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From: Assistant Technical Officer (Medical), U.S. Naval Forces, Germany
To: Chief of Bureau of Medicine and Surgery, (Attn: Chief, Publications Division).
Via: (1) Technical Officer, U.S. Naval Forces, Germany, (2) Chief of Naval Operations (Op-32-F2).

Subject: Experiences in 221 Aneurysms - by Dr. med. H. RUSSELT - Forwarding of a translation.

Enclosure: (A) Subject translation.

1. Because of its bulk enclosure A will be forwarded directly under separate cover to each recipient of this letter listed below.

2. This report prepared by Dr. Russelt of the Surgical Clinic of the University of Giessen is a straight forward excellently prepared discussion of the experience with 221 aneurysms. This is surely one of the largest collections of this sort compiled from the experience of a single clinic. It covers the early and late results observed in this series, including several cases of unusually long history and the operative results of 172 cases operated by Prof. Dr. Bernhard, the Chief of the clinic.

3. At the present time the University of Giessen is closed. An attempt is being made to reorganize the Medical Faculty and open an Academy of Medicine in the remaining buildings of the University Clinics. This is as yet only in the "hopeful" stage.

4. This manuscript is as yet unpublished and if publication in the U.S. is desired this officer has been promised that a release can be obtained.

5. The reserve supply of this folio is limited. It will be forwarded on a government bill of lading to the Publications Division, Bureau of Medicine and Surgery, Navy Department. Requests for further distribution should be directed to that division.

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

EXPERIENCES IN 221 ANEURYSMS

by

Dr. med. habil. H. N U S S E L T

With Illustrations

Translation prepared by:

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

I. SYMPTOMATOLOGY AND DIAGNOSIS

While the number of cases of damage to the vessels with subsequent clinical problems following such injuries does not play too big a part in peace time, an accumulation of such clinical pictures will always be observed in war times. Even in prehistoric wars the surgeons were dealing with the problems arising from injuries of vessels. The term "aneurysm" (aneurynein - to extend, one of the most important effects following injuries of big vessels) was first formed by HIPPOCRATES. In comparison with the last two world wars aneurysms occurred very seldom in earlier wars. Thus only 44 cases of aneurysms were counted in the war of 1870/71. It is certain that thousands of cases were observed in the first world war (1914/18). This makes it understandable that at that time extensive experiences could be collected in this special field. A further increase of this clinical picture was observed during the last war on account of the increased use of small calibre infantry bullets and shell and bomb splinters, but most important of all, however, on account of the increased flat trajectory of modern arms. Further problems arose in this connection and further experience concerning the early and late results and the operation technique could be collected, especially by new methods of examination, such as arteriography, oscillometry, measuring of the blood pressure in the veins and others. It seems indicated, therefore, to report about our experiences in more than 221 cases of aneurysms. In the beginning, however, we want to make some remarks, which seem to be important for the further understanding.

One can no longer believe in the former point of view that the vessels could parry a gunshot on account of their elasticity. In spite of the fact that some of the so called "fortunate gunshots" can only be explained in this way, gunshot experiments and more than that the experiences on men have proven that the above mentioned point of view is erroneous. While injuries of the big artery in the chest and stomach cavity regularly have a fatal outcome, this does not need to be true in cases of damage to the big peripheral vessels. A blood staunching might occur, especially in cases of gunshot wounds with narrow canals, on account of the piling-up of the

soft parts or on account of the counter pressure from the soft parts on account of the hematoma arising, or even on account of coagulation in the surrounding area. Besides these mechanical processes the decrease of the force of the heart and the blood pressure, the reduction of the speed of the blood stream and the centrally directed vessel contraction caused by the anemia all play an important part. Furthermore the active participation of the wall of the vessel is of importance as well as the formation of a thrombus which closes the vessel. While STICH regards the last mentioned circumstances as of subordinated, even of secondary importance and places the segmental contraction and retraction of vessels before, WILDEGANS regards the separation and coagulation thrombus as of the highest importance. Everybody who has seen numerous injuries of the vessels in the field will have to support the last mentioned point of view. Under special circumstances the ends of big vessels, separated by gunshots, are lying completely free in a big and gaping wound and are on both sides closed by a thrombus. At the time of a removal of this thrombus an arterial bleeding arises immediately. WILDEGANS did in numerous histological examinations of arteries injured by gunshots not find the "leaf-like rolling-in of the intima" as taught years ago. On the other hand tears of the intima were observed, running transverse or in the direction of the longer axis with widely separated inner layers and a development of fibres and more or less severe destruction. The knowledge of these processes in cases of injury to big arteries seems to me to be important for understanding the clinical development of the most frequent clinical problem following such injuries: The aneurysm-arterial.

According to how much such a blood staunching process develops, a more or less extensive hematoma occurs. The pulsation waves of the arterial blood stream are communicated to this hematoma especially in cases where a defect on the side of an artery exists. Thus we have the picture of a "pulsating hematoma". In contrast to the "quiet hematoma", where this communication is insignificant, the extravasated blood is absorbed only to a small extent. Moreover, a capsule of compact sclerotic connective tissue forms and limits the pulsating hematoma. This "formation of the sack" requires different periods of time and therefore no exact time limit is possible between the fresh injury of the vessel and the formed aneurysm. Regularly this takes several weeks. VON HABERER has seen it in 2 cases of axillary aneurysms as early as 8 and 12 days. VON BONIN has seen all symptoms of a completely formed aneurysm after 10 days. Therefore no free collection of blood can be found in the tissue in the case of this "fully developed aneurysm", but all the blood runs in closed spaces. A resorption and therefore a self-healing are then only possible by a thrombosis of the sack, a very rare occurrence. This we have seen, however, and we shall refer to it in the discussion of the spontaneous healing of aneurysms.

As we could confirm by numerous examinations, no endothelial lining of the sack is found histologically in the final state of the pulsating hematoma. At the most a participation of the layers of the vessel walls can be recognized in the neck of the sack, while the rest of the limitation consists of a more or less delicate fibrinous membrane corresponding to the age of the sack, which contains connective tissue like components. In only one case have we found an arrangement of connective tissue cells with an epithilial character as the lining of an aneurysm, and this aneurysm was 25 years old. Although the inner lining is sometimes smooth and shining, it is not formed of endothelium. The wall can furthermore be reinforced by the development of elastic fibres. Sometimes we see a piling up of calcium (see Ill. 10 and 11) and sometimes we can even see placques of bone, especially in such cases, where the bone is also injured. However, we have once observed bone cells in the wall of the sack of an aneurysm without any injury of the bone.

The size of the hematoma as well as the size and shape of the sack are multiform, different and changeable. This does not in all cases, depend on the size and the position of the vessel alone, but it depends on the kind of wound, on the surrounding coating of the soft parts, transport and so on. The pictures of the different regions of the body give an idea about the different sizes of aneurysms and their many varieties. In some cases the damaged artery extends for some distance right through the middle of the sack (according to STICH). The knowledge of this event is of some importance for the operative treatment. The effect of the modern arms of our days whereby several splinters may strike one vessel, makes it understandable that several aneurysms might develop in one vessel. On the other hand, one gunshot can as well be the cause of multiple aneurysms. BIER has observed a case where one gunshot has caused 3 aneurysms; two arterial, one each of the art. anonyma and subclavia, and one aneurysm of the artery subclavia. In one of our own observations we have seen how the carotis, the vertebralis and the v. subclavia were involved in an aneurysm.

As already mentioned above, an aneurysm can develop clinically in another method as well. A hemorrhage and an aneurysm might arise as a result of the separation of a thrombus which had closed a defect in the vessel for days and weeks. In all cases of quickly healing non-infected gunshot wounds of the soft parts, one's attention should be directed to this fact, especially, however, in cases of gunshots which pass through the effected part.

The greatest number of aneurysms arises on account of gunshot injuries, also by stab injuries. It has to be pointed out, however, that other causes might be considered as well, such as fractures, luxations,

strains and continuous rubbing or pressing of the vessel, (for instance the development of an aneurysm of the prof. fem. between the shell of a prosthesis and an osteophytic roughness of the stump of the femur. The effect of blunt force occurring but once also might cause an aneurysm. One should furthermore think of developing aneurysm subsequent to emboli as well as of lues and of arteriosclerosis.

Symptoms of the Aneurysma Arteriale

Direct and indirect symptoms help us to establish the diagnosis of an arterial aneurysm. The following procedures belong to the category of the direct symptoms

1. The formation of a tumor, which is caused by one or several more or less organized blood sacs attached to the artery.

2. The synchronous pulsation in this sac with the arterial pulse wave.

3. The thrill, synchronous with the systole which can be recognized by palpation as well as by auscultation.

The following procedures are regarded as belonging to the category of the indirect symptoms:

4. Interruptions of the circulation, where the pulse cannot be detected or with a weak pulse.

5. Irritation effects arising from the nerves.

6. Contracture position of the surrounding joints.

It will be easy to establish the diagnosis in cases where all or a large number of these symptoms, especially the direct ones, are found. Frequently, however, several of them and under special circumstances all of them are missing, so that disastrous mistakes may happen, as in one case of BRAUSCH, where the right leg was amputated in the hip joint because of a tumor (sarcoma) which really was a luetic aneurysm of the hollow of the knee. Furthermore a perilous situation might arise, if the diagnosis "Abscess" is made because of a tight elastic or even board-like tension which is accompanied by fever and other clinical symptoms suggesting an inflammation. A dramatic bleeding follows the incision, which can only be controlled by a very active intervention to avoid the danger of bleeding to death. Especially in cases of aneurysms of the throat vessels, symptoms occur occasionally which simulate a retropharyngeal abscess and their incision means death in almost any case.

