably by the redevelopment of the lungs. Unfortunately this proceeding is limited by the often very thick pleural callus and frequently also by the presence of an infection. Consequently the thoracoplasty cannot be avoided in the case when careful exercise continued for a long period has failed. For this purpose the lattice plastic operation of HELLER is most suitable. Since this method does not show an alarming death-rate (among nearly 100 empyema residual cavities which are to be considered as more severe, I lost only 3 soldiers by brain abscess) and does not leave any significant cosmetic deformity, contrary to the well-known plastic operation of SCHEDE too great a reserve towards the surgical action is not justified.

In spite of all a careful indication is suitable. The course of the first nine residual cavities of the hemothorax which I operated according to the method of HELLER were easy and smooth. After a few weeks they could be released. After the tenth and eleventh thoracoplasty, however, in spite of having dusted sufficient Marfanil-Prontalbin powder into the wound area, suppurations, which lasted for many weeks, appeared which transitorily endangered the general state of the elder of the two wounded men in a most severe manner. Both cases finally healed. The sorrow which they had caused, was, however, the reason to study again the possibility of a less dangerous treatment. Therefore I undertook the experiment to reduce or to close the residual cavity, by introducing a drainage tube and joining the same to the airpump operated by a jet of water. Favored by the old fibrin clumps and the residuals of the hemorrhage, a serious mixed infection occurred. As it was feared already, an empyema residual cavity developed that had to be removed finally, after a long and dangerous illness, by a thoracoplasty. Thus valuable time had been lost

and the wounded soldier had been brought into additional danger.

Except for the suction drainage, the use of which is obvious at the present state of thorax surgery, I do not believe that it is right to report on all our tentative attempts. Perhaps it is most suitable to describe the proceeding which proved best in our case. With each residual cavity of the hemothorax we ascertain at first its capacity by means of the above described puncturing technique injectioning a physiologic saline solution. The liquid which is withdrawn is bacteriologically examined. The extent of the cavity should be established radiographically in the beginning of the treatment after the injection of a contrast medium. After the rinsing of the intrathoracic cavity, we produce there a lower pressure of such a degree that the patient complains of a disagreeable drawing or a feeling of pressure in the chest. Occasionally we made a trial of leaving negative pressure in the cavity, even up to 35 millimeters hemoglobin. After a week the same process has to be repeated, since in this period the lower pressure has declined to 5 millimeters hemoglobin on an average. By new determinations of the capacity or if necessary by an X-ray control, one can ascertain at any time the result of this treatment.

With some patients we combined the negative pressure procedure with the injection of Fregl-Pepsin solution. According to the good recommendations on this agent given to several persons by PAYR, we expected firstly that it should dissolve the thick fibrin clumps as well as the other residuals of the former hemorrhage, and secondly a modification of the thick pleural callus and therewith better conditions for the expansion of the lung. Unfortunately, we did not observe convincing results, as the subsequent operations revealed.

The most promising of all conservative methods is without doubt the negative pressure treatment. Until now it has been used with 9 wounded men with a residual cavity following a hemothorax. With 5 patients success was achieved by means of this treatment in obtaining their health and fitness for military service. The other 4 of these patients had to undergo a thoracoplasty operation. With one of them the cavity had diminished so that the operation could be made less extensive while the reduction with the other ones must be considered as dubious.

With the patients, treated without success, it was a waste of time. On the other hand, the conservatively healed cases required 16 punctures on an average and a stay in the hospital for 5 months. The results with the wounded soldiers, with which the residual cavity following hemothorax was removed by means of a thoracoplasty, are very satisfactory compared with these figures. If no special incident happened, they left the hospital even within 3 to 4 weeks. When comparing the results one must consider that even with a careful control no security is given concerning the cavities which

remain after the negative pressure treatment and which are associated with the danger of a later comlication, while by means of the thoracoplasty the focus of disease is radically removed. Therefore, unless showing improvement the negative pressure treatment should not be continued for too long a period, and the cases which are suitable for the conservative method should be selected carefully. Conclusive directions cannot be given considering the small number of our patients. According to our observations the negative pressure treatment fails with cavities of more than 100 cubic centimeters capacity and above all with these shown to contain bacteria. With these latter cases it is more advantageous to carry out the thoracoplasty immediately and to abstain from the puncture treatment.

It is unnecessary to describe our results in detail. With all 24 wounded men the phenomena of disease disappeared after the operative or conservative treatment. After recovering from the operation they were transferred into a special hospital for patients with gunshot wounds with the missile remaining in the lungs for the purpose of their after treatment. Healing was obtained with all cases and there is the foundation for the belief that a great number regained their complete fitness for military service who without an energetic action would have fallen into a severe chronic dehabilitation. In spite of this pleasant result it is necessary to inquire if there was no possibility to avoid the development of a residual cavity of the hemothorax in the beginning by adequate prophylaxis. Late criticism is always an unpleasant matter. But since it shows a way how to prevent injuries, the impression which I gained when looking through the hospital reports, might be of some value for the wounded men. The report can be summarized as follows. First, with the penetrating gunshot wounds in the chest the removal of the accumulation of blood in the thorax had not been done in good time and secondly that the punctures had not been repeated frequently enough. The cause of this failure is to be seen in the fact that the occurrence of a posthemorrhagic pleuritis after an accumulation of blood in the pleural space is not sufficiently known or not at all known. Clear consequences resulted from the formation of exudates connected therewith. This process is of an extremely unfavorable effect when during the removal of the hemorrhage, whether by carelessness or consciously by false suppositions, air enters. The same is not absorbed by the inflamed pleura or at least is only slowly absorbed and can contribute to the development of the residual cavity following hemothorax in the same way as HELLER and GRAF have shown for the development of the empyema residual cavity.

Without doubt the residual cavity following hemothorax is an aspect of disease which belongs particularly to war surgery and is entirely unknown. In single cases I had seen it, however, after puncture wounds and rib fractures after secondary hemothorax. It can

be assumed that some wounded men after an unsuccessful treatment on account of a formation of callus are released after a penetrating gunshot wound into the chest, behind which such an old cavity is hidden. This complication could have therefore a certain importance for the medicine of treatment; SAUERBRUCH and JAHN already have called attention to this after the last World War that also the clinically noninfectious hemothorax may cause pains which last for many years. The assumption is not to be rejected that the hemothorax residual cavity with its serious shrinkage phenomena is to be taken into consideration as the cause of the considerable distortions and dislocations of the heart and of the mediastinum as well as for the numerous pains after gunshot wounds in the chest. Therefore I hope that my statements concerning the occurrence, the knowledge, and the treatment of this aspect of disease may contribute to protect many wounded men from the dangers of this complication.

SUMMARY

With the hemothorax after penetrating injuries of the chest, in spite of frequent punctures there remain occasionally large closed residual cavities in the thorax which appear in the X-ray picture only as a callus or are thus interpreted. By the absorption of the products of disintegration of protein many phenomena of disease arise. They disappear, however, after the operation of the hemothorax residual cavity. These cavities can be partial or total in size. It depends on the posthemorrhagic pleuritis. The infection has a decisive influence on the development. The diagnosis can be ascertained by the radiographic demonstration of the hollow space. The aspect of disease itself is caused by a chronic intoxication and can easily be recognized with some experience. Smaller hollow spaces can be cured by negative pressure treatment while larger ones require a large thoracoplasty in order to avoid more severe injuries. The experiences made with 24 patients concerning the aspect of disease of the hitherto still unknwon hemothorax residual cavity are given. The same occurs chiefly after penetrating gunshot wounds in the chest and occasionally after stab wounds and fractured ribs.

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Director: Prof. Dr. B E R N H A R D

EXPERIENCES WITH HELLER's LATTICE PLASTIC IN 100 EMPYEMA RESIDUAL CAVITIES, TREATED OPERATIVELY.

By

Prof. Dr. Fr. BERNHARD

with 20 Illustrations

Translation prepared by:

U. S. Naval Technical Unit, Europe, (Medical Section)
Office of Naval Advisor
Office of Military Government (U. S.)

Operative methods for closing the residual cavity.

In the last few decades the closure of the empyema residual cavity has kept surgery busy. Generally acknowledged no method, which was reliable and not risky has as yet been found. From time to time new proposals were made to improve the usual methods of treatment. They also prove that in this field we have to deal with a surgical problem not yet solved in a satisfactory way.

On principle we have three possibilities at our disposal. The first method of treatment consists in opening the rigid armor surrounding the shrunken lung in cases of a chronic pleural empyema. Certainly the best physiological method is the peeling off of the serous coat of the lungs according to FOWLER and DELERME with the aim to enable this organ to expand again. But this involves considerable danger and has not been used by us consistently because of other disadvantages.

The second possibility gives up a reexpanding of the lungsand makes the cavity disappear by bringing the mobilized thorax wall to the surface of the lungs after ribs, and if necessary, the hard layers of the pleura have been removed. As early as 1878, SCHEDE for the first time removed not only the ribs, but also the solid parts between the ribs, so that only a flap of skin or skin muscle and scapula remained. SCHEDE's plastic operation allows the obliteration of all empyema residual cavities with the greatest, but not as was first believed, absolute safety. Failures occur with cavities which are situated most unfavorably within the cupola pleurae and the costovertebral angle, as well as in the posterior mediastinal area, so that afterwards it must be filled up with a "living tampoon". The most important thing is the experience that SCHEDE's plastic operation considerably endangers such patients as have suffered severe injuries owing to the long duration of their complaint and to the chronic secretion of pus and that it often ends fatally, even if they were performed in several stages. If patients survive this grave operation, a considerable mutilation of the thorax and on account of the removal of the intercostal nerves a paralysis of the abdominal wall remains. The numerous proposals for improvement could not quite remove these and other disadvantages of the thoraco-plastics of the empyemal residual cavity.

The third possibility consists in peeling off the serous coat of the lungs combined with plastic compression of the thorax. This procedure succeeds sometimes but not always, and therefore cannot be recommended routinely.

In 1934, HELLER described a new procedure for the removal of the empyema residual cavity. This method doubtless belongs to the second group. It avoids the disadvantages of SCHEDE's plastics and has numerous advantages. I have used it in nearly 150 empyema residual cavities, and in each case could close the cavity, even in the cupola pleurae and the posterior mediastinal space. Of my first

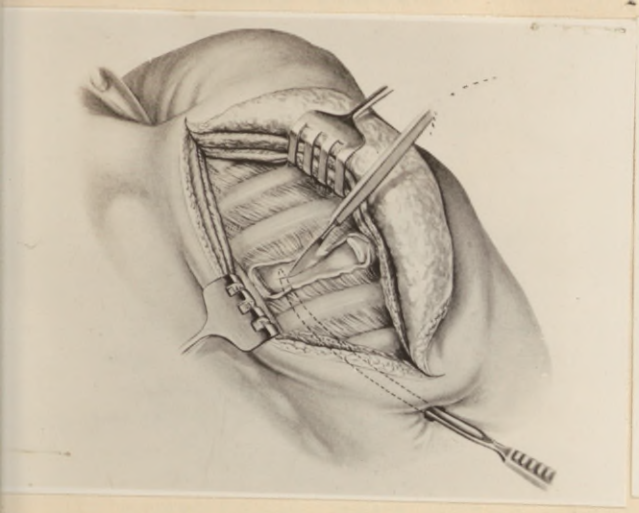
hundred cases, I lost only 3 patients after the operation, but even this small number, as we shall see, was not due to the operation itself. The progress resulting from HELLER's method compared to SCHEDE's plastics is so great that I feel obliged to describe my experiences of the first hundred cases of empyema residual cavities that I personally operated according to HELLER. Above all, every surgeon who knows this method of treatment and performs it with exactitude is enabled to close every residual cavity, how ever complicated it may be, and if he has only small xperience in this field he is not puzzled anymore by the numerous modifications of thoraco-plastics, as to which method of treatment to choose according to the directions given in the manuals of surgery.

HELLER named his method of treatment "Lattice plastics". It was illustrated excellently by KLEINSCHMIDT in KIRSCHNERS "Science of Surgery" (Ill. 1). So I describe this method in so far as it is absolutely necessary in order to understand the follwoing explanations.

Above the lower section of the residual cavity one rib is resected subperiosteally. Then follows the splitting open of the pleura callus in the middle section of the exposed periosteum in the line of the removed rib. By palpating or probing, the size and extent of the cavity may be ascertained. Then all the other ribs above the residual cavity are subperiosteally resected step by step. The ribs should be removed anteriorly. ... , 3 centimeters beyond the edge of the cavity, while posteriorly they should be removed as far as the transverse processes, even if the cavity does not extend so far to the rear. By splitting up the pleura callus in the middle and in the line of all the removed parts of the ribs the intercostal vessels and nerves are preserved, and above all ligaments of the soft parts are created consisting of intercostal muscles, pleural callus and periosteal striae. They can early be made mobile and with correct technique they hang down so loosely that they can often fill up extremely deep cavities. Placing some tampons, drainage tubes and approximation sutures complete the operation.

So far only SALZER and SARAFOFF have reported about the advantages of this modern method. But during the war, as I often learned, it was used far more frequently than the scant reports make one suppose. As early as 1935, WANGENSTEEN, too recommended the use of soft part ligaments for closing empyema residual cavities. In 1934, I too, made a thoraco-plasty on the same principle. But I did not take into consideration splitting open the rib periosteum in the middle which prevents effectively injuries to the intercostal vessels and nerves and thus irregularities in the nutrition of the soft part ligaments as well as the formation of abdominal herniae. I opened the callus along the upper border of each removed rib.

After getting to know of HELLER's far superior method, I gave up my technique, and when the war came with its numerous and extensive residual cavities I used lattice plastics exclusively in operating them. In 1943, I reported 20 cases, all successfully provided for according to HELLER. The further plastics, too, yielded such fine



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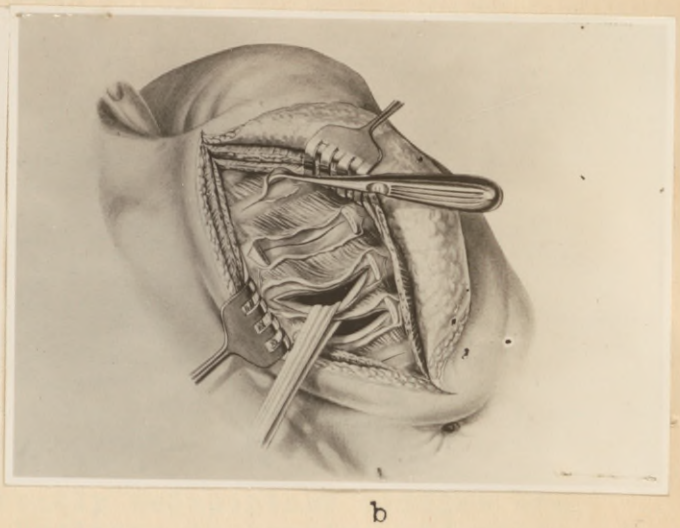

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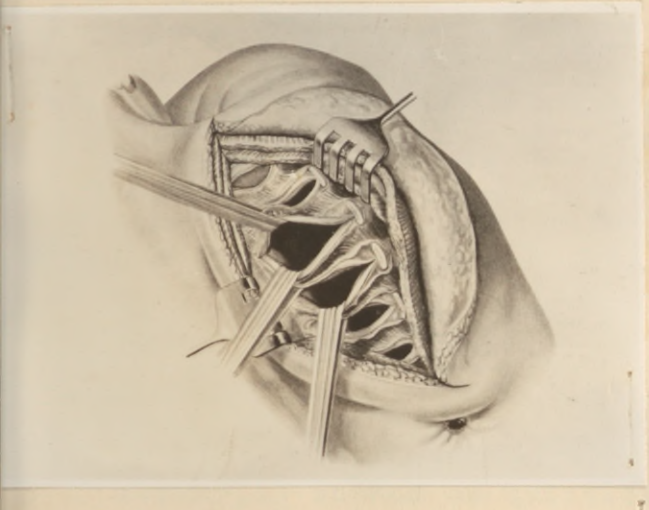

c

Illustration 1
Lattice plastics according to HELLER.

a) The skin, the trapezius and rhomboideus muscles are cut and the ribs exposed. The sixth rib is removed subperiosteally for 6-8 centimeters length. The inner periosteum is split open by the rib probe introduced into the cavity through the fistula.

b) According to the extend ascertained, the ribs above and below the one removed first are subperiosteally removed too. The intercostal muscles and the periosteum are held by bridle bandages, so that the cavity may be surveyed well.

c) The ribs 2-7 have been removed subperiosteally. The cavity is laid open so that it is easy to survey.

results that cases of r sidual cavities were sent to me from many quarters for operation.

Thus my lattice plastics numbered one hundred, even two years ago. I am going to give an account of the first hundred cases, as sufficient time has passed to allow one to judge about a lasting success..At the same time I can compare it with my experience gathered in a great number of other operations. I think the communication of my observations is the more justified as lattice plastics fulfil all the requirements for the aspect of so grave a disease as the empyema of the residual cavity: Low mortality and full certainty of success, not to speak of the other improvements on SCHEDE's classic plastic operation. It is of importance that I operated nearly all the patients myself and studied this disease thoroughly. I was of opinion that, as in many other methods of operation, very often apparently unimportant trifles are decisive, and I made it my business to examine and study all the points of view personally on which the success of lattice plastic might depend and my assistants supported me loyally in every way.

In judging our experience with HELLER's method we think it necessary to give a short survey of our patients. Only isolated cases of pleural empyema were treated in our clinic before. As far as I know, residual cavities remained only in about 5%, if some care and right comprehension were shown. All the other cases were sent for operation to our clinic from outside.

16 patients had had pneumonia before. 2 had bronchial pneumonia, whilst 82 had received injuries of the thorax by bullets, shell splinters, contusions or fractures of ribs. The operation findings yielded 71 partial and 29 complete or nearly complete residual cavities. Of the former,13 showed an unfavorable site, 3 were situated near the cupola pleurae, and the rest in the posterior costovertebral or mediastinal area. Of the 100 patients, 3 were under 10, 5 over 40 years, 53 between 20 and 30, and the rest in the second or fourth decade of life. Finally I must mention that in 8 cases unsuccessful thoracoplastics had been undertaken previously by other physicians.

CAUSES OF RESIDUAL CAVITIES

Ever since the asepct of disease of the empyema residual cavities has been known, one has been busy finding out the preliminary conditions contributing to its origin Opinions agree as to the causes, but not as to their frequency. Therefore, I give a short survey of the findings which according to the hospital records and the results of operations caused the residual cavity. I wish to add that similar percentages are to be expected in the second hundred cases.

Illustration 2a could not be reproduced with the facilities available.

Illustration 2b could not be reproduced with the facilities available.

a

Rib ring formed after resection of the rib and drainage,

b

Formation of a ring between two neighboring ribs after BULAU's drainage.

Illustration 2

Special findings in ribs in thoracoplasty.

TABLE

The Causes of an empyema Residual Cavity in 100 Cases.

1)	mistakes in drainage (occasionally only fistula with cavity behind it) a) too narrow b) too high c) too deep (compare Ill. 3) d) too far forward	27
2)	Formation of callus by puncture and rinsing continued too long	25
3)	Closed cavities	18
4)	Bronchial fistula	16
5)	Osteomyelitis of ribs	6
6)	Pockets	3
7)	Tuberculosis	2
8)	General condition of health	2
9)	Foreign bodies	1

This table shows that in 27% of our patients the empyema residual cavity was caused by errors in drainage. Especially a space too narrow for drainage prevented curing of the chronic empyema. Some patients were sent to the clinic for a fistula of the thorax secreting only little pus, but having existed for months. Close examination and X-rays showed that behind such evidence astonishingly large cavities may be hidden. We had the same experience when the elastic drainage-tube, lying in the area of resection, was so thin that pus could not sufficiently discharge itself, as urgently required, and so the residual cavity was formed.

I observed that those frequent failures in the treatment of empyema are due to the insufficient knowledge of thoracic surgery of the surgeons. Above all, they do not take into consideration the normal tendency of the place of drainage to contract which afterwards becomes rigid, or is transformed into a bony ring. (Ill. 2). When, in changing the dressing, the thick elastic drainage-tube is replaced by a thin one too early, accumulation sets in, even if small quantities of pus are secreted and the cavity remains.

Though I could always demonstrate in my clinics, how after widening the fistula or introducing a thick drainage tube the general condition of the patients improves or normal appetite comesback, I observed again and again that my own assistants had this incomprehensible inclination, therefore I ordered, if conditions allowed it, the drainage tube only to be shortened, but not to be replaced by a thin one, when the dressing was changed.

The after treatment of a pleural empyema needs special care even in apparently regular cases. Resection of ribs and use of an aspirator are not sufficient. At every inspection one should make sure that the aspirator works

a

Picture from front to back seems to represent a narrow cavity.

b

But the picture from the side shows the real extent. Note especially the long narrow fistula passing into the broad based, lower boundary of the cavity. In such a case, a resection of the rib at the base of the cavity must precede the plastics and sometimes it brings recovery. This frequent finding is often misunderstood or not properly recognized.

Illustration 3
Contrast illustration of an empyema residual cavity from two sides. Residual cavity. Long drainage canal.

Illustration 3$_c$

State after the thoracoplasty. First and second rib preserved.

well, and the negative pressure actually exists. The elastic drainage tube is frequently stopped up, often by thick clots of fibrin.. As the leitmotiv for the surgical treatment of empyema I should like to mention a sentence which C. EGGERS wrote down as the result of his great experience: "In treating an acute empyema it is not only necessary to form a well fitting opening, but also to preserve it." The surgeon who takes this advice seriously will avoid the development of residual cavities.

Surely the choice of the resection site is of importance. I prefer the deepest point of the pleura cavity and generally over the ninth and tenth rib entering somewhat back of the posterior axillary line. Though afterwards the diaphragm will raise, I avoid placing the drain too high because otherwise pus is accumulated in the costophrenic gutter (DENK). I saw several, especially basal residual cavities, no doubt caused by this mistake.

Another measure not too well known to avoid empyema residual cavities is roentgenological examination (Ill. 3). A survey photo of the lung is not sufficient to state the cure of the pleura empyema before the drainage is finally removed. To serve this purpose a filling of the fistula should be made in every case. And, to avoid errors, MERIO's method is to be recommended here. By this method one often finds, after injection of a contrast medium, in the X-ray itself, even in cases of insignigicant secretion of pus, contrary to expectation, an enlargement of the fistular canal at its end or even a small cavity in the thorax. In these circumstances the drainage must be continued to avoid great damage. In spite of removing the elastic tube, the fistula often closes. Then a closed empyema residual cavity remains which spontaneously perforates after months or years or by manifestation of disease enforces reoperation.

A number of patients acquired a chronical empyema by gross mistakes. Fither the treatment by suction and the drainage were not continued long enough or were stopped too early because diminishing secretion of pus and improving general health were considered as symptoms of recovery. There undoubtedly are empyema residual cavities where every criticism is unjustified. On the other hand I am convinced that by correct drainage combined with an appropriate after treatment numerous empyema residual cavities can be avoided.

The table shows as the next most frequent cause the formation of callus with 25% caused by puncture and rinsing continued too long. No doubt this treatment occasionally succeeds in curing an acute pleural empyema. But if there is thick pus with large clots of fibrin, we risk that they form a deposit on the pleura causing a considerable thickening of the pleura, which seriously delays or even makes impossible the complete expansion of the lung, even with strong suction. In such cases a resection of ribs and the establishment of a continuous suction drainage should not be delayed more than two

weeks, For this indication one should not rely alone upon the decrease of temperature or improved general health alone.

The percentage of failures in empyema treatment is rather great. Probably this is due to the abnormal conditions in every war. Probably many a soldier's ribs would have been resected earlier, had the setting up of suction drainage not influenced his evacuation possibilities or had not other points of view been of importance.

The third place with 18% is taken by closed empyema residual cavities. This number, too, seems to be considerably influenced by the war. Several patients had pleural empyema that at first had been treated operatively. The fistula closed spontaneously but a residual cavity remained giving rise to symptoms of disease lasting for months. Every experienced thoracic surgeon knows such cases. Wounded patients developed a hematothorax from the wound which was treated by puncture. Just in such a case, favored by an infection not too virulent, a closed residual cavity often remains, which influences unfavorably the general condition. Based on my experience and thorough occupation in this field, I usually resected a rib over the callus, if clear symptoms of diseases were stated, whenever callus had been developed by proceeding empyema or wound, and could be demonstrated in the X-ray. Every operation revealed a cavity in the thorax, which I could cure by subsequent thoracoplasty. I could demonstrate, that after hemorrhage into the thoracic cavity, the so called hematothorax residual cavity occurs.

Pleural empyema which escaped notice may also result in residual cavities. FGGFRS described such an example which had been discovered 23 months after influenza. We also made a few observations of that kind, Generally such closed residual cavities are combined with bronchial fistulae through which the pus can be secreted. KONJETZNY saw two such cases, where the pleura empyema had not been noticed for 18 years on account of a forgotten drain tube. There are also some cases among our patients, where great empyema residual cavities existed for years, and where by misinterpretation of the callus shown in the X-ray, the origin of the purulent sputum was not properly explained. Two patients who were soldiers, were even reported fit for service (Ill. 4).

If one sees such patients with total residual cavities one scarcely believes that the human body can stand a strain like this for years, and that recovery can be possible by applying a thoracoplasty with obliteration of the bronchial fistula.

In the classification of empyema residual cavities those cases belong in the group of bronchial fistulae (Ill. 5). According to the table, they are the cause in 16%. In our table they have the fourth place, according to their frequency, whereas other investigators have

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Illustration 4b could not be reproduced with the facilities available

a

Contrast filling of the cavity before the plastic. Fluid level. Some contrasting medium enters the lung.

b

Condition after total plastic with preservation of the first rib.

Illustration 4

A total pleural empyema not recognized through three years. Purulent sputum by a great bronchial fistula. Lattice plastic in two sessions.

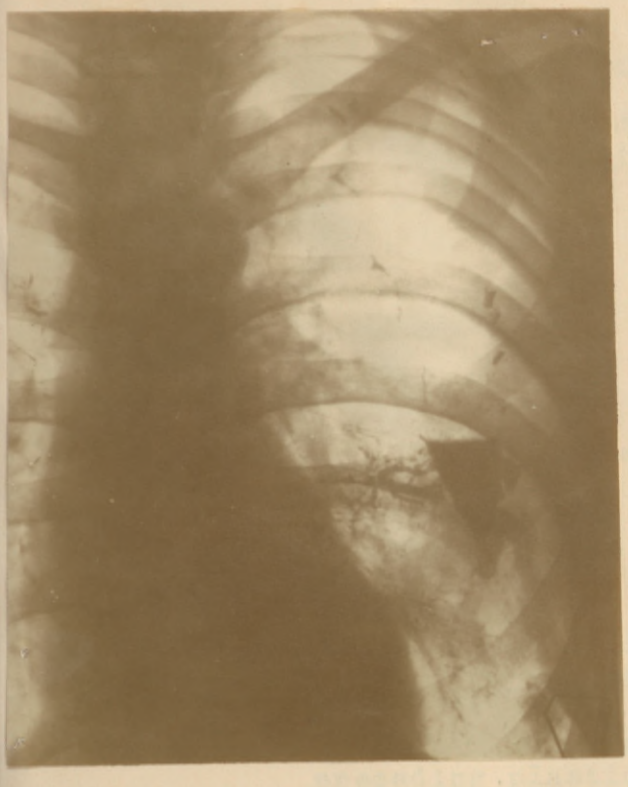


Illustration 5

Contrast medium has spread into the lungs after a reontgenological demonstration of an empyema residual cavity with bronchial fistula.