On the other hand, swellings with a liquid content such as abscesses or cysts or soft tumors might be mistaken for an aneurysm, if they are lying over a large vessel in such a way that the pulsation waves of the vessel are transmitted to these swellings. In some cases even a pulse synchronous thrill can be recognized by means of the stethoscope, if pressure is put on the artery lying underneath. However, we are not dealing with an expansion pulse (lit: expansive pulse) as would be characteristic for an aneurysm, but with a transmitted pulsation. In such cases arteriography, to which we shall refer later, will be useful, although even it may fail in rare cases for the differential diagnosis between swelling and aneurysms. Thus DYES reports 2 cases, one where the filling of a "traumatically developed blood sac with contrast liquid failed to occur and may regularly fail, while in the other a solid swelling was dyed in toto by a contrast medium and was thus demonstrated in the X-ray". By knowledge of the medical history of the patient and by clinical observations, one usually succeeds in differentiating pulsating swellings, sarcomae with many vessels, angiomae pulsans cavernosum and similar clinical pictures from an aneurysm. The trial aspiration serves as an important auxiliary means for the recognition of an aneurysm. This trial aspiration is performed according to the directions applicable for a cold abscess. It extracts blood in case of a pulsating hematoma and a chocolate colored liquid in the later stage. Also from other signs one might detect the existence of an aneurysm, such as for instance from the kind of nerve interruptions. If a complete or far reaching loss of the nerves occurs in the moment of the damage, this is not considered in the aneurysm diagnosis. However, it can be used in cases where the same interruptions of sensation occur in course slowly, which can increase from a mild drawing pain to the point of intolerableness. Slowly arising paralysis as well as the formation of trophoneurotic interruptions should be evaluated in a similar method, In case of an enlarging aneurysm the patient often places the limbs in a relaxing position. Therefore, one should think of an aneurysm even in cases where no other signs are present but contractures of the joints,

All these clinical pictures, which are important for the recognition and for the differential diagnosis, were well known to the surgeons of the first World War 1914/1918. Recently additional methods of examination have been used, which are not only of diagnostic importance but which have also led to further criterias for the entire clinical process of an aneurysm. Such are:

Arteriography
Oscillometry
Measurement of the skin temperature
Measurement of the venous pressure

As these are of import nce for the arterial aneurysm as well as for the arteriovenous aneurysm, they will be discussed later on.

Complications

The patient suffering from a large injury of a big artery, which, however, did not lead directly to death from bleeding, is still exposed to the danger of death from bleeding. The spectre of postoperative bleeding is well known to every war surgeon. This postoperative bleeding sometimes occurs as a slight trickling of blood. Thus it must lead to the suspicion of an aneurysm and should furthermore be the reason for a careful revision (examination, renewed treatment) of the gunshot wound. The degree of danger of these postoperative bleedings can be recognized by the fact that LANG ascribes to it a mortality rate of 57%. Furthermore an internal hemorrhage may lead to a perilous condition. The following clinical pictures should direct our attention to this point: increasing pain in the extremities, paraesthesiae, swellings, edemas arising peripherally to the wound and a rising temperature. On the other hand, the opposite of a hemorrhage might arise as well, namely a thrombosis. The artery or the uninjured vein can be effected by this and a fatal lung embolism might be the outcome Arterial embolisms are also not too rare, although only in the brain do they lead to severe clinical pictures. Local necroses might by caused by the pressure of the aneurysm especially in the muscles but also even in the bones. We shall refer to all these complications later on because of some of our own observations. By the fact that our hospital reports camefrom clinics in the home territory, it can be explained that we did not see another very serious complication; gangrene of a limb, which might be caused by a thrombosis or by a compression of the main blood vessels by pressure from the hematoma. These clinical pictures were observed only in hospitals very near the front lines. Changes of the heart and of the blood circulation due to arterial aneurysm will be discussed later.

The Aneurysma-Arterio-Venosum

If the artery and the vein are opened during an injury and an open connection is thereby caused, the possibility of the formation of an aneurysm-arterio-venosum exists (VIRCHOW). The different forms of the mechanical process can be seen in Illustration 1. If the formation of the sac is missing we speak of an arterio-venous fistula. HUNTER who is regarded as the discoverer of this clinical picture, called this condition "aneurysma peranastomosim". The terms

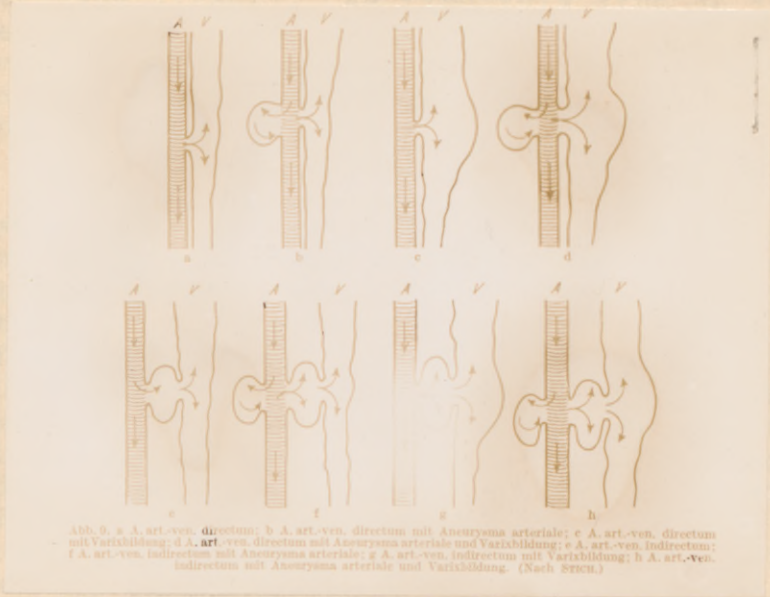


Abb. 9. a A. art.-ven. directum; b A. art.-ven. directum mit Aneurysma arteriale; c A. art.-ven. directum mit Varixbildung; d A. art.-ven. directum mit Aneurysma arteriale und Varixbildung; e A. art.-ven. indirectum; f A. art.-ven. indirectum mit Aneurysma arteriale; g A. art.-ven. indirectum mit Varixbildung; h A. art.-ven. indirectum mit Aneurysma arteriale und Varixbildung. (Nach STICH.)

Illustration 1

a) Aneurysm art. ven. directum
b) Aneurysm art. ven. directum with aneurysm arteriale
c) Aneurysm art. ven. directum with the formation of varix
d) Aneurysm art. ven. directum with aneurysm arteriale and the formation of varix
e) Aneurysm art. ven. indirectum
f) Aneurysm art. ven. indirectum with aneurysm arteriale
g) Aneurysm art. ven. indirectum with the formation of varix
h) Aneurysm art. ven. indirectum with aneurysm arteriale and the formation of varix (according to STICH)

"varix aneurysmaticus" and "aneurysma varicosum" were originated by SCARPA while SUBBOTITISCH has called the varix aneurysmaticus as "aneurysma arterio-venosum direct". We find this kind of aneurysm especially often as a result of rough small calibre missiles. According to our own observations the aneurysm arterio-venosum is far more frequent than the aneurysm arteriale.

With regard to the operative technique which will be discussed later on, it seems to be important to point out that in addition to the communication injury of the artery or of the vein or of both of them, a second place of damage may exist, out of which further traumatic aneurysms or varicosities may arise. On account of the increased arterial pressure which effects the vein we often find it considerably thickened in the peripheral as well as in the central direction, the vein thereby being "arterialized". The distension of the vein can therefore be explained on a purely hydrodynamic basis by the arterial blood stream entering the vein. According to WACHSMUTH it depends on the kind of aneurysm whether or not the widening effects the peripheral section of the vein or whether it effects principally the central part of the vein leading to the heart as we shall explain later on.

The clinical pictures are in many respects similar to those of the arterial aneurysm. It can be understood that in this case the danger of a bursting of the sac is relatively slight. Besides the formation of a tumor there is frequently in the background the presence of a continuous thrill which is transmitted towards both sides and which increases in systole and decreases in diastole. The same fact can as well be proven by palpation. In this case the hand lightly laid on feels a pronounced vibration.

We shall later on refer to changes of the skin temperature, the conditions of the blood pressure and so on. However, we want to point out right in the beginning, that a positive pulsation of the veins is the best indication of an arterio-venous connection.

On account of the interrupted conditions of the blood circulation we find edema, elephantiasis, trophic complications all of which are frequently far more developed than with the arterial aneurysm. Although the process of an arterio-venous aneurysm hardly ever develops, or with few symptoms, subjective complaints occur in almost every case. These subjective complaints, however, may be entirely different in each case and frequently are relatively slight. Thus it is understandable that arterio-venous aneurysms often remain without treatment for several years. In spite of the possibility that the clinical picture of the patient remains constant, there is always the danger of a sudden rapid growth, possibly even of a sudden

bursting. Furthermore the patient suffering from an arterio-venous aneurysm can be endangered by changes of the heart or of the blood circulation as will be shown later on.

Arteriography

Since the time when the demonstration of the vessels by contrast medium was introduced by MONITZ and SANTOS this method has won numerous supporters. The main indications for arteriography are diseases of the brain and changes in the circulation with chronic interruptions and acute obstructions. On the other hand, injuries of the vessels with their subsequent clinical problems (aneurysms) constitute a large field where arteriography is indicated.

Technique of Arteriography

In former days arteriography was used only on the exposed vessels. Later on the method of the percutaneous demonstration of vessels was used more and more and in our numerous arteriographies of recent years this percutaneous method was used exclusively. With some skill it will in almost any case be successful. It would be advisable, therefore, that one physician acquaints himself with this technique, and thus his skill and experience increases steadily. The largest number of the arteriographies of this clinic were performed by the assistants of the clinic, Dr. STOTZ and Dr. GLOCK. The instruments necessary for these purposes can be seen in Illustration 2.

It seems to me to be especially important to point out that needles of very small calibre should not be used.

Compared with the exposure method the percutaneous puncture of the artery has the advantage of causing only a small puncture wound and to reduce the danger of infection thereby. A repeated arteriography as is sometimes necessary, is much easier possible. Furthermore, it is easier to obtain an agreement with the patient for this procedure.