Illustration 6 could not be reproduced with the facilities available.

Illustration 6

Transformation of ribs (formation of rings and synostoses)and osteomyelitis of ribs after multiple injuries by shell splinters as the cause of an empyema residual cavity.

Illustration 7 a b could not be reproduced with the facilities available.

a b

Illustration 7

Special findings of ribs in thoracoplasty.

a) Osteomyelitis of ribs with development of a cavity. A small splinter is still sticking partly in the rib and a small part of it may still be seen in the cavity.

b) Bony plaques arising from ribs after preceding plastic.

described them as the greatest obstacle for curing residual cavities. An explanation for this may be that small and very small fistulae were not considered in our tabulation if progress and findings clearly showed that other influences had to be made responsible for the development of the chronic empyema.

It is little known, that a chornic osteomyelitis of the ribs, too, may be the cause of an empyema residual cavity (Ill. 6). This was true with 6% of our patients. In some impressive cases with formation of a sequestrum the cavity secreted its pus into the thoracic cavity and thus gave rise to a constant recurring reinfection (Ill.7). Our first case in this regard showed a renewed formation of abscess after periods of months when cavity and skin thrice seem to have been cured. I resolved therefore to perform a subperiosteal resection of several ribs over the repeatedly recurring focus. In doing so, I discovered an osteomyelitic focus on one rib, by removal of which final recovery, after two years of illness was attained.

In a similar way the often numerous and grotesque pockets of the residual cavity too, support the chronic empyem. By expansion of the lungs the canal uniting the pockets is slightly narrowed, changed into a thin fistula, or even totally blocked. Such pockets like a diverticulum maintain the infection of the chief cavity, as their accumulated contents are a favorable culture medium for bacilli. Such conditions often cause an apparently unintelligible increase of temperature.

In only 3% the existence of an accessory cavity was made responsible for the failure of the curative treatment (Ill. 8). This calculation as well as that of the bronchial fistula is based on really convincing observations. Probably we have to take a greater number for granted here too. In many cases the development of pockets surely has contributed to the persistence of the empyema residual cavity.

In the case of two patients a bad general condition might have to be considered. A discussion of these cases can be spared.

But we have to explain the enumeration of tuberculosis in our index, as we excluded from the very beginning mixed infection pleural empyemae from the report about the lattice plastic. Both patients were sent to us for operation on the supposition of an empyema residual cavity after a preceding pneumonia. In the case of a 26 year old woman an unsuccessful thoracoplasty and in the case of a man of almost the same age a resection of ribs had preceded. The cavity of the woman healed slowly after the secondary operation. By scraping out the fistula, tissue was taken for a histological examination which showed indisputable tuberculous changes. The cavity healed completely and the woman patient regained full health afterwards, while in the case of the man a fistula remained. During the treatment a severe spondylitis tuberculosa began and in addition to that a fatal miliary tuberculosis.

Illustration 8

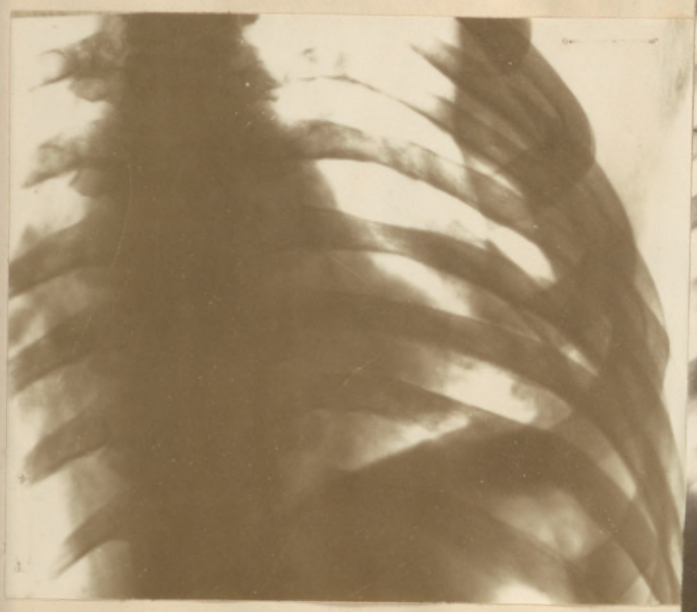
Empyema residual cavity with bronchial fistula and accessory cavity.

The impression in both observations was, that one had to deal with postpneumonia partial residual cavities. It is justified to suspect that this was based on a specific infection. It is possible, that errors in this regard occur often. Nevertheless I quoted both cases in the index of the causes of the empyema residual cavities because the discussion of these pathological symptoms is very instructive. There are reports of chronic suppurations of the pleura, which at first seem to be trivial, but later on prove to be tuberculous. J. ALEXANDER alone described 8 observations which, although operated already, came with a fistula to him for treatment. Exploratory excision showed in all cases only ordinary symptoms of inflammation at first. At a repetition after several months, however, there were to our great surprise little tuberculous knots.

In case of our two patients it is not possible to prove convincingly if, in spite of apparently incontestable precedence and progress up to the plastic, there existed a postpneumonical or a mix-infection empyema from the beginning. In both cases it seems recommendable to use exploratory excisions of the pleural callus at the thoracoplasty itself, in case of bad healing and first of all always before each subsequent operation.

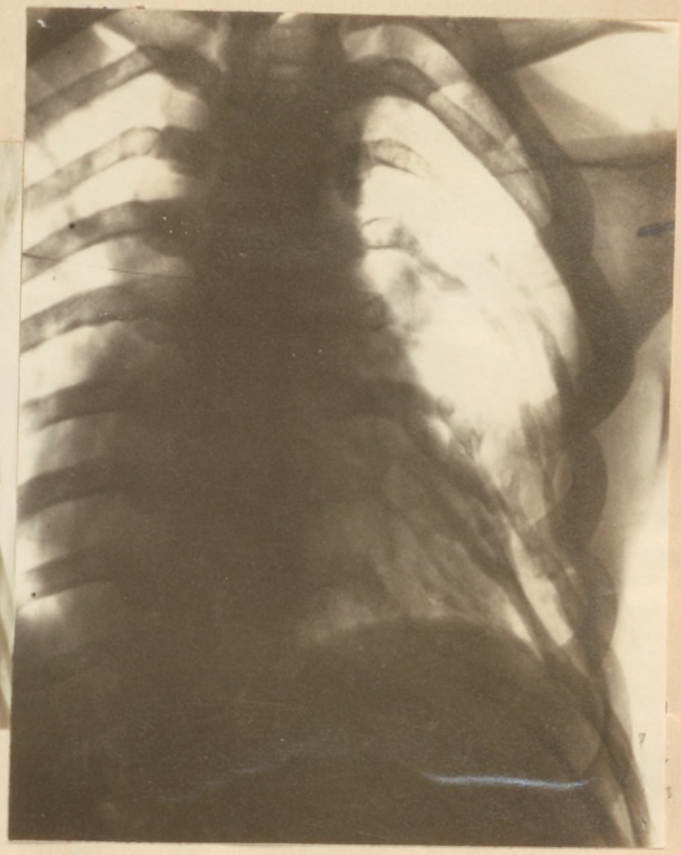
After this digression, which was necessary to avoid repetitions in a later chapter, we still have to discuss the last cause of the empyema residual cavity. Contrary to other statistics, in only the case of one patient a chronic empyema residual cavity did not heal due to a foreign body. In this case it was a rubber tube of 8 centimeter length (Ill. 9), that had slipped unnoticed into the pleura cavity and thus maintained for one year a totally closed empyema residual cavity without any connection with the bronchial tree. In some plastics, parts of projectiles, especially shell-splinters were found, which had not been taken into consideration as they were not the decisive cause for the existence of large cavities.

With this summary the most important causes are discussed. This table surely has the disadvantages of every scheme. Without doubt, in the case of some patients several factors had to be regarded, but it was difficult to determine the most important one.
A further disadvantage is that the pleural empyemae were not treated by us according to homogenous rules after resection of the ribs, but nearly all came to our clinic with an existing residual cavity. Clinical records used for research of the origin of an aspect of state may result in mistakes. Surely grave omissions in after-treatment, especially insufficient breathing gymnastics, are not appropriately mentioned. On the other hand the survey of so great a number of patients shows in a general way what has to be done to avoid the origin of the dreaded empyema residual cavity.



a

Rubber tube in the survey picture.



b

Condition after lattice plastic which shows the extent of the surgical obliterated residual cavity.

Illustration 9

Rubber tube in the thorax as the cause of a closed empyema residual cavity, is easily overlooked, if the film contrast is too faint .

THE INDICATIONS

There is no generally authentic indication as to the moment of the operation. Some manuals suggest not to wait more than 2 months. Even in case of a bronchial fistula this period is too short. Generally the cure of large cavities of adults with chronic suppuration from the thorax cannot be expected anymore after a lapse of 6 months, on the other hand PERTHES, HARTERT, NEVILLE, GOETZE, WESTHUES, etc., furnished proof that they can be cured permanently by a suitable suction treatment, even after a longer period. One therefore, must have the guarantee that this treatment is or has been conscientiously performed before the operation. Though old cavities cannot be closed, they are often reduced so that a smaller plastic will be sufficient. We therefore treated every chronic empyema, that has been treated before by others, again with a suction treatment and used a very strong suction. Even in apparently hopeless cases we gained progress by using the water-jet suction apparatus. Opinions differ as to the employment of negative pressure in case of a bronchial fistula. Surely, chances are more unfavorable in this case, but on the other hand cures of empyema residucal cavities are possible this way. It is recommendable to interrupt the suction frequently in order to enable the bronchial fistula to heal.

Because of these different treatments we succeeded in closing every fourth or fifth empyema residual cavity that was sent to us for plastic, without any operation. It is to be understood, that no precious time may be lost by conservative treatment. Complications rising in the brain are especially dangerous here. Although they are rare, I ordered the collection of all cases of cerebral abscesses and meningitis, which occurred during the last decades with acute and chronic empyema residual cavities in the clinic of Giessen. They uniformly cover such large periods of time that there is no special hazard during the first or second 6 months period. The possibility to close or reduce the cavity is so great, that there is nearly no objection to chance either cerebral complications if conservative treatment is continued, or the danger of the well known toxic damages (amyloidosis etc.) Nevertheless the moment of the operation must not be postponed unnecessarily. An exact fixation of the moment is therefore necessary. It certainly has come, when a further diminishing of the cavity cannot be expected. Today this moment can be fixed by X-ray pictures of the residual empyema taken at various periods of time (Ill. 10). We therefore make X-ray controls every 4 weeks. According to our experiences a further diminishing is not to be expected if, in spite of intensive sucking treatment in connection with breathing gymnastics, no reduction in the extent of the contrast-shadow is recognizable in the X-ray picture after 4-8 weeks.

a
View from front to back.

b
View from the side shows the extent of the cavity and especially the pockets and sack formation. The long fistula canal is striking as to be seen also in Illustration 3. Here too, a resection of ribs at the base of the cavity has to precede the plastic.

Illustration 10

X-ray picture of an empyema residual cavity from two sides.

Greatest caution, however, should be used in the evaluation of the X-ray pictures. To determine the real extent of the residual cavities, X-rays from two sides always have to be made. The differences are considerable. We learn, by comparing with operation findings, that the cavities are always larger and more extensive than appears in the X-ray pictures. Large accessory cavities, connected with the chronic empyema only by small openings, and the often numerous small pockets regularily escape roentgenological detection. If thick fibirin-clots are in the residual cavity, a less extensive cavity may be suspected. The filling of the fistula may be negative and yet a cavity exists all the same. I point towards the value of MERIO's method to avoid deceptions.

Every precaution is to be used in case of a bronchial fistula. In one case we saw thorotrast enter the sound lung by reflex action. Such events must absolutely be avoided (Ill. 11). In case of a bronchial fistula we have to abandon X-rays as the danger of chronic and acute damages is too great.

PREPARATION

One of the most important conditions for success is a careful preparation. In this case several points of view have to be regarded which do not have the same significance in an ordinary operation. First of all we place the care for detoxication, next comes the removal of damages caused by chronic suppuration and finally the increase of protective power of the patients, who are most often extremely weakened.

Though the influence of detoxication on the success of surgical operations in case of fecal stagnation with carcinoma of the large intestine is well known, one is always surprised to see how seldom this knowledge has been used in the treatment of the empyema residual cavity. We never operated upon any patient, if before the operation the outflow of the pus from the pleura cavity might be influenced in the least. Any narrow fistulae are always dilated. If this was not possible on accout of the formation of narrow-bone rings at the place of drainage, the resection of ribs was repeated.

After this simple method of treatment the general condition improves as a rule. Thereby above all things the cavity and the operation can be made the smallest possible. In several extremely grave cases one or two ribs at the lower end of the cavity were removed to begin detoxication as quick as possible and to make it effective. It cannot be emphasized enough, that SCHEDE's classical method of treatment requires in the first act a subperiosteal resection of the lowest rib and thereby a broad opening at the base of the empyema residual cavity, and by this to provide the best conditions for the drainage of pus.

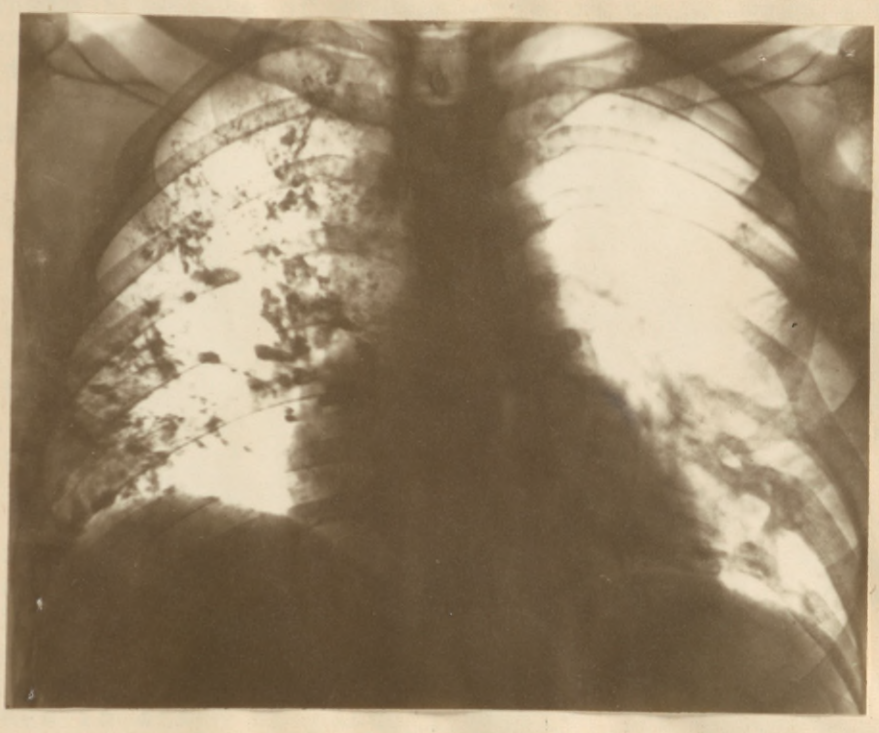


Illustration 11

Condition after thoracoplasty because of left-sided empyema residual cavity with bronchial fistula. During the roentgenological presentation before the operation, Thorotrast was aspired into the right lung after a cough irritation, and is to be recognized months afterwards by the numerous coarse spots.

Irrigation treatment assists detoxication effectively. Numerous exp riments revealed that disinfection of a residual cavity cannot be expected. Its effect seems to be only mechanical. It has to wash out the albumin products of disintegration to prevent a toxic damage of the organism. The kind of rinsing fluid used, is immaterial; we use solutions of Rivanol. We did not observe any special advantage in introducing sulfonamides into the empyema residual cavity.

Irrigations must be used first of all in cases of residual cavities, which secrete putrid, foul pus because these patients are extremely damaged and more liable to relapse, even if the plastic is of small extent. There is a statement of a research from E. SCHNEIDER about the toxic effect of foul pus in case of pleural empyema. He traces it back to the decay of albumin substances of the kind of methylenacrolin and allylamin. I urgently discourage a plastic as long as the pus smells fetid.

Quite as important as the care for radical detoxication is the elimination of the damages caused by the chronic pleura empyema. Here the blood transfusion is the decisive matter. Only today can we fully estimate its importance. Even during the first World War PAYR referred to the dimunition of the hemoglobin values in cases of pleural empyema and demanded a more frequent check to evaluate the aspects of disease. This was not done until during the last war (1939-1945) when WACHSMUTH, DUESBERG and SCHROEDER of the special hospital of the General Headquarters of the Army carefully explored the changes caused in the blood by chronic suppurations in systematic, most careful examinations. The results are of great importance to understand preparation and after treatment. To avoid repetitions they will be described fully here as far as they are of surgical interest.

In case of chronic pleural empyema the damage by long lasting secretions of pus and the loss of protein connected with it, is especially pronounced. The loss of protein is easily to determine numerically as to its extent with this aspect of disease. In serious cases cachexia is developed by a deficiency of protein. A healthy individual disposes of great depots of protein. From them he can deliver within 24 hours protein enough into the blood channel to form 1500 cubic centimeters of plasma. But with chronic suppurations because of the elevated temperature with toxic and bacterial decay of protein, there developes a decrease of these depots by insufficient assimilation of protein and the suppuration itself. Combined with these processes is a deficiency of valuable protein building materials for the vitally important hemoglobin. It is followed by a considerable change in the picture of the red blood corpuscles which finally gives the impression of a sideropic anemia. If ascorbic acid iron is given there is no increase of reticulocytes and no amelioration of the hemoglobin deficiency. On the contrary, the erythroblastic apparatus is prevented from developing completely and remains in a macroblastic state until there are sufficient quantities

of protein to furnish the building material for the normal amount of hemoglobin. If there is an extreme deficiency of protein, hemoglobin will be used to cover the protein deficit. In this stage in case of empyema residual cavities the erythrocytes decrease numerically and the amount of hemoglobin lessens. It is therefore not astonishing that we saw the most serious anemias with soldiers whose protein depots had been much exhausted even before the development of the chronic pleural empyema by the hardships of war in the east and by considerable loss of blood upon being wounded.

The valuable results of the research of DUNSBERG and his collaborators, which have greatest importance for other branches of surgery too, explain convincingly why the transfusion of blood, already frequently used on the basis of practical experience with the empyema residual cavity, is very important for the preparation for the operation. The alternative - restitution of protein by the enteral way is not sufficient or cannot be tolerated. Only by way of blood transfusion is it possible to remove the deficiency of protein and to replace the plasma. In case of considerable deficiency of protein even the transfused red blood corpuscles will be consumed for protein to a greater or lesser degree. Thus they render more valuable service than they might with regard to the respiratory function. Under these circumstances the effect of a blood transfusion lasts for a short time only. Its effects appear visibly only after the protein depots start to fill up again. We have to consider that we possess the richest supply of protein and calories in the erythrocytes which we can supply to a patient parenterally in liquid form and that the highly valuable plasma - and hemoglobin protein as a characteristic protein can be absorbed by the body immediately without any loss. The transfer of serum is less effective, as its protein content is only a third of that of the cells.

These examinations make us understand the value of blood transfusions in case of empyema residual cavities. They enable us to alleviate protein cachexia. If this is done, the patient is able to endure the thoracoplasty and first of all the most important post-operative complications, the operation shock and the danger of secondary hemorrhage, which may place heavy demands on the protein depots of the patient. Blood transfusion has therefore to be repeated before every surgical operation until the body possesses a sufficient stock of protein again. We are able to fix this date to some extent by frequent checks of the blood picture. Continual controls therefore are essential to judge the aspect of disease and set the appointed day of operation. Protein cachexia diminishes as soon as transfused protein will be taken to form hemoglobin-protein and the erythropoesis increases, which sometimes is explained mistakenly as an irritant effect. The increase of the erythrocytes is usually limited and seldom reaches a fully normal level before the most important cause for the decrease of protein, the chronic pleura empyema, is eliminated.

The objections to the employment of blood-transfusion are unjustified. Even with diseases of the pulmonary circulation there is no danger of overstrain. The increased circulating quantity of blood is removed by storage in depots. This is a false doctrine, which has done the greatest damage especially in thorax surgery. After operations in the thorax blood transfusions are nearly always necessary to obtain good success and to avoid post-operative shock.

The improvement of the general condition takes the third place in the preparations for operation. It is common sense that weakened patients should be strengthened as much as possible by food rich in calories and vitamins. In many cases we injected a good quantity of vitamin C intravenously before the operation, but this showed no convincing advantage. In case of toxic damage of the heart and with older patients we used a strophantin treatment. The psychic treatment of patients, who sometimes have passed a long period of suffering and have a serious operation ahead and the calming of the visceral nervous system by doses of Bellergal or Luminal-ets favors recovery, and facilitates the performance of the operation under local anaesthesia.

THE TECHNIQUE OF OPERATION

The success of the operation is influenced very much by the method chosen for analgesia. It is the general opinion that empyema residual cavities can be removed only under general anaesthetics because of the heavy growth of callus. This is not true. In case of nearly 90% of our patients, coming from different parts of Germany and for a smaller part from foreign countries a local anaesthesia, prepared carefully and given some time before the operation will be sufficient. A great deal depends upon the technique of the injection. We were able to perform an extensive second thoracoplasty without any manifestation of pain on the part of the patient which was not possible at his first thoraco-plasty made in another hospital, where a complete ether anaesthesia had to be given. In case of strong formation of callus regional anaesthesia is insufficient; therefore the field of operation itself must be infiltrated.

Others too emphasize the advantages of local anaesthesia to remove empyema residual cavities. VOSSCHULTE reported from FREYTAG's clinic, that postoperative mortality was reduced from 26,7% to 17,4% after replacing general anaesthesia by local anaesthesia. I have successfully performed without difficulties several extirpations of lobes of the lung (once, two lobes in one session) transpleural oesophagogastrostomies and other large operations in the thoracic cavity which require much more of a patient than the thoracoplasty in case of empyema residual cavities under local anaesthesia.

According to our experiences it is justified to try to succeed with local anaesthesia in case of every lattice plastic and even secondary operations. If necessary, "S.E.E. simple solution" may be given (that is: Scopolamin hydrochloricum 0,0005, Eucodal 0,01, Ephetonin 0,025). I do not advise intravenous injections of Evipan and Eunarcon in intrathoracic operations. The least strain in an additional light ether anaesthesia from which the patient can awake any time. With this one is able to judge best the degree of damage done to the general condition and avoid that the patient will be seized with the always threatening danger of a shock. DENEL too, praises the advantages of a slight ether anaesthesia, which turned out well in his use of SCHEDE's plastic.

The technique of the operation itself is simple and has already been discussed in its characteristic features; but I lay stress upon some points of view and experiences. SALZER's opinion is, that HELLER's method of treatment is of no use and can be replaced by the method of SCHEDE, if the pleural callus is thicker than 2 centimeters. Like HELLER we cannot agree with this opinion and consider the callus to be a valuable material to fill out the cavity. Even after thoracoplasty with callus up to 5 centimeters thick, we did not observe any necrosis with marked or long lasting suppurations. The combination of HELLER's and SCHEDE's plastic turned out well. Especially in case of secondary and two stage operations this is the only possible way to remove the residual cavity, whereby the parietal pleural callus has to be removed in the lower sections.

A simple additional method of treatment is recommended in all cases with thick callus. Here sometimes a certain stiffness of the ligaments is to be observed. They do not lean against the lungs without a certain tension, thus favoring the danger of a renewed development of cavities. Under these circumstances I resected from the pleura, thickened by callus a broad based wedge at the posterior insertion of the ligaments at their inner side, carefully preserving nerves and vessels. This results in a total relaxing of the striae which afterwards fit easily into the deepest cavities. The same method can be employed at the front end of the striae. In employing this method one avoids to a great extent the occasional resection of ribs far beyond the anterior border of the cavity necessary for relaxation.

In some cases we formed ligaments of twice the usual breadth. After resection of the ribs only the inner periosteum of every second rib was split longitudinally. This is supposed to assure the nourishment of the stria and to make the incision as small as possible. These broad ligaments are too rigid and it is more difficult to place them into the cavity. Moreover we observed that after this method the infections lasted longer than usual and therefore we declined to alter the technique in this regard.

Most methods for operative removal of empyema residual cavities require special consideration of the question of how to deal with the scapula. In most cases VOSSCHULTE resected the lower part of the scapula to give space for relaxation to the lateral wall of the chest. SAUERBRUCH even removes the medial rim of the scapula. if by pressure against the vertebral column it hinders the lateral sinking in of the wall of the chest. These methods of treatment leave a restriction of the mobility of the arm above the horizontal line. All these functional and cosmetical disadvantages are not to be found in the method of HELLER. In the first hundred operations I was forced only once to remove the lower half of the scapula as in this region it was bonily adherent with the ribs underneath. Since then I have had to resect parts of the scapula in only two cases. They were extremely difficult secondary plastics, where after the proposal of SUDECK I used subscapula muscles to fill out a cavity situated posteriorly high and paravertebrally.

The cure of bronchial fistulae at the same time with lattice plastic is not difficult. Scraping out of the mucous membrane and ligating round the end of the fistula are sufficient. Formation of striae is sufficient for cover and they close the bronchial fistula by means of a well nourished pedunculated flap of muscles, as proposed by NIESSEN in 1932, a matter which is superfluous in case of ordinary residual cavities. This does not mean that occasionally specially situated bronchial fistulae or even lattice lungs may occur, in which cases only NIESSEN's proposal gives the most certain and best guarantee for a cure. I too, used it successfully a short time back in a quite abnormal case, that had been operated four times previously in vain by experienced surgeons.