In order to prepare the patient we give a morphine injection or an injection with S.E.E. (weak) (Scopalamine HCl 0.0005, Eucodal 0.01, Ephetonin 0.025). With these injections puncture of the large vessels of the neck can also be made easier and the patient does not feel that it is so disagreeable, especially in those cases where the area around the canal of the puncture

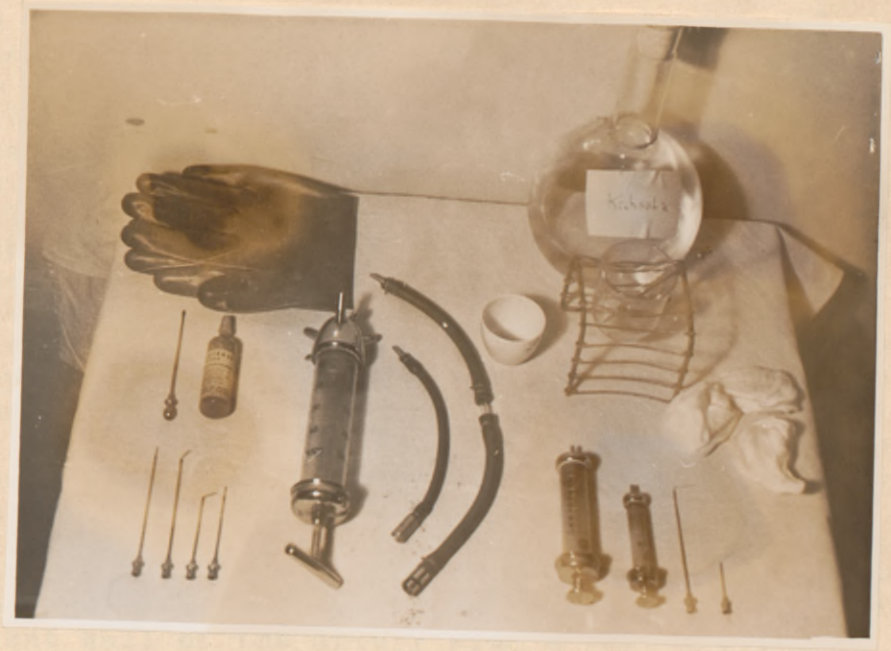


Illustration 2

The instruments necessary for the percutaneous arteriography. (Gloves, local anaesthesia, table salt for rinsing the syringe and the injection needles before use, contrans medium, Rotantaor Record syringe, rubber tube with a glass insert in the middle, up to which the suction might go, short bevel injection needles of at least 1 millimeter up to 1,2 millimeter thickness, according to the size of the vessels.

is rendered insensible previously by a local anaesthesia. The best method is to bring the needle right up to the artery after a careful palpation of the pulsating artery. This is indicated by a motion of the needle synchronous with the pulse. Then the syringe, which is partly filled with a solution of saline, is attached and the injection needle is suddenly pushed through the wall of the artery. A transfixion of the artery must be avoided. The flow of blood will then take place rhytmically and in a strong stream. If the patient does not suffer any pain the contrast medium may now be injected. If the exposure of the vessels for the arteriography cannot be avoided or, if an arteriography is to be performed during an operation, one should desist from holding the arteria carotis communis in a loop of tape as in this case the back wall of the artery may be pierced too easily. In any case holding the artery by a loop according to PHILLIPIDES is unnecessary. I am of the opinion that raising the front wall of the artery with a fine tweezer is much more useful. When puncturing the communis it will be best to insert the needle percutaneously after an exposure, as thus the needle is held more firmly. The piston of the syringe is pressed out by the blood pressure. This indicates clearly that the injection needle is in the proper position. In cases where an internal puncture of the carótid is intended during the exposure of the vessels, it will be useful to introduce the injection needle into the communis beneath the place of bifurcation and to insert the needle on into the interna. For the interna, about 8cc. and for the communis about 10 to 12 cc. of Thorotrast will be a sufficient quantity of contrast medium. The injection must take place as rapidly as possible, (therefore, a small calibre needle should not be used.) In cases where 2 pictures are wanted, a quick change of the plates must take place as well as a rapid turn of the head. DYES has therefore worked with 2 crossed X-rays from 2 tubes and PHILLIPIDES has used an injection and film changing device for the arteriography of the arm and of the leg. Even without these auxiliary means good pictures can be obtained, when the injections are made with a steady moderate pressure if the film changes are made quickly and if the physician and the medical personnel are accustomed to working together. For the demonstration of the aorta abdominalis PHILLIPIDES gives the following descriptions: The patient has to be on the belly. A needle 14 centimeters in length and 1 millimeter thick is introduced along the left side of the second lumbar vertebra 4 centimeters lateral of the mid line at an angle of 60°. At a depth of 11 to 12 centimeters the aorta will be reached. We have not had proper experiences of our own in this field.

In order to obtain a better demonstration of the post traumatic aneurysms one may impede the inflow of blood by an injection into the sack of the aneurysm with a tourniquet applied proximally from the aneurysm. By this method even a retrograde filling of the feeding

vessels may be obtained. In order to demonstrate an arterio-venous fistula the contrast medium has to be brought into the feeding artery. By a slight compression of the veins one can then obtain better pictures. The demonstration of arterio-venous aneurysms in the throat is relatively difficult as the contrast medium is very quickly diluted by the blood stream and carried away. In the case of sufficient skill and technique, however, one may even in such cases succeed in getting very descriptive pictures as shown in Illustrations 26 and 32.

Some authors have proposed the use of arteriography of the vertebral artery in vague cases of aneurysms in the throat. In this case a direct injection of the contrast medium into the aneurysm sack may be performed. If considerable pressure is used, the feeding artery will fill as well. Under special circumstances an exposure of the vertebral artery according to the classical method of KOCHER must be performed. We have been able to demonstrate an aneurysm of the vertebral artery by arteriography (Ill. 28).

The puncture of the subclavia takes place in the cavity of MOHREMHEIM. In this case the arm has to be brought into abduction and downwards traction applied. In order to obtain a better palpation of the artery, it might be useful to increase the pulsation by increasing the blood pressure by means of some drug, perhaps 0.5cc. Veritol injected intravenously. When the proper arteriographic technique is used the injection of 20 to 25 cc. Thorotrast will bring about a picture rich in contrast of the entire vascular tree. For the vascular tree of the femoralis, which we injected in the femoral canal, we need about 40 cc.

Obviously we must try first of all to perform arteriography with a minimum of pain and hazard. On the other hand we must also get pictures rich in contrast. We have used Uroselektan, Thorotrast, Perabrodil and Vasoselektan as contrast media. None of these contrast media can be said to be ideal for they do not meet the requirements, which we consider necessary. The iodine solutions which we formerly used for brain arteriography led to such severe and in some cases even fatal complications that their use had to be discontinued for demonstrations of the vessels of the brain. Thorotrast is undoubtedly the contrast medium which is best tolerated and has the least subjective inconveniences. However, we must not overlook the considerations expressed against Thorotrast. VON HABERER, first and later SCHUMANN and BAUER have expressed their opinion against it. Thorotrast is a radioactive substance which is not elminated and separated like other contrast media but is stored in the human body, principally in the reticuloendothelial system. In case of paraarterial injections it can be demonstrated in the tissue by X-rays for many months (Illustration 3) However, artifical radio-activity of tissues carries with it the danger of ulcer formation. The reason why we

Illustration 3

Contrast medium after paraarterial injection.

have not yet been informed about such clinical problems may be that we have to reckon with a latent period of 10 to 25 years. ECKSTROEM and LINGREN have demonstrated that the contrast medium persists in the shape of small drops or spicules in the very fine vessels of the brain in 60% of the fatal cases where an arteriogram was performed prior to death. These authors believe that the danger of damage to the brain increases parallel to the amount of Thorotrast used. In cases of careful consideration one will, therefore, desist from Thorotrast more and more and use another contrast medium, especially in such cases where repeated arteriographies are required. 50% Perabrodil, for instance is more suitable for the arteriography of the extremities than Thorotrast. In cases of sound kidneys it may be used repeatedly without danger. In this case, however, the sensitiveness of the patient to iodine has to be determined previously by potassium iodine solution.

The contrast medium "Uroselektan" has the disadvantages of causing pain during the injection and that the patient is therefore restless during the X-ray. Pictures with insufficient contrast might be a result of this restlessness of the patient. We have tried to avoid this by doses of S.E.E. (S.E.E. - Scopolamin, Eucodal, Ephetonin), 30 minutes before the arteriography. These attempts were not always successful, however. During the demonstration of the vessels of the neck of one patient we have had a very alarming incident with Uroselektan.

On account of injuries on the right side of the neck with interruptions of the circulation in the right hand we have first made an arteriography of the right subclavia with Perabrodil, which the patient tolerated without complications, During a further arteriography three weeks later with injection of 15 cc. Uroselektan into the percutaneously punctured carotid with a squeezing off the carotis at the upper part, a clear contrast shadow of the jugularis interna was seen in addition to an arterio-venous fistula. A few seconds after the injection life endangering complications arose with a tonic state of spasm, unconsciousness and respiratory arrest. The spasms started in the right side of the face and extended quickly to the upper and lower extremities. This condition lasted about 2 minutes. After the use of Lobelin, Calcium and Euvaperin, the threatening effects decreased. During the night the spasm recurred at an interval of three to four hours. Neurologically a considerable irritation of the brain was observed without any special localization. No abnormal clinical findings of the retina of the eye were observed. During the following days the spasms were less frequent and not so severe. However, only a slowly decreasing somnolence could be observed. For the period of three and a half days there was a retrograde amnesia from the moment of the arteriography on.

Vasoselektan gives pictures rich in contrast. The injection of this contrast medium takes place with practically no pain and only in cases of para-arterial injections do pains arise. The effects following the injections are in the form of a feeling of heat in the corrsponding limb or, more frequently, in the entire body. In some cases a clear dilatation of the capillaries with a pink skin was observed as well as a state of condition similar to a collapse.

In the case of carotid arteriograms PHILLIPIDES reported about irritation effects of the brain such as unconsciousness, aphasia, hemiplegia and spasms, in about one third of the cases. Therefore, if we want to express an opinion concerning the different contrast media at the end of these considerations based on our experiences, we would say that Thorotrast is the preferable contrast medium compared with all others, in spite of its radio activity, for arteriography of the brain. For all the other regions of the body, however, Vasoselektan or Perabrodil could be justified for first choice.