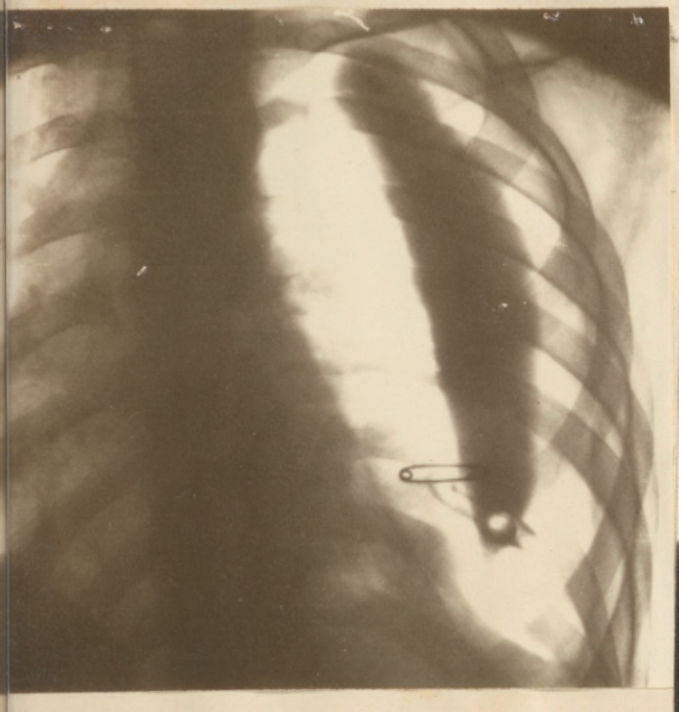
With this case I used the principle of relaxation which was pointed out by LEZIUS in 1938, and which is quite sufficient to obliterate ordinary indirect bronchial fistulae. LEZIUS recommends the removal of the ribs or their regenerates surrounding the fistula within 7-10 centimeters, to cause the recovery by the flexibility of the lung-tissue thus created and its shrinking afterwards. This situation is nearly always created, if lattice plastic is used. Only in exceptional cases is a more extended resection of ribs than would be necessary for the closing of the cavity necessary to get a sufficient relaxation. According to HELLER the possibility of shrinking is great, as proved by the following observations. In the case of a closed, total empyema residual cavity, that had been unobserved for three years, we decided on a two stage operation on account of the bad general condition of the patient. The ribs 6-10 were resected subperiosteally in the first session and the thoracic wall was treated according to HELLER's method. In the area of the hilus there was a bronchial fistula with a lumen larger than I have ever seen before. The fistula was not touched. Its closure, which caused us some worry, was supposed to be performed in the second session. Three months later, to our surprise, the bronchial fistula had disappeared.

No doubt there are aspects of disease where one is obliged to apply a muscle plastic in connection with a relaxation at the same time. In case of a residual cavity, however, HELLER's plastic assures sufficient flexibility of the surrounding tissue of the lungs, and thereby cures the bronchial fistulae. Up to now we were able to close them all this way. In cases of secondary operations too, which were necessary with some of our patients the continuation of a bronchial fistula never was the cause of a second operation.

In completion of this, the finding at one operation may be mentioned of a condition which is rarely discussed, but on the other hand requires a great deal of the surgeon in every operation. It is generally known that, if the thorax shrinks, the distances of the ribs will grow more narrow and it is possible that the ribs may telescope like tiles. But the changes in the ribs themselves are seldom mentioned. BISGARD made thorough examinations here. The roundish ribs loose their shape above the residual cavity. They become more triangular or rectangular by aggregations at the lower rim and at the inner side. The change is especially marked in the area of the angle of the rib. Occasionally even synostoses of neighboring ribs arise.

According to the experimental findings of BISGARD the changes originate in an aseptic inflammation and an abnormal pulling effect on the periosteum. The first one seems to be more important. Generally there is considerable similarity to the reaction of the bone in the neighborhood of osteomyelitic foci. The periosteum is stimulated to an increased formation of bones and grows thicker. Above all, the bone itself thickens. Both developments render subperiosteal resection of ribs difficult in cases of empyema residual cavities, whereas they are easy to perform with thoracoplasty in cases of pulmonary tuberculosis. The inflammation can spread along the periosteum up to the joints where the ribs are connected with the vertebral column, and cause purulent inflammations there. On close examination the often marked changes can be observed quite frequently, but they are seldom taken into consideration. But they must be considered as a cause of the occasional appearance of the otherwise inexplicable meningitis with the empyema residual cavity, as we shall see later.

It is a question of utmost importance to decide if the thoracoplasty should be performed in one or several sessions. According to general opinion, the operation of residual cavities is never a trivial operation and on account of the preceding suppuration is always a great strain on the weak patient. Therefore SCHEDE's surgical removal of all the ribs in one session associated with the removal of the pleura thickened by callus is discarded. It is generally believed, that several sessions are necessary (Ill. 12). If lattice plastic is employed, the residual cavity can nearly always be closed in a single operation. With the first 100 patients I made the plastic in two sessions only in two cases. Both were in a bad condition. In the first operation I therefore removed only the lower



a
Before the first plastic.

b
Before the second plastic.

Illustration 12

Presentation of a total, two stage, operated residual cavity.

4 respective 5 ribs, and closed the total cavity by a later second operation. In my later plastics I choose the two stage procedure more frequently, but then the patients were extremely grave cases. HELLER recommends the use of more than one stage more often. Today I do not consider this necessary, if preparation and aftertreatment are made carefully. As secondary operations after lattice plastics are especially difficult on account of the numerous regenerates of ribs and the solid callus, a preceding subperiosteal resection of ribs above the residual cavity helps to reduce the operation in size. But this is only a makeshift.

According to my experiences nearly all partial empyema residual cavities can be closed in a single session by means of lattice plastic. Patients usually endure the removal of 3-4 ribs well and of 5-6 without considerable damage. Every precaution is to be used in case of total and subtotal cavities. As to the extension of the plastic I depend on my own judgement of the patient during the time of preparation, his general condition and his reaction during the operation. A careful and extremely conscientious control is necessary if sudden serious surprises are to be avoided. If a serious shock arises, everything has to be stopped. In the case of several patients I first intended to operate in two stages, but after due consideration during the operation I resolved on a one-session plastic. Here the patient's reaction to the operation influenced considerably the change of my decision. To judge approximately the seriousness of the operation and to keep constantly informed about the extension of the removal of bones from the thoracic wall, the length of the resected parts of the ribs may be measured continuously. Generally the removal of 60-80 centimeters can be endured without danger. Greatest caution should be used, if it goes beyond 120 centimeters. In case of two stage operations, lattice plastic should preferably be started from below. If possible, somehow, I recommend to extent the first session up to the removal of the fourth rib. On account of this I observed later on in case of several patients, who were to have a second session afterwards a surprising recovery of the upper section of the cavity.

The length of the intervals between the sessions depends on the patients general condition. A period of at least 3 weeks is essential. Generally second operations are tolerated better after a longer interval. With one patient I performed a small lattice plastic for detoxication by resection of three ribs. In case of this severely damaged 21 year old patient who only weighed 36 kilograms for a height of 182 centimeters at his hospitalization, the second session could be performed only after a lapse of 9 months when his weight was stabilized between 49,5 and 50 kilograms.

According to the development, which SCHEDE's plastic has undergone during the last decades concerning the subdivision of the operation, one will be critical of my recommending to perform nearly all the operations in one session with HELLER's method. This proposal seems to be

contrary to every assured experience. Without doubt it is possible to increase the power of resistance against the operation by a careful preparation and a conscientious after-treatment and on account of this the patient is able to endure more strain. Our method of treatment for the first and second rib surely has special importance in case of lattice plastic.

In the first period of use of thoracoplasty one could observe the so called vibration of the wall of the chest which occurred after total removal of the ribs. Today this severe complication is seldom observed after the operation of an empyema residual cavity. On the other hand, the removal of the first and second rib is an additional great strain on the circulation. In the methods of treatment used for the removal of empyema residual cavities up to now, the closing of the recessus epitympanicus meets difficulties, even if the method of treatment is used, which was first recommended by SAUERBRUCH for the operation of mixed infection empyema. VOSSCHULTE writes impressively: Even by total removal of the upper ribs a depression of the mobilized thoracic wall against the visceral pleura of the collapsed lung cannot be enforced, as the shoulder girdle still acts as a support, keeping the recessus epitympanicus extended. While in thoracoplasty in case of pulmonary tuberculosis the first rib takes some kind of a key position and in the usual method of treatment for removal of an empyema residual cavity is judged similarily, it can be disregarded with total cavities, if lattice plastic is applied. Using this method of treatment, I never removed the first rib, and later on almost regularily left the second rib in its place too. (Ill. 13 and 14). The recessus epitympanicus, the closure of which is so difficult by other methods, may be filled up easily by a careful formation of freely movable striae with thick callus.

To meet the possible objection, that only light cases were treated, I give a short survey of the number of ribs removed. In about one quarter of the cases 4.5 - 6 ribs were resected in 16 cases, 7 ribs, in 9 cases 8 and in 2 cases 9 ribs. To evaluate the extent of the operation I think it is essential to state the length of the pieces of ribs removed. In our last plastics, an average of $5\frac{1}{2}$ ribs with a length of 105 centimeters were removed. In the case of one patient the total length of ribs removed in one session amounted to 180 centimeters. His postoperative recovery met no difficulties.

The removal of ribs may not be performed too thriftily or inappropriately otherwise recovery even after lattice plastic fails and a new plastic will become necessary. On the other hand not too many bones should be removed from the thoracic wall. As I demonstrated in a previous publication, the lung tissue recovers perfectly after a lattice plastic, especially in case of young patients. This is explained by the important observation of SAUERBRUCH that the collapsed lung is able to extend again, if it is still under the pulling effect of a remaining part of the thoracic wall, and that by the influence of its function it may even recover. SAUERBRUCH therefore, though he urges to remove the bones radically,

Illustration #13a could not be reproduced with the facilities available.

a b

Illustration 13
Total right sideded empyema residual cavity (a) before and (b) after the lattice plastic, with first and second rib preserved.

Illustration 14a b

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a b

Illustration 14

Total empyema residual cavity before and after the plastic.

a) Contrast filling of the cavity before the operation.

b) State after the plastic. Preservation of the first and second rib.

demands to preserve as much as possible of the thoracic wall. This apparently impossible demand may be fulfilled in an ideal way with the lattice plastic, because one exposes the cavity by sacrificing no more ribs than absolutely necessary and moreover new ribs can be formed from the preserved periosteum of the ribs.

To allow the lungs to expand, one can make some incisions crossing one another vertically in the callus on the surface of the lung. Even more effective is an early start of breathing gymnastics after the operation; special stress is laid upon this in the after treatment.

As to the technique of the operation we still have to mention, that before finishing the plastic and after a careful control of hemorrhage and cleaning of the field of operation we dust in an abundance of sulfonamides in powderform. Usually we introduce only one drain occasionally two, with some gauze strips at the lowest point.

After the operation we regularly use the rubber tension bandage, which has to be applied very carefully. By slight pressure it has to keep the strips in their position, avoid the new development of a cavity and also a secondary hemorrhage. Because of the bacteriostatic power of the sulfonamides it is usually possible to leave the bandage on for a week. Even in case of big cavities we use a slight pressure bandage in the aftertreatment.

POSTOPERATIVE COMPLICATIONS

To perform a conscientious after treatment, one must have exact knowledge of the most important complications, which in case of empyema residual cavities, threaten to arise after every thoracoplasty. They ought to be especially discussed, because only by avoiding the dangers arising from them is it possible, to reduce the formerly high postoperative mortality rate to an astonishing low percentage.

First of all we have to mention the shock, which can occur in case of lattice plastic as well as any other intrathoracic operation during the operation, and than demands an immediate blood transfusion. Therefore, in every case of thoracoplasty a suitable blood donor has to be at hand. As mentioned before, the false doctrine representing the greatest obstruction to thoracic surgery which stated that blood transfusions are bad mistakes in case of disease in the region of the pulmonary circulation has been abolished now. Even after an apparently well tolerated plastic, patients, are frequently and sometimes surprisingly liable to shock. For 3 years we proceeded after careful observations and in spite of all scruples to make a blood transfusion immediately after every lattice plastic which is the best means to avoid shocks.

A transfusion of at least 4-500 cubic centimeters is advisable after large operations. S all transfusions include the possibility that shock repeats in the course of the day of operation. In this case the blood transfusion has to be repeated immediately. There is no rule as to which patients will be liable to renewed shock symptoms after the lattice plastic is made. The danger does not depend solely on the extension of the operation and the general condition. Deceptions in a good or bad sense occur quite frequently. As long as we do not know, the cause of the shock and a reliable prophylactic is impossible, greatest caution in supervision is recommended. In case of several patients a renewed menacing deterioration of the general condition could only be eliminated by a twice repeated blood transfusion on the same day as the operation. In some cases, if necessary, we did not hesitate to use this sovereign means of avoiding shock and collapse not only during the operation but even the first and second days postoperatively.

Based on impressive observations and convincing experiences, indications, which were always examined exactly were first given cautiously and then regularly. Unfortunately there is no substitute of anywhere near the same value. Infusions of serum are definitely not so effective. Periston too, should be used only, in an emergency. Since we make blood transfusions systematically right after the operation and besides that as a rule in case of a deterioration of the general condition we could desist more and more from using continuous intravenous clipis of physiological saline solution with additional circulation stimulants. In a few cases it rendered valuable services.

After the operation it must be prevented by all means that the chock with its grave consequences may take full effect. In many regards it is justified and instructive to compare it to the reaction of the blood pressure in spinal anesthesia. But if blood pressure has sunk below 80 or even 60 millimeters hemoglobin it is difficult to bring it into balance again. Just as it is possible to avoid the threatening danger by giving blood pressure increasing remedies in time, a prophylactic blood transfusion succeeds in preserving patients, who after a thoracoplasty are liable to shock and collapse, from damage which sometimes can never be eliminated.

The second important as well as dangerous complication is secondary hemorrhage. The clinical consequences are manifested in collapse. As the shock too results into collapse, the effects of the shock as well as secondary hemorrhage are the same. This is the great danger after a thoracoplasty. If a patient is not sufficiently protected against postoperative shock, secondary hemorrhage may be fatal. Shock causes a change in the composition of blood, which is marked chiefly, without mentioning the displacement of ions, by the extravasation of plasma from the vascular system. An additional loss of plasma, caused by secondary hemorrhage, may have unfavorable or even life endangering effects. Both events are especially dangerous for patients with empyema residual cavities, as there preceded or still exists damage due to the protein deficiency caused by a chronic

suppuration. The depots of protein from which a healthy organism is able to replace its plasma in case of loss of blood, are very small and soon exhausted, even after a good preparation. So after a collapse, caused by secondary hemorrhage, quick and effective aid is only to be expected from a blood transfusion.