In cases of an aneurysm arteriography has proven to be extraordinarily useful for clarifying the circumstances. No matter that an expert vascular surgeon like VON HABERER has a rather critical attitude towards arteriography or at least believes that he can refrain from its use, the opinion of numerous other experts in this field indicates clearly that the arteriography is one of the most important methods of examination of aneurysms available today. Negative statements of LOEHR and CHRIST concerning an imperfect filling of an aneurysm should therefore be considered as outdated. By means of the above described skillful technique using a tourniquet which can be inflated applied above the vessels in question, the flow of blood can be reduced or interrupted as one chooses and the contrast medium can therefore be kept at the desired place. In this way arteriography gives us the necessary information concerning the kind, condition and localization of an aneurysm. The knowledge of these facts can be important for the preliminary planning of the operative technique. We can also draw conclusions concerning the formation of collateral circulation by means of arteriography. On the other hand the demonstration of the vessels may protect the physician from a false diagnosis and the patient from an unnecessary operation. Also the demonstration of the vessels <u>during</u> the operation may sometimes bring about important conclusions. Principally, however, it is the <u>postoperative</u> arteriography which permits us a far reaching judgement concerning the success of the operation, which gives us information concerning the patency of the sutured vessel and which, therefore, permits important conclusions concerning the advantages or disadvantages of the different methods of operation. Especially in cooperation with clinical examinations we can obtain a reliable picture. From a completely patent vessel we may

properly expect full capacity and there will probably be no limitations necessary during the cold of winter, while with a blood supply maintained only by collateral branches a different opinion has to be made.

In spite of all these advantages a too high estimation of this procedure must be avoided. As in the cases of organic diseases of the vessels we have to ask the question, when dealing with the aneurysm, whether or not the arteriogram corresponds to the real anatomical circumstances or if filling defects have to be considered. In the cases of an exposure of big vessels we see repeatedly a state of contraction which may even become a complete blocking. Also, in cases of operations of an aneurysm we find such segment spasms and we shall refer to that again later. On account of the examinations of MAGNUS, we know that not only mechanical irritations, such as for instance a prick, but also chemical irritations, as for instance blood's carbonic acid, adrenalin or histamin, Pituglandol may cause local contraction of the vessels, while in the larger surrounding area a contraction or dilatation takes place according to the strength and degree of the stimulus. The war surgeons of old times profited by this fact. They staunched the hemorrhage of large blood vessels in amputations by pressing on hot sponges which were soaked in vinegar-water. All these possibilities have to be considered when judging an arteriogram. The demonstration of vessels is, as a matter of fact, dependent on several components, furthermore, on the intruisic reactivity of the vessels to chemical or mechanical irritations, from the contrast medium (Uroselektan for instance might cause spasms, while Thorotrast does not cause any vascular spasm), on the differences in the concentration of the contrast-medium in the blood, on the different speed of the blood stream and finally on the technique of arteriography and X-ray. In spite of all these facts, arteriography is today an important and useful means for the judgement of the circumstances of the blood circulation with an aneurysm before, during and after the operation. With our patients, arteriography was used as well as measurement of the skin temperature, oscillometry and measurement of the venous pressure. In a dissertation SEDLACZEK has reported about measuring the skin temperature and oscillometry in case of aneurysms.

As mentioned before, the symptoms of severe congestion occur frequently with arterial as well as with arterio-venous aneurysms. In the case of arterial aneurysms, this congestion depends on a mechanical displacement of the channels of drainage, on the limitation of the arterial blood supply because of the hematoma which was formed or by the thrombosis. In case of an arterio venous aneurysm, however, the congestion is the result of a flow of arterial blood into the periphery of the venous system. The pressure in the veins which is thus increased is opposed to the normal venous drainage. On account of these different causes, different values had to be expected in the different cases of aneurysms when

measuring the skin temperature. The purely arterial aneurysms regularly showed a decrease of the temperature on the affected extremity or at least an approximately equal temperature in comparison to the sound side. With the arterio-venous aneurysms, however, we have regularly found a clearly increased skin temperature on the affected extremity in comparison to the sound limb. In some cases, this difference of the temperature amounted to several degrees Celsius. This increase of temperature was not only observed in the immediate area about the aneurysm but it could also be recognized further peripherally from the aneurysms. These differences in the temperature cannot be understood only in connection with the congestion. Today we know, as FRANZ pointed out before, that other additional regulatory means of the human body exist for the preservation of the body temperature in a certain section of the limb, which are of central origin as well as of sympathicotonic origin. With the sympathicotonic influence, the increase of temperature which remains or even increases postoperatively can as well be explained, similar to the rise of temperature following the periarterial sympathicotony. FRANZ has repeatedly recognized this postoperative rise of the skin temperature. At the same time he observed a lengthening of the leg amounting to 3 centimeters, 18 months after the traumatic development of an arterio-venous aneurysm on the thigh of a boy 12 years of age. HERLYN has recognized the same increase of the growth in length with a man 21 years of age as a result of disorders of the circulation because of an arterio-venous fistula of the popliteal artery, from which the patient had been suffering for 8 years. One can therefore take an increased arterial blood supply in the case of an arterio venous aneurysm for granted. This is also proven by arteriographic observations.

In numerous cases of arterio-venous aneurysms which have been demonstrated arteriographically, we have found a clear dilatation of the artery proximal to the communication, while peripherally a clear stenosis of the lumen could frequently be demonstrated. As V. BRAMAN has explained, the peripheral change of the artery is effected by the constant incomplete filling and the imperfect tension of its walls. We explain the dilatation by the fact that, on account of the communication with the vein, a new and larger area for the drainage of blood is open for the arterial blood. This circumstance must lead to a decrease of the pressure in the main artery. If we had to deal with an inflexible vessel system, a rapid decrease of the pressure in the main vessel, as well as in the side vessels extending from it, should develop according to purely physical laws because of this drainage of the circulating arterial blood.

A decrease of the tension would be closely connected herewith, which should result in a narrowing of the lumen of the supplying artery. The human body now

tries to accomodate to these circumstances. In order to equalize the difference of pressure in the main artery and the branches arising from it, an increased blood supply takes place, whereby a dilatation of the artery results. Thereby other arteries which form the collateral circulation and which soon branch out as far as the skin area, get essentially more arterial blood than before the existence of the aneurysm. This increased blood supply of the surface of the body explains the increase of the temperature. In other cases, we observed a clear rise of the temperature, especially in the area of the tightly filled veins. Undoubtedly a reflux of arterial blood is the cause of this event, which congests the veins backwards, starting at the fistula. On account of these observations, it is not quite understandable why BRAMANN could recognize a decrease of the temperature peripherally to the communication. He explains this by the fact that an increased loss of heat takes place on account of the slower blood circulation and on account of the marked distension of the blood vessels of the skin. For this process, however, considerable congestion might be necessary. Our numerous observations also did not confirm an explanation of BRAMANN concerning the dilatation of the artery. It is the assumption that a vein obliteration near the place of communication would influence the dilatation of the arteries, especially in the peripheral section, but not so frequently in the central section. By the congestion of the venous blood in the peripheral section, which depends on the above mentioned circumstances, the passage of arterial blood from the peripheral arteries into the capillaries and veins is considerably more difficult. This would lead to an increase of the pressure in the artery and to a dilatation. Apart from the fact that, according to our experience, we have no reason to assume a more difficult blood exchange in the periphery in the case of obstruction of a larger vein, we have found an obliteration of the vein in only one case, a carotid aneurysm, among our numerous aneurysm operations. According to our opinion, no purely mechanical and hydrodynamic circumstances cause the change of the artery, but principally physiological causes and above all the "blood hunger" which is caused by the arterio-venous fistula.

Besides these clinical symptoms in the artery (dilatation in the proximal section and narrowing in the distal section), the often enormous dilatations of the vein which were observed with the arterio-venous aneurysm can be easily explained. By the passage of the arterial blood, an increase of the pressure in the vein takes place purely hydrodynamically, which leads to a dilatation. According to WACHSMUTH, it depends first of all on the kind of the aneurysm whether or not only the part of the vein through which the blood drains off centrally takes any part in this process or if in addition the peripheral sections are more or less affected by this dilatation, This depends on whether we are dealing with only a small arterio-venous fistula or whether we are dealing with a fully developed aneurysm with the formation of a sac.

In the latter case, a diversion of the blood stream is easy on account of the "wind tunnel", so that the arterial blood is immediately led in the central direction and therefore venous congestions in the periphery fail to occur. In cases of small arterio-venous fistulae, however, the blood runs into the peripheral veins and there often leads to a high degree of congestion.

These conditions of the vessels can also be proven arteriographically. In Illustrations 4, 8, 9, 56 and 58 they can be clearly recognized.

The results which we have obtained by measuring the blood pressure of the affected extremities are in close cooperation with the above mentioned clinical effects. One can, therefore, not always work with the hemodynamometer of RECKLINGHAUSEN as in the case of fistulae located more proximally; the placing of the cuffs proximal to the fistulae causes difficulties. On the other hand, the ausculatory or palpatory observation of the pulse wave, which can just be recognized, is not always practical on account of the reduced blood stream peripheral to the aneurysm. In case of disorders of the blood circulation, we have used the oscillometer for years, an instrument which seemed suitable to us for obtaining an impression of the circumstances of the blood pressure without using the assistance of ausculation or palpation. We do not wish to describe details of this instrument, but it should be pointed out that by the use of this instrument, we possess the possibility for drawing conclusions concerning the nature of the wall of the vessel and the cross section of the vessel besides the fact that we can use this means for the observation of the blood pressure.

In both kinds of aneurysms, namely the arterial and the arterio-venous, we always find peripherally a decrease of the blood pressure. In cases of arterial aneurysms, this depends on their circumference and their location, in cases of arterio-venous aneurysms, it depends on the size of the arterio-venous communication. In any case, the decrease of the blood pressure is regularly more obvious with the arterio-venous aneurysm than with the arterial aneurysm. According to the above statements, a strong increase of the oscillometric index had to be expected with the arterio-venous aneurysm proximal to the arterio-venous communication. In fact, this is the case as the cross section of the vessel is not decisive for the oscillations. The cross section of the vessel, however, has to be considered as considerably enlarged, on the one hand because of the above mentioned dilatation of the artery itself and on the other hand indirectly because of the veins which contain back-flowing arterial blood and which, therefore, contribute to an increase of the pressure. The abnormally high oscillatory vibrations proximal to the arterio-venous connection are, therefore, even characteristic for the arterio-venous aneurysm. Peripheral to the communication, we can always see a marked flattening of the curve compared with the sound side. This means that the blood supply in this area is worse.

In case of arterial aneurysms, we have recognized normal vibrations proximal to the place of injury. Only in such cases where the lumen of the artery is narrowed by the pressure of the hematoma, by the formation of scars or of thrombi could we find decreased values. Also PHILLIPIDES obtained similar results with posttraumatic aneurysms.

By the measuring of the pressure in the veins, we have a possibility to support the above statements concerning the increased arterial blood supply with the arterio-venous aneurysms by the recognition of a positive venous pressure. In addition to that, we can exclude an arterio-venous aneurysm with certainty when these symptoms are missing. This is a procedure which we have used in uncertain cases (pseudo-aneurysms) for the forecast of the diagnosis.

Besides these more local peripheral effects of an aneurysm, we sometimes find very considerable changes of central nature in the heart and circulatory system. WIGDOROWITSCH was one of the first to point this out. During the first World War, GUNDERMANN collected basic knowledge in this field, together with WEBER, In a work performed during the recent war in our clinic, STOTZ has reported about "Changes of the Heart and Circulatory System in cases of Traumatic Aneurysms" and we shall copy his statements. This work, which was fully prepared in 1944, could not be published on account of the general circumstances of that time and especially as the author is still a prisoner of war in Russia (1946)).

GUNDERMANN and PAULY have observed several cases where a definite slowing of the pulse rate occurred when pressure was applied on the arterio-venous aneurysm. Thereupon further examinations were made in cooperation with Prof. WEBER, Bad Nauheim. GUNDERMANN (1915) and WEBER (1917) have later on reported about the results of these experiments, I do not want to discuss now the details of the explanatory descriptions of the findings, they are written down in the above mentioned medical reports. It was observed that with a decrease of the pulse rate of 20 to 36 pulse beats per minute associated with compression on the arterio-venous aneurysm, the duration of the diastole was increased three times its previous extent within a period of 3 cardiac cycles. Together with the decrease of the pulse rate, an increase of the blood pressure amounting to 15 to 25 millimeters, occurred and a distinct reduction in the size of the heart was observed during the pressure on the aneurysm. WEBER has explained this clinical event as follows: Because of the direct connection between a large artery and the vein, the average blood pressure can be kept at a moderate height only by considerable additional work of the heart muscles or the vessel muscles. Hypertrophy of the muscle elements which effect the compensation is to be expected. Now, if the aneurysm is compressed, the loss of pressure ceases suddenly and an increase of the pressure must occur because the compensatory activity of the hypertrophic muscles of the heart vessel system continues. This increase of the blood pressure causes a decrease of the pulse rate because of irritation of the depressor nerve. While normally a decrease of the pulse rate because of more complete diastolic fillings usually leads to an enlargement of the heart, the circumstances are different in cases of an arterio-venous aneurysm because a congestion exists in the right heart. This congestion is created by the fact that too much blood is brought into the central vein under high pressure and because of a broad arterio-venous connection which is relatively near to the heart. This surplus of blood is kept away by the compression of the aneurysm. As the system of the veins as well as the heart get only their normal quantity of blood, the diminution of the right heart can be understood.

Later, these symptoms have been confirmed by numerous other authors. During the treatment of more than 150 patients suffering from aneurysms during this war, we could observe that these symptoms, which were created by the pressure, can frequently be seen with arterio-venous aneurysms and, when this is the case, particularly on the large vessels next to the heart as well as in those cases with a broad arterio-venous connection. When dealing with aneurysms which are situated well in the periphery, even in cases of a broad arterio-venous connection, as well as in cases of aneurysms next to the heart with or without a small arterio-venous fistula (for instance in case of a small arterio-venous aneurysm of the art. carot. comm.) these symptoms are completely missing. Therefore, they are undoubtedly of a certain value for the evaluation of the seriousness of the vascular injury or for the changes of the heart and of the circulatory system, which in this connection also gives some clue to the prognosis and our indication for operation. Furthermore, I believe that they are an indication concerning the good adaptability of the organism; for in case of a mere dilatation of the heart and vessel system because of a flaccid insufficiency of the corresponding muscles against the enormously increased pressure created by the aneurysm, the above mentioned symptoms cannot be expected. For this, the permanent elasticity in the entire circulatory system is necessary, which the human body preserves by the hypertrophy of the muscular elements and by the possibility of an increase of the tonus which might perhaps be required as a measure of defense.

During the treatment and our examinations of several of our patients suffering from aneurysms since the first World War, we could observe how great the adaptability of the human organism is to the consequences of patients with a broad arterio-venous fistula which might even have been existing for a long time. In some of these cases, the aneurysm was successfully removed by an operation, even after such a long time. The results of these extensive examinations will be published later. In the following lines, we only want to take into consideration some observations of changes of the heart and of the circulatory system. In this connection, the result of a late examination of a patient seems to be especially interesting, of whose disease first of all GUNDERMANN (1915) and later WEBER (1917) have reported. On account of our request, Prof. WEBER, Bad Nauheim, was so kind as to make one more late examination of the same patient, whom I could present to him 28 years after his first examination. At this point, I want to express my very particular thanks to Prof. WEBER for the evaluation of this case and making the result of his late examinations available to me.

At the time of the late examination of the 54 years old patient (F.SCH., hospital report # 2832-42/43), an orthodiagram with and without compression of the aneurysm was made (Ill. 4) after an arteriographic demonstration of the aneurysm which had existed for 28 years. If we compare this illustration of the heart with the illustration of 1914 (Ill. 5), we find it remarkable that the diminution of the right side was essentially more pronounced in 1915 than in 1942 while, on the other hand, the diminution of the left side of the heart was far more pronounced in 1942 than 28 years ago. The increase of the blood pressure and the decrease of the pulse rate in the case of pressure on the aneurysm existed now, although they were not present to such an extent as in the former times. The difference of the pulse rate amounted only from 6 to 10 pulse beats per minute and 10 millimeters hemoglobin. The pressure of the vein in the percutaneously punctured vena femoralis amounted to 156 millimeters hemoglobin, at a point a few centimeters above the

Illustration 4

Arteriography of a 28 years old broad arterio-venous fistula. An extended dilatation of umerous veins as an indication of a considerable venous congestion and surplus blood in the periphery can be seen. The artery is demonstrated as widened out for the breadth of a thumb above the fistula.

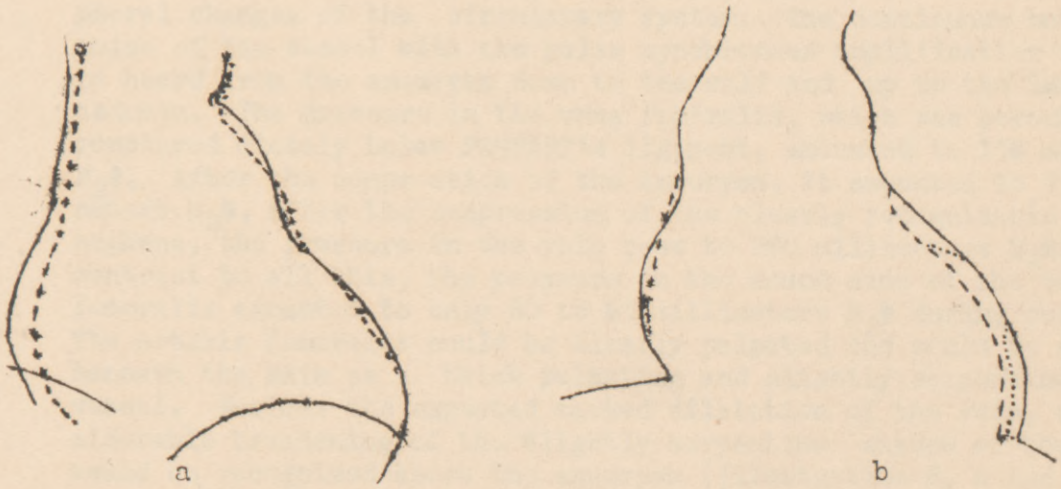


Illustration 5

(1914 accord. to GUNDERMANN)

——— border of the heart in case of an uninfluenced aneurysm

– – – – – border of the heart in case of compression of the aneurysm

1942

..... border of the heart in case of pressure on the aneurysm for 5 seconds.

– – – – – – – border of the heart after a pressure of 20 seconds on the aneurysm.

(To the case F.Sch. Nr. 2832-42/42)

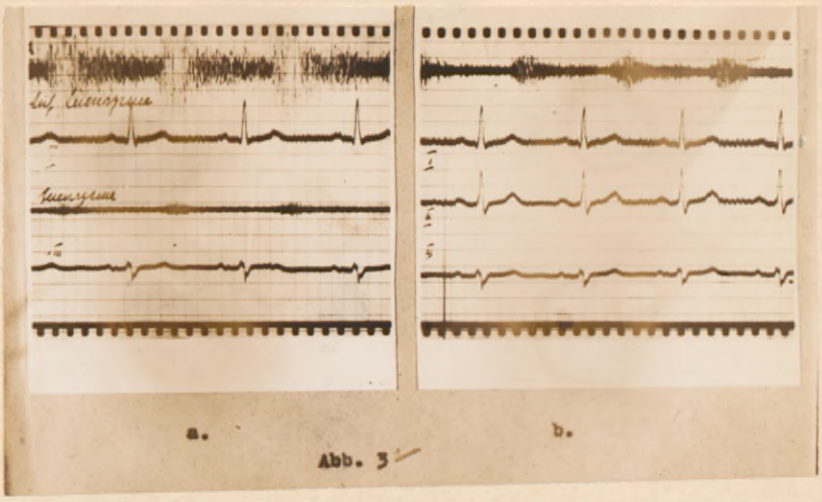
The orthodiagrams of a heart which is dilated on both sides in the case of a broad arterio-venous fistula of the art. femoralis, which existed since the gunshot injury in 1914).

arterio-venous fistula, and it amounted to 5 millimeters hemoglobin on the sound right side. If we now use the electrocardiogram for the completion of the entire clinical evaluation (Ill. 6), we shall see that there are no pathological changes recognizable with or without compression of the aneurysm. The patient himself declared that with his wounding in 1914, his pains increased slowly but steadily, especially in the left leg. (War disability was fixed at 80%). However, he could not make up his mind, for an operation as he had an easy job as a tax inspector, which he could perform quite well. The difficulties of two other patients suffering from large arterio-venous aneurysms due to an injury of the first World War, finally increased so considerably and the changes became so important that they came for an operation. One of them, W.M., was a locksmith in the age of 44 years. Since he had received an injury by a shell splinter in 1918 he was suffering from an arterio-venous aneurysm of the right thigh with a sac of the aneurysm as big as a cherry at the beginning (War disability 60%). Because of the rupture of the sac , this aneurysm sac grew in several stages to the size of a child's head and thus led to severe peripheral disturbances of the circulatory system with pain. In the course of the years, the patient was, furthermore, suffering from increasing heart trouble, The examination showed a dilatation of the heart, especially to the left side (Ill. 12). In the electrocardiogram (Ill. 7), no definite sign is seen of myocardial damage.