The origin of secondary hemorrhage, connected with the thoracoplasty is a complicated, not quite explained proceeding. It does not depend solely on a more or less careful control of hemorrhage or on the extent of the operation. One cannot be sure if shock occurs more frequently in case of lattice plastic with its large wound surface but it is possible. Secondary hemorrhage seems to be predominantly of a capillary nature. It is therefore essential, to apply a pressure bandage after the operation.

The chief cause is a change in the composition of the blood and an impaired contractility of the vessels. Moreoever we have to consider the insufficient possibility of shrinking in the callus tissue. Sometimes one has the impression of a septic secondary hemorrhage. The blood seems to be very poor - serous. This is frequently caused by a serous exudation and on account of change of the color of the serum it may be mistaken for a secondary hemorrhage. This loss of protein increases the danger of a collapse or may even be the cause of it; but this consequence can be eliminated by a blood transfusion. If the general conditions deteriorates after the operation, one can be sure that almost regularily a transfusion of blood is necessary. We always acted according to this point of view and our successes showed that we were right. There is no doubt that on account of the repeatedly mentioned investigations about the condition of protein deficiency in case of chronic suppurations it is possible to solve the problem of secondary hemorrhage after plastic closure of the empyema residual cavity. The osmotic pressure in the blood is changed by this and it can easily flow into the tissue. Toxic paralysis and damage of the vessles, as well as a special inclination towards hemorrhage can be observed here. As in this case too, we are dealing with the consequences of a chronic loss of protein, a blood transfusion is the only means to combat it.

The general opinion is, that pneumonia takes the third place in postoperative complications. According to SAWROWA it will especially occur in two stage operations, after the first session. Increase of temperature was believed to have its origin in pneumonia in some cases which proved to be wrong later on. I do not believe that a pneumonia exists in more than 2 cases out of a hundred. Considerable and long lasting fever as a rule was not caused by complications in the part of the lungs as was supposed first, but by an accumulation of pus. An insufficient outflow of pus after lattice-plastic is observed quite frequently. This is the most important cause for increase of temperature after the operation.

After lattice plastic fever sometimes occurs which is not caused by these two complications mentioned before. It is possible that it is caused by the abnormal washing out of toxin, which is created by mobilization of the thoracic wall and the formation of soft-part ligaments. One must also think of the development of an infection from little foci of pus in the pleural callus, where they remain untouched in contrast to SCHEDE's plastic. Whatever may be the cause of this postoperative increase of temperature, a copious dose of sulfonamides as a prophylactic is recommended.

AFTERTREATMENT

First attention should be given to avoid the postoperative shock and the frequent occurrence of secondary hemorrhage. The methods of treatment, which have to be used, were mentioned before. But this does not close the discussion about aftertreatment; several other points have to be considered.

Immediately after the operation, an effective massage is recommended. Thus the substance, which according to HENDERSON stimulates the respiratory center physiologically, becomes disengaged, and the pulse gains strength. Freshly operated patients feel better by improved circulation. It is of advantage to continue the massage every day, until the patient can get out of bed.

As mentioned before, a well fitting pressure bandage has to be applied after the operation. In most cases it has to be renewed only after 6-8 days. A careful survey and observation of temperature and pulse is essential on account of the danger of phlegmons of the thoracic wall and the possibility of accumulation of pus . Even on renewal of the first bandages it is recommended to apply slight pressure so that the strips remain well pressed against the pleura pulmonary. If this is not done, new cavities between these two parts are favored. The outflow of secretions, however, must not be hindred. Sometimes it is not easy to find the right way between these two alternatives. It often depends on paying attention to the outflow of secretion, if a second operation after the lattice plastic will be necessary or not.

The treatment of the wound does not show any peculiarities. Recovery often progresses astonishingly fast. In other cases the secretion of pus sometimes continues for a long time with inexplicable causes. The early starting of irrigations has to be made with every change of the bandage. For this purpose Rivanol has turned out well. The effect surely is only mechanical. It has to avoid the danger of even small accumulations of pus, a matter which must not be underestimated after a lattice plastic. In 10 to 15% of the cases abscesses occur during and even after the healing of the wound of operation, which break open spontaneously and therefore are better opened in

time. In all probability they form between the stripes or result from little foci of pus which may exist in the callus of the pleura, sometimes only visible by microscope.

In cases of patients, where the secretion of pus continued longer than usual, we had good success by treating the field of operation with diathermy. This treatment should be taken before each renewed operation if the filling of the fistula by contrast medium shows no new development of a cavity. This method of examination should be used frequently, if the healing of the wound is delayed, or secretion of pus continues. It often reveals surprisingly romified cavities where further delay is dangerous and scraping out of the fistula is of no use, but only a renewed operation performed in time may bring recovery.

Breathing gymnastics should be started, as soon as the pains of the wound ease. It can be observed in some cases that the lung extends again after a lattice plastic.

Exercise in moving too, has to start in time. If this is done, no restriction in the mobility of the arm remains that is worth mentioning, even after a total empyema residual cavity. A still more important task is to avoid scoliosis. It develops always after SCHEDE's plastic, but never after lattice plastic. It is seen occasionally in a minor degree, but then it never injures either the functional or the cosmetical result. It is necessary and can be accomplished easily to preserve the long dorsal tensors and leave the transverse processes untouched in the operation.

It is certain, that especially after the removal of an empyema residual cavity an appropriate and copious nourishment adds much to a quick recovery and healing of the wound. As we saw in this aspect of disease, the supply of protein is frequently diminished by different influences. Therefore special stress should be laid upon giving food rich in protein and vitamins.

Most generally a sulfonamide treatment is tried when temperature increases from possible bacterial causes. I do not know to what extent a treatment with penicillin may improve recovery faster and eliminate various other dangers. In case of one patient we saw favorable influence. In one session I had removed his right inferior and middle lobes on account of bronchiectases. Thereby a medium sized residual cavity developed, which I tried to remove by means of a lattice plastic. After the operation a long lasting suppuration with an inexplicable increase of temperature remained, which could not be decreased by treatment with sulfonamide. His condition weakened by bronchiectasies, lobectomy, the empyema residual cavity and the following lattice plastic remained unsatisfactory for weeks. Due to the interest, which the removal of two lobes of the lungs in one session still has today, I was supplied with penicillin, of which the patient got one million units. After this remedy was given, the temperature decreased and complete recovery followed. The success of penicillin was im

pressive. I am inclined to believe, that the use of penicillin, especially after lattice plastic will be of great value in many regards.

According to our discussions about the value of blood transfusions for preparation it is understandable that this method of treatment is one of the most important remedies even in the treatment after an operation. In case of good general condition, normal postoperative development and quick recovery, the body disposes of sufficient resources of its own. If there, however, is strong and long lasting secretion of pus, accompnaied by fever, the reserves of protein, already diminished before and after the operation are quickly totally exhausted in case of empyema residual cavities. As the deficiency of protein cannot be supplied by parenteral sources alone, symptoms of deficiency of protein appear again. These are also displayed as we observed, by a decrease of erythrocytes and hemoglobin. In their analysis we have a valuable means to judge the protective power of the body, or its damage respectively. Anaemia delays the healing of a wound. It has to be eliminated by blood transfusion, if the resources of the organism itself are not sufficient. Indication is based on the analysis of erythrocytes and hemoglobin, which must be repeated after every plastic so one can perform a blood transfusion in time and sometimes more often even during the aftertreatment. So we are able to cure the wounds more rapidly and gain faster restoration of health.

POSTOPERATIVE MORTALITY

Thoracoplasty to remove empyema residual cavities is connected with the idea of an operation with an immense death rate which in case of success leaves a considerable cosmetic deformity. This opinion is chiefly based on the previous experiences with SCHEDE's plastic. With this method of treatment the mortality rate amounted to 33⅓ % during the first World War, according to SAUERBRUCH. In the meantime the results have been improving. During the last war DEMEL operated 22 empyema residual cavities without any casualties (cases of death). By the time he made his report, however, the aftertreatment of all cases had not been concluded yet and three of his patients still had large bronchial fistulae.

No notable experiences have been made yet about lattice plastic, SALZER and SARAFOFF only published their observations on a small number of cases. Therefore the question as to the mortality rate is of special interest in so many cases as we have, considering that our patients could be observed until their final cure and even afterwards.

If one imagines, that in the first hundred cases treated with HELLER's lattice plastic, only three patients died, this fact has to be registered as an immense progress in eliminating the dreaded aspects of disease of the empyema residual cavity. A mortality rate of 3% would be tolerable. But even this small percentage here is not due to the method of operation but caused by deadly complications which cannot be brought into definitely causal connection with the operation itself. This may be clearly seen in a short survey of those three patients who died after the plastic:

1) A 28 year old man. On December 29, 1942 he received a small arms gunshot with the bullet lodging in the right thorax. A pleural empyema followed. Afterwards we had to perform a resection of ribs. In spite of suction treatment, an empyema residual cavity developed. On July 2, 1943, lattice plastic was made, after the 5-9 rib had been resected. (length of ribs resected 74 centimeters). At first the postoperative course was normal. On July 28, 1943 the patient started to vomit and on 29 July he got headaches. His general condition worsened suddenly on the first of August 1943 and showed meningitic symptoms. He died on August 2, 1943.

The post mortem examination showed: Perforation of an older abscess in the left frontal brain into the lateral ventricle.

2) A 29 year old man was severely wounded by a bomb splinter in the left side of the thorax on August 12, 1942. Two cavity gunshot. A pleural empyema developed which was treated by resection of ribs and suction drainage. In spite of all treatment, however, an empyema residual cavity remained. Then an abscess developed around a splinter below the diaphragm. Surgical exposure and drainage. On May 17, 1943, another operation was performed on account of suppuration below the diaphragm. On December 7, 1943 we made a lattice plastic on account of the empyema residual cavity. Ribs 3-9 were resected subperiosteally. The length of the resected ribs was 87 centimeters. For three weeks the postoperative course was without complications or fever. Then a sudden increase of temperature occurred followed by chills. Repeated revision of the field of the plastic without satisfactory findings. Finally a large subphrenic abscess was opened. Septic general condition, not influenced by any means. The patient died on Feburary 20, 1944. Post mortem examination showed that the thoracoplasty was generally in order. It was connected with the abscess cavity, situated subphrenically and including the spleen. The diaphragm was partly destroyed. Nowhere retention of pus. Small abscess in the left temporal lobe. Cause of death: Sepsis.

3) A 29 year old man was wounded on August 19, 1943 by machine gun shot, which resided in the right lung. A pleural empyema developed. A resection of ribs had to be made. An empyema residual cavity developed. Thoracoplasty was made on July 5, 1944. 2-8 ribs were resected subperiosteally. Right after the operation considerable continuous increase of temperature begun. Temporary suspicion of a relapse of malaria. Field of operation without finding. On August 19, 1944 headaches and subsequent somnolence. On September 10, 1944 hemiplegia and death. Post mortem examination showed a large multilocular abscess in the right frontal lobe. Residual cavity was closed, only a small fistula was found.

Cause of death: Cerebral abscess

If we consider critically these three pathologico anatomical determined causes of death, we observe, that in no case the operation can be made responsible for the fatal ending. According to the post mortem examination the first patient had the cerebral abscess even before the operation, while in case of the third patient it probably developed after the plastic and thus caused the fatal end. In the second case, it was the consequence of the two cavity gunshot. The origin of the sepsis was not the empyema residual cavity, but the subphrenic suppuration. It is remarkable that the temperature of two patients was normal for weeks after the operation until the symptoms of the complications which caused the death, could be observed.

Autopsies showed in every case that the field of operation was in order or even already cured. In no case was a retention of pus in the thorax found or could any connection between the lattice plastic and cause of death be surely proved. Our three failures have to be regarded as fatal events, as they could not have been avoided with any other kind of operation. Far more important than this statement I regard the fact resulting from the short descriptions of the origins that caused death, that there never was, not even in a single case, neither shock nor secondary hemorrhage, hitherto especially dreaded as the most important postoperative complication.

With all pulmonary diseases, even after the removal of splinters sticking in the lung, the danger of metastatic cerebral abscesses is threatening, as they were found in the post mortem examination of all three patients who died after the lattice plastic. Even in case of this grave aspect of disease it is possible to help by diagnosis and operation in time, as soon as the localization can be made. Perhaps in one or the other of our cases quicker action might have been appropriate.

In case of pleural empyema and its secuel, meningitis may occur occasionally besides cerebral abscesses. C. BAUER described two impressive observations where he could prove the two important ways of infection. In one case the suppuration had perforated from the thoracic cavity into the central canal of the spinal cord. In my findings of operation I already pointed out the collection of pus in the joint between ribs and vertebral clumn. In the second case a basal meningitis existed. By preparation during the section its origin could be proved on the level with the empyema. The intercostal nerves were considered responsible as the way of infection.

I personally observed some cases of fatal meningitis in case of pleural empyemae and with empyema residual cavities which had not yet been operated upon. In the chapter "Preparation" I already mentioned the importance which these complications as well as those of the metastatic cerebral abscess have on the choice of the time of operation. Both hang like the sword of Damocles over the patients with empyema residual cavities and over the results of the surgical operations. Probably symptoms of meningeal irritation occur more frequently. Before and after the operation patients often complain about pains in the neck and headaches. Explanations can be given by lumbar punctures, and various modern medicaments might sometimes prevent the development of a real meningitis. At any rate, both cerebral abscess and meningitis require medical action and no passivity. Therefore, the surgeon who has to do with operative treatment of empyema residual cavities must be thoroughly familiar with these two complications and their origin.

The three cases of death we had among the first hundred of our operations were caused by unavoidable accompanying diseases. In our further cases of lattice plastic, mortality did not amount too much. Up to date, we lost two patients after the operation. Though their cases have nothing to do with this report, I should like to give a short extract because it proves, that lattice plastic alone does not succeed, but that greatest care is required to obtain outstanding results.

4) A 21 year old man was taken ill on February 2, 1943 of spotted typhus, followed by pneumonia and pleuritis. In spite of resection of ribs a residual cavity remained in the right side. On April 25, 1945 lattice plastic was made. Multilocular system of cavities with bronchial fistula developed. Ribs 2-8 were resected subperiosteally. In the days after the operation the patient was strangely restless, the temperature was slightly increased, and the pulse moderately accelerated. He died on May 6, 1945. Autopsy was impossible.

Cause of death: Sudden collapse of circulation.

5) A 24 year old man was wounded by shell splinter in the right thorax on January 23, 1945. A pleural empyema developed. We applied BUELAU's drainage system without resection of ribs. An empyema residual cavity developed. We made the lattice plastic on January 18, 1946 and resected 4 ribs subperiosteally. In addition to that was a gas-containing, putrid infection of the thorax, going down to the thigh and spreading there. Incision was made in vain. The patient died on January 26, 1946.

Cause of death: Failure of circulation.

In case 4, the cause of death is obscure. After the extensive thoracoplasty neither shock nor secondary hemorrhage was observed. In the days following the operation the patient showed a strange motor restlessness. Possibly external influence effected the patient unfavorably. After the operation the patient had to be moved to a hall were many prisoners were crowded together. Our trained staff was not allowed to take charge of the nursing upon which so much depended. We used to place all the other patients with thoracoplasty in small, single, and well aired rooms. Perhaps the basic (original) disease may be traced as the cause of death. I observed several times that patients who had serious spotted typhus could generally not stand major operations very well. Finally the fact that the residual cavity had already existed for two years may have been of influence. It is regrettable, that in this single case, where death was probably solely due to the lattice plastic, we were not able to perform an autopsy. Perhaps in this case too, a cerebral abscess caused the fatal end.

The cause of death is very clear in the fifth case. Being exhausted after finishing the plastic, I ordered an experienced assistant to finish the operation by some sutures. Against my strict orders he sewed skin and muscles near the drainage tube and the striae so tightly that the secretion could not drain out and therefore a gas-containing phlegmon of the thoracic wall developed, which caused the death. This case shows, that success often depends upon trifles in technique and greatest care in the aftertreatment. This robust patient could almost surely have survived the small plastic if this mistake had not taken place.

Summarizing the causes of these five death once more, we must state that the lattice plastic is without special dangers. The mortality rate is low, compared to the gravity of the disease. If a patient dies after the operation, this is nearly always an inevitable event, if no unavoidable mistake has been made.

THE RESULT OF THE OPERATION

Judging the results of the operation we have to consider several points of view. The duration of treatment after the lattice plastic reveals clearly the usefulness of the method. Eight patients recovered so rapidly, that they could be discharged from the clinic within 4 weeks after the operation. Most of the patients, 43 exactly, had to stay in the hospital for 8 weeks, 22 for 12 weeks, 12 for 16 weeks and the rest even longer. Though in some cases suppuration occasionally continued a long time, the period of treatment after the thoracoplasty is generally short. It cannot be explained what causes the great differences in these cases.

There is a certain disadvantage in the later development of abscesses in the field of operation. The wound of one patient had been healed for 9 months already. This late complication could be observed in 12 patients. After drainage, the abscesses generally healed without difficulty. They start from small foci of pus which have apparently remained in the field of the plastic, or exist in the callus itself. Sometimes small residual cavities develop which may even require a secondary operation. At any rate the probability of a later development of abscesses is so great, that patients should be informed about this possibility, or, even better should be asked to come to secondary examinations periodically.

By exact inquiry we are able to find out with certainty the cases where the wound of operation had healed externally but inflammed foci existed underneath. The sedimentation of the blood corpuscles may be normal, but the red blood picture gives better information. A slight anemia means toxic damage and thereby the existance of a suppurative focus. According to our experience the best means of finding out consists in watching the general condition of the patient and in asking himself. Increasing weight after the thoracoplasty is a very favorable omen. The same holds good with regard to the appetite. If the patients complain about anorexia, insufficient convalescence, bodily weakness, or easy fatigue, one can be sure of a suppurative focus in the body.

As a proof I should like to add an instructive observation. After the thoracoplasty one patient complained about the above mentioned troubles. An abscess formed, which was incised. But even after healing the patient still complained and the bad general condition remained. I therefore reopened the field of the former abscess and found a small hidden empyema residual cavity. To find such hidden foci requires experience in this field and some luck. After two ribs respectively their regenerates had been resected subperiosteally, the focus healed quickly. This was followed by excellent recovery, good appetite, increase of weight, and a decided improvement of productive power. As my experiences proved

impressively in such cases one should not hesitate to perform a secondary operation, even after an apparently successful plastic. In no case have I ever regretted a secondary operation.

But the following case proves that caution should be taken: A patient did not recover well after thoracoplasty. It was suspected that a suppurative focus had remained in the thorax and a secondary operation was taken into consideration. The indications for a second operation were not entirely fulfilled, so we desisted from it. Finally another cause for the symptoms of disease was found. After nine months, a lymphogranulomatosis developed on account of which the patient died soon afterwards.

Not every abscess developing afterwards should be regarded as a consequence of lattice plastic. Visiting another hospital once I was shown a patient whom I had operated before and who was said to have a relapse respectively an abscess in the field of operation. The filling of the fistula revealed, that the suppuration had nothing to do with it but was caused by a shell splinter which was not removed in the operation Ill. 15. In the case of another patient in our clinic, we had to remove a shell splinter two years after the plastic, because of symptoms of inflammation. Missiles generally heal in without complications. As the plastic is no simple operation, we do not seek for them. If the splinter is easy to find, it should be removed to avoid another operation, as happened in the two cases mentioned before.

By careful after treatment and good food we are able to avoid the danger of a renewed collection of pus in the field of operation. The small foci of inflammation between the striae or in the callus heal quickly, if the power of resistance of the body grows strong enough. I saw some impressive cases, myself, which proved this indirectly. After a successful thoracoplasty and discharge from the hospital, one of my patients was taken prisoner. He had to stay in an open field for weeks without sufficient clothing and food. This caused an inflammation in the field of operation connected with a marked suppuration. In case of another fully recovered patient who was not operated in my clinic, I observed a similar relapse. Several operations had proceeded. After some week's stay in the oepn with insufficient food which caused death by starvation of many soldiers, a secretion of pus from all scars in the field of the thorax began to an extent I had never seen before. If one has met with such negative cases, one can easily estimate the value of good food during the after treatment, which should be given after every cured thoracoplasty.

Contrary to cases where late abscesses develop after the patient was discharged from the hospital, it sometimes occurs that the healing of the lattice plastic is delayed, or even a residual cavity remains. With 5 patients we did not succeed in obliterating the re-

Illustration 15

Shell splinter, causing an abscess one year after the lattice plastic. At first the abscess was regarded as a consequence of the thoracoplasty.

sidual cavity with one operation, but had to perform second operations. 8 of our patient had a plastic before by another surgeon. I intend to discuss these 13 cases in another chapter as naturally the causes of these failures and the ones of the secondary operations must be examined very carefully, to find out if they were based on avoidable mistakes.

To judge a new method of operation, not only the immediate but the lasting result is important. We therefore tried to watch our patients even after their discharge from the hospital. The months following the discharge we succeeded in doing so. Nearly all of them came back for a late examination or otherwise were sent to us. About 90% of the patients reported to us the sequel of the operation during the first following year and sometimes even during the second one. On account of the influence of war we were not able to obtain complete reports, but the particulars we have are sufficient for our purpose. In several chapters we already stated some interesting observations about diseases after the lattice plastic. Little can be reported about consecutive disease. To our surprise we never found an amyloid kidney. In the case of one patient a nephrosis developed several months after discharge from the hospital; frequent tests of urine before and after the plastic had shown a negative finding for albumin. With another patient an exophthalmic goitre developed, the cause of which was probably favored by the preceding long period of suffering.

Some patients showed an inclination towards bronchitis. In one case with a total plastic only it was purulent and could not quite be cured. It is astonishing, that after an often extensive collapse of the lungs and the distinct formation of callus this complication does not occur more frequently. Most patients stated in the late examination that they felt fit for work again. A very frequent complaint was shortness of breath. Reduced productive power was only stated by patients with total plastic, especially one in the right side of the thorax. Contrary to this, patients with partial plastic regained their full strength after months and sometimes even after years of having suffered the greatest hardships and bodily strain.

It is not easy to judge the protective power after the lattice plastic. If the surgeon is asked to do it, he predominantly must rely on the statement of the patient, as is to be seen in the discussion of the success. If possible, a spirographical examination should be made.

One of the most important advantages of lattice plastic compared with SCHEDE's plastic, is, that with the first one mentioned no paradoxical respiration remains. One could draw the conclusion, that the lungs functioned better. AMELUNG performed spirographic examinations but did not find any basic difference between the two methods. We must state on the other hand, that the number of cases examined is too small

to be fully convincing. Clinical experience in cases observed for years is against it too. Therefore a renewed examination is desirable.

Most striking is the cosmetic result. After SCHEDE's plastic severe mutilations of the thorax remain. This is not the case in lattice plastic, as shoulder girdle, and shoulder blade the first and usually the second rib are preserved and no scoliosis develops if the after treatment is carefully done. (Ill. 16).

Another highly important advantage is the preservation of the intercostal nerves. Therefore no paralysis of the muscles of the abdominal wall occurs which has an unfavorable influence on the work capacity after SCHEDE's plastic. According to OEHLECKER's examinations, even the sixth intercostal nerve has to be preserved. KONJETZNY also has lately tried to preserve the intercostal nerves in his plastic.

REPEATED THORACOPLASTIES AND SECONDARY OPERATIONS

Unfortunately lattice plastic does not in every case result in the obliteration of the empyema residual cavity. A second thoracoplasty was necessary in case of 5 patients, whom I had operated myself. In our hospital we have 8 other patients who had had an unsuccessful thoracoplasty-which was not made in our clinic - before. It is highly essential to examine the causes of these failures, because one can learn best by one's own and other's mistakes.

Among my own failures one can observe one case, that clearly and impressively shows one disadvantage of lattice plastic. On a 16 year old boy, 5 months after the resection of ribs, we had to perform a lattice plastic on account of a metapneumonic pleural empyema to remove a small residual cavity. However, we did not succeed. Three more plastics, partly according to HELLER, partly to SCHEDE and the removal of the transverse processes were necessary to gain a final result. After the first secondary plastic a large cavity had developed again, which caused suppuration. This result was miraculous, as no technical mistakes had been made in the first operation and the striae filled the cavity well.

At last we succeeded to obtain a cosmetically and functionally good result. But difficulties and relapses caused us to reflect. How was this to be explained? I rendered special attention to this question. According to my experiences up to now it is based on a quick power of regeneration of the periosteum of ribs which is especially expressed in young people. In this age, it takes a short time to form new ribs. If a suppuration develops after lattice plastic and the striae do not stick to the surface of the lungs, the ligaments of the soft parts be-

Illustration 16.

Cosmetic and functional result after lattice plastic in a total residual cavity.

a) X-ray picture of the residual cavity

Illustration 16
b,c,
could not be reproduced with the facilities available.

b

Condition after plastic with preservation of the first and second rib.

c

Picture from the front.

Illustration $16_{d,e}$

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d e

Illustration $16_{d,e}$

Picture from the side.

Picture from behind.

come bulky and finally stand off in such a way, that once again large cavities can develop beneath them. The quick development of regenerated ribs is also a cause of long lasting fistulae and sometimes even secondary operations as we shall see.

It should be considered therefore, if the power of regeneration of ribs should be stopped or delayed as is done similarily in case of thoracoplasty, because of tuberculosis of the lungs. The problems are quite the same as those with empyema residual cavities. MAURER uses a 10% solution of formalin for this purpose . MEISS proved by experiments that the regenerative power of the ribs can thus be delayed, without damaging the pleura. Up to now I could not resolve to use his method, although it is said, that it does not influence the healing of the wounds unfavorably. According to LOUBAT and MAGENDIE the regeneration of ribs can be delayed for 2 to 3 months, by spreading a solution of tannin over the periosteal tubes, which means, that the tissue has time to shrink. However, this proposal has to be examined, because SAUERBRUCH states, that the retraction of the lungs continues for ½ to 1 year, and that the ligaments formed by the lattice plastic stay limp and flexible for a long time.

The second cause can be traced back to an abnormal stiffness of the striae. It can be observed especially in case of a strong development of callus. It is understandable, that SALZER prefers the technique according to SCHEDE, if the pleural callus is thicker than 2½ centimeters. When using this method one sacrifices valuable material for filling. To increase the flexibility of the striae under such circumstances and to obtain a good filling of the cavity, I lately have removed the callus tissue, especially at the inside of both places where the striae are attached. So the ligaments become better attached, even if the pleura is markedly thickened and one has the impression that a new development of a cavity can be avoided by eliminating the unsuitable shape of the filling material.

The two first sources of mistakes were based on the method itself, which does not apply to the two other ones. The third cause is failure to observe accessory cavities which many times are connected only by a small fistula with the main cavity. This danger can be avoided only by greatest caution and experience. One should not underestimate it. The fourth mistake is favored by the tendency to make the plastic as small as possible. Thus, either too small pieces of the ribs, lying over the cavity are removed, or not enough ribs will be resected. In case of a patient we had to remove 2 more ribs in the field of the first plastic done in one session because pus had collected behind them like a lake. In the first session we had the impression, that the conditions for the outflow of pus would be favorable. I have observed this same event several times lately. This is apparently favored by shrinking of the lungs after lattice plastic, where the ribs below, which have been preserved, cause retention of pus or development

of cavities by interception which were not expected according to the findings at the time of the thoracoplasty. On a cured patient one can sometimes observe an abnormal standing out of the lower costal arch and the preserved ribs below the field of the thoraco plastic, by which this occurrence might easily be explained.