On account of the abnormal size of the aneurysm sac and because of the intense filling with blood, there were extensive peripheral changes of the circulatory system. The continuous buzzing noise of the vessel with the pulse synchronous amplification could be heard from the aneurysm down to the calf and up to the lower abdomen. The pressure in the vena femoralis, which was percutaneously punctured closely below POUPART's ligament, amounted to 150 millimeters H_2O. After the compr ssion of the aneurysm, it amounted to 95 millimeters H_2O, after the compression of the clearly recognizable vena saphena, the pressure in the vein rose to 280 millimeters H_2O. In contrast to all this, the pressure on the sound side of the vena femoralis amounted to only 60 to 65 millimeters H_2O during rest. The arteria femoralis could be clearly palpated and could be well seen beneath the skin as a thick pulsating and slightly serpentine vessel. Besides the expected marked dilatation of the vein, a considerable broadening of the slightly serpentine shadow of the artery could be recognized above the aneurysm (Illustration 8, a and b).

During the operation (Prof. BERNHARD), the large sac of the aneurysm was removed in toto, the arterio-venous connection was removed and the artery as well as the vein were supplied with a suture. Because of its size, the extirpated sac of the aneurysm was very impressive, even as a macroscopic preparation (Ill. 10). In the structure of the aneurysm wall, it could be clearly recognized which part of the sac had to be considered as the older one and which part had to be regarded as having developed only recently by the last rupture (Ill. 11).

The success of the operation was excellent with regard to the local as well as to the general findings. The artery which was treated by a circular end-to end suture has remained quite patent. (Ill. 9, a and b).

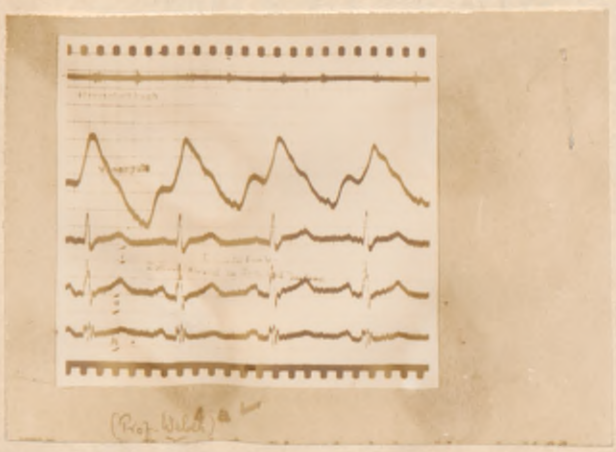


a b

Illustration 6

EKG with photographic reproduction of the sound of the aneurysm of the patient F.Sch. (Prof. WEBER). In tracing a, we have the sound curve of the aneurysm with the degree of amplification exactly as we are used to seeing for the heart tones. One can see extraordinarily large amplitudes of a high frequency, constant noise, which is considerably amplified during systole. In tracing b, the sound of the aneurysm is drawn with a considerably dampened amplification, so that the systolic noise contrasts especially well. The electrocardiogram is absolutely normal, the picture of the sound of the heart shows an insignificant systolic noise.

Illustration 7a



The electrocardiogram of W. M. (Prof. WEBER) shows: sinus tachycardia, indifferent type of the ventricular complex, no definite sign of myocardial damage. Heart sound with low and high definition of the amplifier completely normal. Venous pulse: very large presystolic wave and a small systolic wave. The systolic collapse ends in time. According to the tachycardia and the short diastole due to it, the diastolic wave is only slightly developed. The large presystolic wave speaks for an increased activity of the right auricle. The small systolic wave speaks for a small pulse volume.

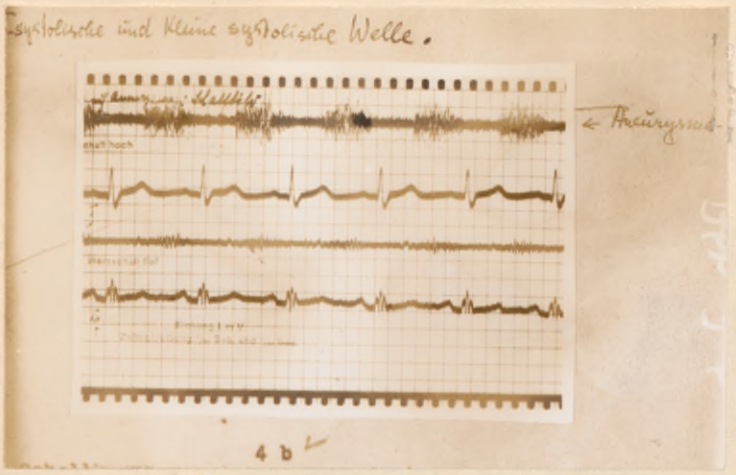


Illustration 7b

The sound curve of an arterio-venous aneurysm, taken near the place of exit of the bullet, shows a continuous series of high frequencies which indicate a strong crescendo and then again a descrescendo beginning from the last third of systole until well into diastole.

Illustration 8
(a and b, could not be reproduced with the facilities available.)

(Case W.M.) The arteriogram in two planes shows a large arterio-venous aneurysm with two broad shadows of the highly dilated arteria femoralis and corresponding vein. In the soft parts, several shell splinter shadows can be seen. Above an aneurysm sac the size of a fist with a calcium infiltration in the wall, another bigger sac without a calcium shadow can be recognized.

Illustration 9
(a and b, could not be reproduced with the facilities available.)

(Case W.M.) The arteriogram shows the condition following the operative removal of a 24 year old arterio-venous aneurysm with a circular suture of the artery. The abnormal difference of the size is particularly marked at the place of the suture, which is quite patent between the highly dilated and tortuous upper section and the lower part of the arteria femoralis, which is only normally wide.

Illustration 10

(Case W.M.) The pathologico-anatomical preparation of the sac of the aneurysm of the femoralis which was removed and which had grown as big as a child's head within 24 hours.

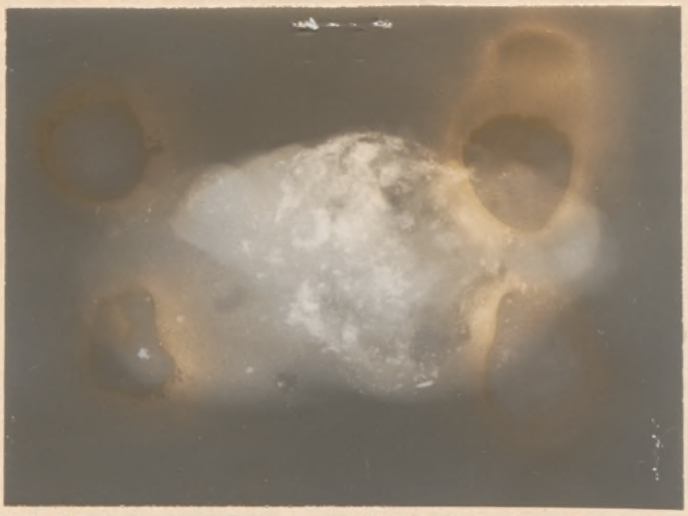


Illustration 11

In the soft X-ray of the aneurysm-sac demonstrated in Illustration 10, it can be seen that there are numerous irregular shadows in the sections marked by the arrow (↓), corresponding to calcium infiltrations in the sac wall of that part which has existed for a long time. In the rest of the area of this preparation, no or only a very few calcium particles can be recognized. This corresponds to the total size of the aneurysm, which has developed only because of ruptures of the sac wall during the last few years.

Illustration 12

could not be reproduced with
the facilities available.

Illustration 12

Case W.M. In the X-ray, a dilatation of the heart, particularly towards the left side, can be seen with a 24 year old large arterio-venous aneurysm of the arteria femoralis in the lower part of the thigh. In the illustration, the contours of the heart of the control X-ray are marked, on account of which a diminution can be recognized, especially on the left side.

The peripheral disorders of the circulation as well as the other troubles have decreased considerably; even the heart trouble has improved according to the statements of the patient. The heart itself decreased slightly after the operation, as can be seen in the X-ray controls in comparison to older photos (Ill. 13). Also in the case of the other arterio-venous aneurysm which was removed by an operation 28 years after the wounding, the changes and inconveniences of the circulatory system and of the heart were within tolerable limits for many years. The patient, who is now 50 years old, (F.St., Nr...), was not particularly disabled at the time the disability was evaluated at 40% so that he decided to ask for an operation only now, since increased trouble has arisen. The heart of the patient was only slightly dilated on the right with an otherwise normal finding and an unchanged electrocardiogram, although the patient was suffering from considerable disturbances of the circulation in the injured leg. Besides a dilatation of the vein in the form of a sac , the arteriogram of the aneurysm with a broad arterio-venous connection in the middle of the lower leg shows an essentail dilatation and a slight winding of the artery femoralis above the aneurysm.

The observations of several aneurysms which were all older than 20 years demonstrate that the human body disposes of a far-reaching adaptability to the given pathological circumstances. On the other hand, they also prove that in case of the existence of an aneurysm sac , the danger of a rupture with the corresponding results will always remain and that this danger is not completely removed by the protecting calcium deposits in the wall of the sac . Furthermore, the increase of the disorders of the circulation can be explained by the fact that with the increase of the size of the lumen of the artery and of the vein in the area next to the aneurysm, the connection between the artery and the vein becomes wider as well, and that, therefore, a circulus vitiosus develops . In cases of arterial, as well as of arterio-venous aneurysms, the size and localization are of decisive importance with regard to the late results as well as with regard to the changes which develop soon after the injury, while in cases of large arterial aneurysms, the menace of dangerous complications (such as rupture or gangrene) exists most often only in the periphery, one has to reckon with early severe changes of the heart and of the peripheral circulatory system in cases of broad arterio-venous connections with and without sac formation.

In the case of several of our aneurysm patients whom we have treated during this war, we could observe how intense these disorders of the circulation may be even within a relatively short time after the injury. Thus, we have treated a soldier 20 years of age (W. FR., case Nr. C1) who was suffering from the following considerable peripheral and central disturbances of the circulation because of a broad arterio-venous fistula on the left side of the iliaca communis, closely below the aorta: There were marked signs of congestion in the left leg with a swelling of the thigh of up to 11.5 centimeters in contrast to the sound side, a dilatation of a high degree of the subcutaneous veins of the left leg and of the lower abdomen, pronounced ascites and a swelling of the liver as well as of the spleen, bronchial congestion and a considerable dilatation of the heart in all directions (Ill. 13). Over all ostia, a systolic noise could be heard, which was the loudest in the second intercostal area (ICR) on the left and beside the sternum at the bottom, left. Electrocardiogram: Sinus tachycardia of 100, PQ 0.13, QRS widened to 0.12, high T-waves, high P2 and P3,

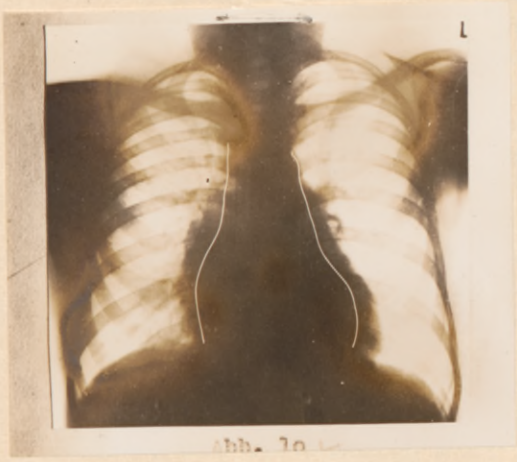


Illustration 13

(Case W.F.) Considerable dilatation of the heart in all directions in the case of a broad arteriovenous fistula in the left common iliac, closely below the aorta, 8 months after the injury. The contours of the heart marked in the control X-ray picture a fortnight after the operation of the aneurysm show the essential diminution of the heart.

no evidence of a myocardial damage reflected by a disturbance of the conduction system. Dr. KORNMANN, a specialist for internal diseases, regarded the considerable decompensation of the circulatory system as due to the tonogenic dilatation of the heart, especially towards the right side with tricuspid and probably also with mitral insufficiency. As a result of the operation of the aneurysm made by Prof. BERNHARD, 8 months after the injury, all disturbances of the circulation have decreased surprisingly early. The diminution of the heart after the operation , which can be recognized in Illustration 13, is especially impressive. We have furthermore treated a 28 year old patient who, on account of a war injury, suffered from an enormous dilatation of the heart with the formation of a broad arterio-venous fistula of the femoralis closely below POUPART's ligament, which in the same way has decreased rapidly as a result of the operative removal of the arterio-venous connection 5 months after the injury (Ill. 14). In this case, the peripheral disturbances of the circulation were considerable even before the operation, whereas the electrocardiogram was practically normal.

The extensive ability of the heart for recovery from this marked degree of dilatation is considerable. The hearts of the patients who were wounded only a short time ago have decreased more after the operative removal of the arterio-venous aneurysm than those of the patients with aneurysms as old as 20 years and more. This can be probably explained by the fact that the dilatation is later joined by hypertrophy. The long-lasting pathological state will later have definitely unfavorable effects on the elasticity of the heart.

This is true also with regard to the often considerable dilatation of the arteries above an arterio-venous aneurysm, as can be seen in Illustration 8. The dilatation has only slightly decreased after the operative removal of the 24 year old aneurysm. Furthermore, the observation, obtained from arteriographs seems to be of importance, that the section of the artery lying above the broad arterio-venous connection increases its size in all directions. Not only a broadening, but also an increase of the length can be observed, which can be recognized by the tortuosity of the artery and turning to the side as an angle at the level of the quite patent location of the suture (Ill. 9, a and b).

We have observed such dilatation of the artery not only with the aneurysms of the first World War but also with aneurysms following injuries of this war. In every case, several months seemed to be necessary for the development of such changes of the artery. Thus we have seen a clear widening of the arteries in the case of a 2 year old arterio-venous fistula of the popliteal artery (Ill. 15). Also on a smaller vessel of the peroneal artery, an essential increase of the size of the artery above the arterio-venous connection could be observed with an arterio-venous fistula of 21 months duration (Ill. 16), which has promptly recovered after the operative removal of the aneurysm. The vessel of this 29 year old patient had not lost any of its elasticity at that time.

These were the statements of STOTZ. In addition, it should be pointed out, that as a result of their examinations, WACHSMUTH together with KLEINSCHMIDT and RIDER all came to the conclusion that the phenomena observed in the heart, caused by the arterio-venous aneurysm are, above all, of a mechanical nature. GERLACH and HARKE have observed decreases of the pulse after a spinal anaesthesia and after a periarterial sympathectomy. It was mentioned that during the narcosis of the experiments, the decrease of the pulse frequency was not so very pronounced.

Illustration 14
could not be reproduced with
the facilities available.

Illustration 14

(Case J.F.) Dilatation of the heart in all directions with a broad arterio venous fistula of the femoralis closely below Poupart's ligament, 5 months after the injury. The heart size, which is marked, is noticeably smaller and corresponds to the contours of the heart of the control X-ray four weeks after the operative removal of the arterio-venous connection.

Illustration 15

(Case G.N.) The arteriogram shows an arterio venous fistula at the level of the large shell splinter at the bend of the knee, 2 years after the injury. The point of the needle lies in the popliteal artery, which is percutaneously punctured for the contrast medium injection. The popliteal artery can be clearly seen as a widened vessel band above the fistula, which is of only normal size beneath it. Behind the artery, one can see the broad vein.

Ill. 15

Illustration 16

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the facilities available

Illustration 16

(Case O.B.) The arteriogram shows a widened vein besides the arterio peronea demonstrated as evidence of an arterio-venous fistula at this place, 21 months after the injury. The arteria peronea is clearly widened above the fistula in comparison to the other arteries of the lower leg.

As the local influence can be eliminated at the place of the pressure by disconnecting the paths of conduction, it can be presumed that the decrease of the pulse rate is caused by the variation of the pressure in the heart itself. This happens in a reflex manner through a very sensitive nerve arising at the mouth of the large veins (BAINBRIDGE). WACHSMUTH has also made examinations concerning the reaction of the minute and pulse volume and has found an increase of 100%, especially in those cases where an infection existed at the same time. However, also after the disappearance of the general symptoms, a certain difference could still be clearly recognized, and that can be demonstrated by interrupting the circulation on the sound side and the ill side by pressure. Only after the operation, an interruption of the aneurysm by pressing produced hardly any change of the pulse volume and minute volume.

For the completion and the illustration of the values of the blood pressure, the change of the pulse rate and the oscillometric results, we are now going to describe another case of an arterio-venous and one case of an arterial aneurysm:

Case C 20

Diagnosis: Arterio-venous aneurysm of the right femoral artery. The injury was caused by a gunshot with an infantry bullet through the right thigh, No serious arterial hemorrhage arose. On the 5th day after the injury, the aneurysm was recognized because of a buzzing and the pulsation. For a longer period, an infected hematoma and an acute osteomyelitis existed.

Measurements before the operation:

Blood pressure (oscillometric)

	right	left
Thigh, above the aneurysm	220	140/65
Lower leg	95	135/55
Upper arm, above the elbow, normal	108/55	
upper arm, above the elbow, during compression of the aneurysm	102/65	
upper arm, during compression of the sound femoral artery	115/60	

Pulse:

Normally	74
during compression of the aneurysm	62
during compression of the sound femoral artery	74

Illustration
to case C 20. Description see there.

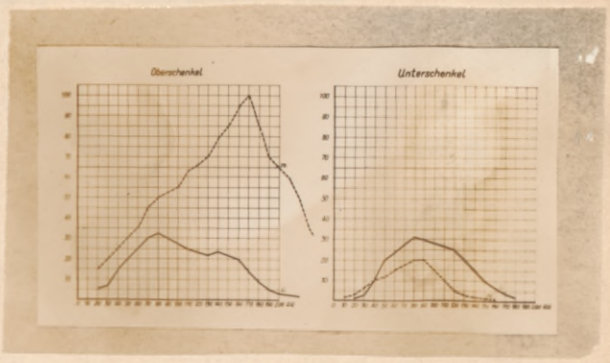


Illustration
to case B 30. Description see there. (Measure before operation)

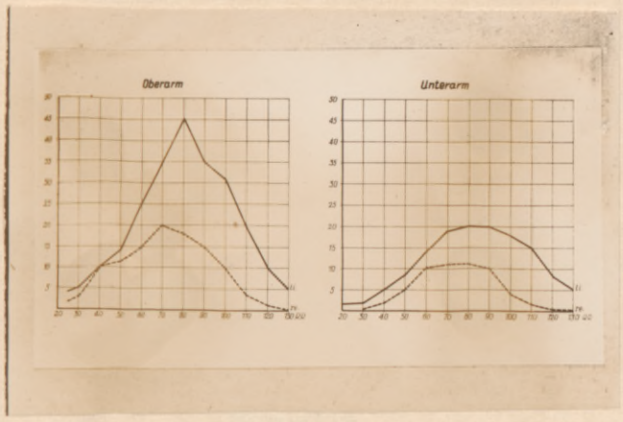
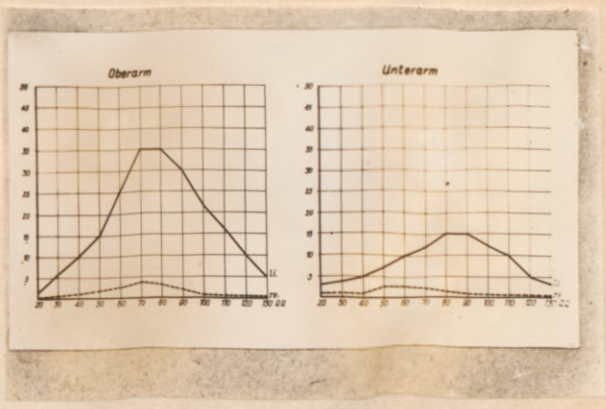


Illustration
to case B 30. Description see there. (Measure after operation).



Oscillometry:

The curve for the affected thigh above the aneurysm is many times as high as the one of the sound thigh, because of the markedly increased blood supply by the "Arterial" vein blood. In contrast, the oscillometric variations of the affected side are considerably less than those of the sound side in the lower leg as a result of the poor blood supply with arterial blood.

Case B 30.