In case of 4 other patients we were, not to mention an occasional scraping out of fistulae, forced to perform secondary operations, which cannot be called secondary plastics according to their extent. In one case a small abscess cavity developed beneath a preserved rib. In other operations we had to remove regenerates of ribs, which prevented the falling together in the depth by the thick callus tissue. Under these circumstances the callus cannot shrink sufficiently and thus supports the cavities in its field. For fistulae and suppuration which often remain for a long time, the same causes have to be made responsible as the ones leading to the development of large cavities, which sometimes require another plastic. Furthermore the possibility has to be taken into account that small pus and inflammation foci are in the pleural callus which can lead to a secretion of pus or formation of fistulae after a lattice plastic. Therefore it should be considered, in case of thick callus whether part of them should be removed at the inside of the ligaments and thereby eliminate the changed, most inflammable field. I tried this in some recent operations without up to now being able to say anything about the final result. The preservation of the thickened lateral callus of the pleura and its use for filling out the cavity does not only have advantages, but disadvantages too, but without doubt, the advantages generally prevail.

This discussion reveals, that after a lattice plastic one cannot depend on too much success if fistulae are scraped out. If secretion of pus continues for some time, it is recommended to clear the canal of the fistula for comprehensive view. (III, 17). Sometimes it is possible by means of X-ray of the fistula which should precede each operation, to find at its end in the depth of the thoracic wall a cavernous enlargement, sometimes even an osteomyelitis of the ribs or a sequestrum of bones which are the cause. The origin of the pus has to be removed and by relaxation of its callus thickened surroundings the focus of disease must be enabled to close by shrinking, which sometimes is rather difficult. Though fistulae existing for a long time may close themselves and little cavities of pus encapsulate in depth, I nevertheless advise an active attack. Lately I have performed more frequent operations and up to now I have never regretted my more energetic action.

The eight thoracoplastics, of which the first ones had been performed without success in another clinic do not have the same importance as our own observations, as one cannot follow the procedures by reports about findings and sequel especially in case of operated

Illustration 17

Could not be reproduced with
the facilities available.

Illustration 17

Filling of a fistula with renewed formation
of a cavity after thoracoplasty. All stumps
of ribs were left too long

empyema residual cavities. We therefore should be careful with our criticism. With 2 of these 8 cases a lattice plastic had preceded. With one patient, who had a total residual cavity, we tried to close it by an extended subperiosteal resection of the first - to third rib, removing the transverse processes at the same time. Thus the cavity diminished a little, and could only be eliminated by a lattice plastic. This combination of the methods of ESTLANDER and HELLER sometimes is justified and saving. Apart from this case I saw several other patients thus operated in two sessions. But a repeated resection of ribs requires considerable strain. Two other secondary plastics were caused by costal osteomyelitis. Besides this not enough ribs had been removed and furthermore the pieces of the ribs removed were too small.

In case of the remaining 5 patients, the posterior back stumps of the ribs had been preserved in abnormal length as we can see in Ill. 17. This is a most important but avoidable mistake, which can occur in case of surgical removal of the empyema residual cavity, if the basic rules of thoracoplasty are not generally known. BOIFFIN through his student GOURDET proved already in 1895 with excellent examinations which are still of value today, that the compression of the thorax can be best accomplished by removing the posterior angle of the ribs. SAUERBRUCH and BRAUER always pointed out the importance of paravertebral resection of ribs for the collapse of the lungs. It is understood, that for the treatment of tuberculosis of the lungs one has to have exact knowledge of the numerous surgical proceedings which he has to know too for the removal of empyema residual cavities.

Setting aside this technical error, we must summarize that only one important avoidable cause for the failure of thoracoplasty and its repetition can be made responsible: Too small an amount of the resection of ribs or the removal of not enough ribs. Though one endeavors in every plastic to render the operation as preserving and small as possible, one should always face this fact in every plastic, lattice plastic as well, and the removal of empyema residual cavities

CONCLUSION

If one occupies himself thoroughly for years with empyema residual cavities, and operates far more than 100 patients with a method scarcely known hitherto, one should like to discuss points of view which seem to be important in special chapters. It could, however, not be avoided, to state some remarkable facts in different chapters before. Concluding this, I should like to point them out and show their importance.

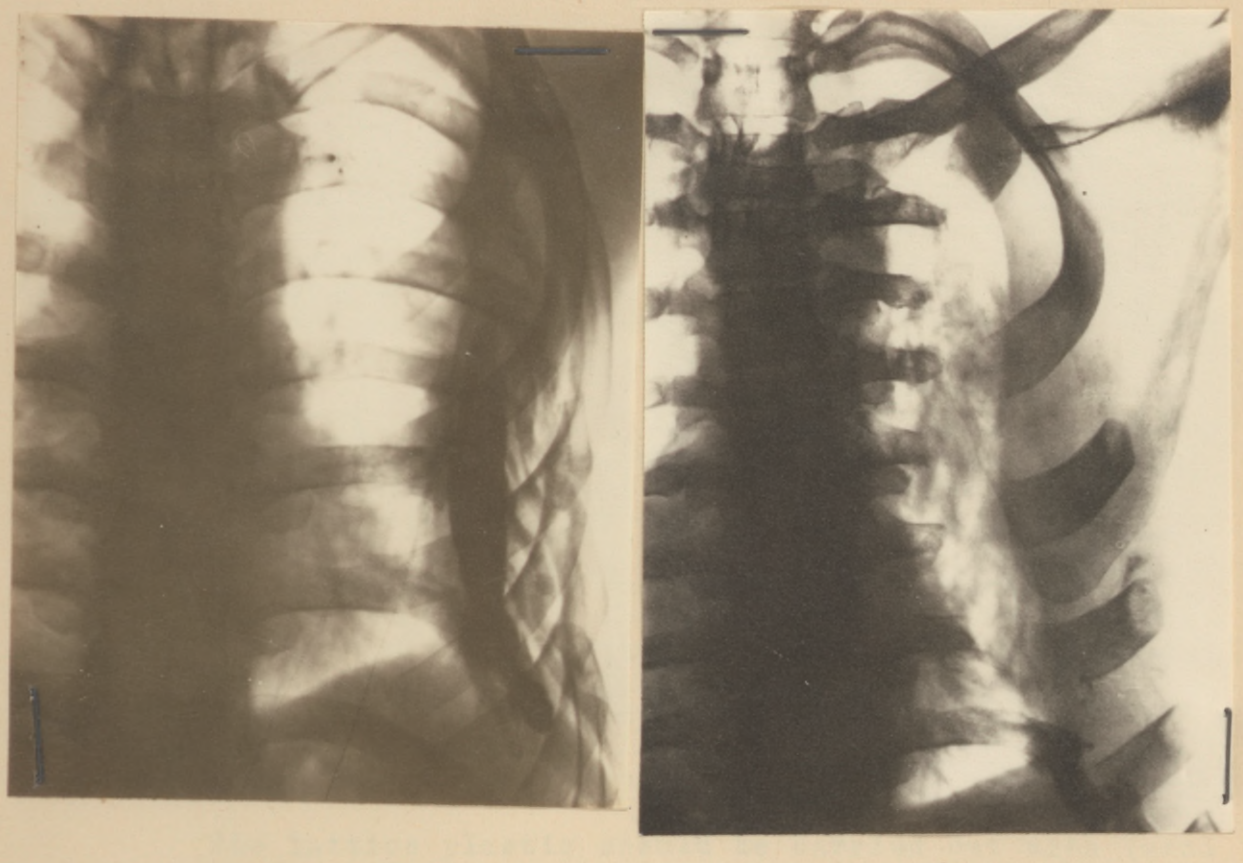
First of all we have to mention the blood transfusion. Its value is increasingly acknowledged in case of pleural empyema and its sequelae. K. VALENTIN pointed out that since taking up this method of treatment for pleural empyema in juvenile age, the mortality rate rapidly lowered. The false doctrine, prevailing for a long time, that blood transfusions, used for diseases in the field of the pulmonary circulation was a mistake, seems to be abandoned. Blood transfusion can in no case be eliminated for the preparation of the operation of empyema residual cavities, for fighting postoperative shock and for the after treatment after the operation. Its great importance can be understood fully, if one deals with the problem of the disease of protein deficiency, which may be fatal in case of pleural empyema. Such great and important progress in the theoretical and practical way has never been obtained in any field. Owing to this a reference to the methods, concerning blood transfusions, which is scattered over some chapters, seems to be useful.

The use of X-ray examination takes a special value for judging the empyema residual cavities. It is associated with several sources of mistakes. Pictures must always be taken from two sides. The cavities are regularly larger in the operation than they appear in the X-ray picture. Accessory cavities are usually not to be seen at all. An X-ray picture may give full information on fistula after preceding plastic.

The discussions of numerous special and rare aspects of disease should be of great interest. The closed residual cavity without bronchial fistula is not very well known, but the hemothorax residual cavity, recently described by me, is entirely unknown. In case of three patients empyema residual cavities have been discovered, which had been operated later on. They had 7, 11 respectively 25 years before suffered from pleural empyema and after having had a resection of ribs, an ostensible recovery had been obtained during such long periods of time. All these observations show that the empyema residual cavity offers even clinically many interesting problems, but as we deal almost entirely with technical operative questions in this volume, we have to renounce the discussion of the other problems.

SUMMARY

After having critically discussed the so far used methods for removal of the empyema residual cavity, we should like to refer to the new procedure of lattice plastic which, after having the experience of 150 operations with a low mortality rate, enables us, to close every residual cavity with excellent cosmetic and functional results. In this volume we described the observations of our first 100 plastics of which 71 were partial and 29 total cavities.



a
State before the second thoracoplastic. Empyema residual cavity is filled with Thorotrast.

b
Findings after successful second thoracoplasty with removal of the posterior stumps of ribs.

Illustration 18

Abnormally long posterior rib stumps as cause of unsuccessful thoracoplasty.

The cause of the empyema residual cavity was responsible 27% due to a mistake in the drainage, in 25% by too long continued puncture and rinsing, in 18% by a closed residual cavity, in 16% by a bronchial fistula, in 6% by an osteomyelitis of ribs, in 3% by an accessory cavity, in 2% by bad general condition and in 1% by a foreign body, while tuberculosis has been discovered in 2 patients later on. Such changes may happen, and for that reason exploratary excisions should be taken before each plastic.

Treatment with strong suction should be tried before each operation. The time for the operation has arrived, if the X-ray picture of the residual cavity shows no decrease in size of the cavity over 4-8 weeks.

The preparation for the operation is of great importance. First of all we have to take care of an extensive detoxication, furthermore all damages caused by chronic suppuration should be eliminated. Very frequently a protein deficiency is present which can be detected in the changes of the blood; in which case a blood transfusion is necessary.

The lattice plastic should be carried out with local anaesthesia. This can be done in about 90% of all cases, sometimes a slight ether anaesthesia in addition is necessary.

Sometimes a combination of HELLER's and SCHEDE's plastic has to be considered. In cases with thick and rigid callus we recommend to excise some parts of the inside, especially at the insertion point, to make the strips more flexible. Only once I had to resect the apex of the scapula. Bronchial fistulae do not require special methods of treatment in case of lattice plastic and usually heal by relaxation. Only two patients were operated in two sessions. With total cavities we always can preserve the first rib and sometimes even the second one. The lung tissue always shows good recovery after a lattice plastic. To judge the danger of the operation it is necessary to give number and length of the removed ribs.

Shock and secondary hemorrhage were the most important postoperative complications before. They can be avoided by immediate blood transfusion after every plastic or in the course of the after treatment, and by experienced treatment do not end fatally any more. The knowledge of the protein deficiency contributes essentially to its better understanding.

After lattice plastic the further after treatment is very important. The effect of an immediate start of massage is favorable. Breathing gymnastics, exercise in moving the arms and the vertebral column have to start as soon as possible. Blood transfusions too, have to be considered frequently. The treatment of the wound requires special care, sometimes rinsing.

The mortality rate was 3%. No death was caused by the method of operation. There was a discussion about metastatic cerebral abscesses and the danger of meningitis.

The time for treatment required after the operation is usually very short. Quite frequently late abscesses develop in the field of operation. Sometimes foci of pus remain in the depth. The general condition, appetite and increase of weight are more important for the judgement than the blood picture and blood sedimentation rate. One should not be hesitant about secondary operations. The permanent result of 90% of all patients who have been operated has been followed for the first six months after the operation and by others even for several years. The functional ability can be discovered spirographically. The advantages of HELLER's plastic, compared with SCHEDE's plastic are: No remaining paradoxical respiration, no paralysis of the abdominal wall, excellent cosmetical and functional result.

The plastic did not lead to any results in case of 5 patients. The cause was due to the method. The failure depended upon too quick regeneration of ribs, abnormal stiffness of the strips in the thick pleural callus, overlooked accessory cavities and too small an extension of the plastic.

Besides this, 4 secondary operations were necessary in order to dry out long lasting suppurations. The causes were similar to those of the secondary plastics.

The causes of the failures of 8 residual cavities, operated outside of our hospital were mostly abnormally large posterior stumps of ribs, or a too small extension of the first plastic. An osteomyelitis of ribs occurred twice.

Concluding I should like to point out the exceptional position of the blood transfusion in preparing the operation and in the after treatment as well as X-ray examination. Some special pictures of the momentary state in case of empyema residual cavities are displayed.

It might be important to know, that with no patient, hospitalized in our clinic has a plastic been refused or not been carried through.

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