Diagnosis: Arterial aneurysm of the right axillary artery. The patient was injured on 5 September 1943 by a shell splinter with the splinter lodging in the affected part. The aneurysm was recognized for the first time in February 1944.

Measurements before the operation:

Blood pressure (Riva-Rocci)	right	left
U per arm, below the aneurysm	105/55	125/55
Lower arm	80/55	125/65
Upper arm, during compression of the aneurysm		129/55

Pulse:

Normally	64
During compression of the aneurysm.	66

Temperatures (thermo-electric):	right	left
MOHRENHEIM cavity (infraclavicular fossa)	28,3°	29°
middle of the upper arm	26,3	27,2
middle of the lower arm	25,2	27,2
back of the hand	26,3	27,3

Oscillometry:

The curves on the upper arm show an increase of the oscillometric index to 45 on the sound upper arm in comparison to 20 on the affected upper arm.

The curve on the sound lower arm is also twice as high as that of the affected side. This finding corresponds to the arteriogram, which shows an arterial sac of the aneurysm with a clearly recognizable stenosis and an insufficient blood supply. On the 16th of March 1944, an operation of an arterial aneurysm of the axillary artery was made with exposure of the sac, which was about the size of a hen's egg. The ends of the arteries were removed and a circular suture was made. After this, a pulsation could be palpated in the artery where it carried the blood away from the aneurysm site.

Measurements after the operation:

Blood pressure (Riva Rocci)	right	left
Upper arm	----	112/50
Lower arm	----	105/55

The blood pressure could not be measured on the affected arm, as the pressure was too low.

Temperatures:	right	left
MOHRENHEIM cavity (infraclavicular fossa)	31,8°	31.5°
middle of the upper arm	32.0	30.7
lower arm	29.2	28.8
back of the hand	29.9	29.2

Oscillometry:

The curves of the affected upper arm and lower arm are considerably flatter, which fact also emphasized the insufficient blood supply on the affected side after the operation.

II. INDICATIONS FOR OPERATIONS.

A. General Facts.

The operation of an aneurysm can be one of the most difficult operations of all surgery. The principal reason for this is that surprises occur again and again in spite of sufficient surgical skill and wide experience in this field. These surprises do not permit a "typical" method of treatment. In many cases, these sur-

prises and incidents are dangerous to life and only a very active intervention combined with sufficient experience can prevent severe physical damage or even death. As one of the first and absolutely necessary conditions we regard the exact knowledge of anatomy, sufficient surgical experience as well as a knowledge of anatomical function, although one cannot speak of normal anatomical conditions in cases of very extended aneurysms. In spite of these facts, the advice of LERICHE appears hazardous to us, which was to desist from a clear anatomical exposure of the area of operation and to be "less anatomical, less desirous of knowledge of all details". Especially in thoses cases where the method of MATAS is supposed to be used, LERICHE recommends avoiding such an exposure. We can only agree in part with this recommendation not to be too exacting in the knowledge of all details under certain restrictions. As HERLYN has pointed out, too, some freedom should be shown in this case. By incisions which should be large enough and by favorable exposures, the area of operation should be clear and in such condition that everything can be well seen. The sparing of one small nerve must not hinder clear vision or consume time. Large aneurysms often require much time in any case. This fact should be considered before the operation. Furthermore, those big operations require considerable physical and psychic achievements from the surgeon. Therefore, only a fully trained surgeon should dare to perform such an operation, especially as the outcome of the operation can never be predicted with certainty. Difficulties arising during the operation lead either to an inappropriate treatment which is harmful for the patient, or they leave no other choice than that of interrupting the operation, whereby a later operation, which has to be performed in any case, becomes more difficult. Therefore, the instruction in the former German Army to gather all cases of aneurysms in special hospitals seems to have been fully justified. It might be regarded as a proven fact that the success of the operation will increase if the patients are in the hands of some skilled surgeons, and that the experience of the surgeon in this field increases the more he is acquainted with it. Because of this reason, all cases of aneurysms were operated by the director of our clinic himself, Prof. BERNHARD.

b. Indications for operations

Particularly during World War I, but also until a couple of years before the outbreak of World War II, the points of view concerning the necessity of an operation in case of an aneurysm varied widely. BIER, who first favored conservative therapy, later on advised surgical treatment more and more. SAUERBRUCH did not consider the operation of a fresh aneurysm as indicated, however, in cases where an operation was necessary after a lengthy period of time, perhaps after months or years, he did not express any concern against a ligature of the vessels. The above mentioned subsequent clinical problems and the complications which may follow an arterial as well as an arterio-venous aneurysm should leave no doubt, that the removal of an aneurysm is certainly the more desirable method. Even the existence of an aneurysm for weeks, months, or decades does not protect the patient from serious complications, as has been proved in our case W.M., (see page 19) and in a case published by ROTHMANN.

In the course of 20 years following an aneurysm of the common carotid which had grown from the size of a pigeon's egg to the size of a child's head, centers of softening of the brain had arisen in the right parietal lobe and in the temporal lobe of the brain as a result of a compression of the common carotid. Sudden unconsciousness and hemiplegia have quickly led to death.

WILDEGANS describes the case of a woman with a gunshot aneurysm, inflicted during World War I, which had persisted through 25 years. Instead of a fistula, a considerable cicatrical stenosis occurred, which led to a sac like distension and an angulation of the afferent femoral artery, and to an enormous general congestion of the veins. In a case reported by PHILIPIDES, the arteriogram of an arterio-venous aneurysm of a 50 year old man, which was inflicted during World War I, showed a much distended vein at the level of a fistula of a false aneurysm. Even if it shows no inclination to grow at first, even if there are no or only insignificant complaints, even if an operation might be dangerous owing to the unfavorable location of the aneurysm, it should be attempted to remove the aneurysm by operation. Though spontaneous healings do occur and have even been observed by us, they are comparatively rare. Among the 172 cases of aneurysms observed by us, spontaneous healing occurred but 6 times.

Speaking of spontaneous healing, we must make a difference between the healing of fresh injuries of the vessels and pulsating hematomas on the one hand, and that of fully developed aneurysms on the other hand. The fact that the former are healed spontaneously more easily and more frequently has been confirmed at subsequent operation in numerous cases (e.g. at operation on the nerves). At times, the two ends of the vessels are connected only by a string of connective tissue. In case of penetrating or extensive gunshots, the healing process is obviously more easy than in case of smaller lateral holes. The spontaneous healing of fully developed aneurysms is very rare and is possible only through thrombotic filling up of the cavity. The discrepant data with regard to spontaneous healing result from the fact that these differences have probably not always been made. Thus, GUNDERMANN has observed 25 cases of spontaneous healing among 42 men with gunshots through vessels, V. HABERER 6 among 172, FROMMEL 1 among 50, and FRANZ at least 30 cases of spontaneous healing. In each of our cases, the healing was confirmed arteriographically. We mention two cases:

Case B29.

Wounded on July, 17, 1942. At first a large aneurysm in the left armpit, which even suggested the possibility of a perforation. On further observation, however, the aneurysm underwent involution, and, during an operation on the nerves (neurolysis) performed 3½ months later, a globular tumor the size of a plum was found, the puncture of which yielded no blood. Arteriography showed the failure of the axillary artery where it joined the brachialis, with an adequate collateral circulation.

Ill. 17

Illustration 17

Failure of the arteria brachialis as a consequence of the spontaneous healing of an arterial aneurysm, found at operation and arteriographically demonstrated during a neurolysis made 3½ months after the injury.

Ill. 18

Illustration 18

Arterial aneurysm of the cubitalis healed spontaneously during a period of several weeks of observation. Arterial defect, 5 centimeters long, with good formation of a collateral circulation.

Case B 49

A fist-sized aneurysm of the arteria cubitalis slowly underwent spontaneous involution to the size of a plum. Neither thrill nor pulsation could be ascertained thereafter. After seven weeks of hospital treatment, arteriography showed a 5 centimeters long defect of the arteria cubitalis, which was bridged over by collateral circulation. No sac was formed, an operation was not necessary.

In contrast to these observations, spontaneous healing of an arterio-venous aeurysm cannot be expected.

We consider it a lucky incident that we once have seen disappear, after arteriography, an arterio-venous aneurysm of the neck with all typical symptoms (distinct continuous thrill, ringing in the head, shortness of breath). In this case, the vein probably thrombosed, or the fistula opened, or the hematoma caused by the puncture, to which a compressive bandage was applied obliterared the communication or the vein.

Medicinal and dietic measures are no longer considered important and a treatment aiming at making the aneurysm sac disappear through chemical drugs is eliminated because of the dangers connected with it. Of the conservative measures, only compression treatment persisted at the end of World War I. By means of compression of the sac, one endeavored to further agglutination, to diminish the sac and to make it disappear finally. The compression of the artery was meant to stimulate and to form a collateral circulation. According to our opinion and experience, the intermittent compression method of treatment has more disadvantages than advantages, apart from some extension of the collateral circulation, which is even dubious in many cases. Though compression may effect a certain diminution of the sac, the chronic inflammatory changes existing in most cases are intensified by it. The already frequent fragile condition of the vessel becomes even more pronounced, and this renders operation more difficult in many respects. In the case of an aneurysm of the poplitea, we were quite convinced that the previous compression treatment had affected the vessel most unfavorably (see case D 60, page 64, Ill. 55, a and b).

For this reason, it is the surgical treatment only which has remained the most reliable method of treatment up to the present day. The danger of a constant dilatation with subsequent rupture and violent arterial hemorrhage, the deleterious effect which the growing aneurysm has upon the surrounding area, upon muscles, nerves and bones owing to the damage it causes by pressure, the occasional perilous disorders of the circulation, all these facts leave no doubt of the absolute indication for operation of the arterail aneurysm.

In case of arterio-venous aneurysm, it is the cardiovascular disorders which indicate operation. The excessive supply of arterial blood to the right heart, which received considerably more blood in the unit of time than normal, results in a dilatation and hypertrophy of the right heart with later participation of the left heart as well. While this state is at first compensated by corresponding extra labor of the heart, decompensation or insufficiency may occur eventually. Even in

this state, the patient may be saved by an operation, but the grave injuries of the heart and of the circulation caused by arterio-venous short-circuiting and the local disorders of the circulation which may largely impede the functions, require an early operation in most cases of arterio-venous aneurysms. Under these circumstances, an operation is advisable even if the symptoms are still slight, particularly as its performance is then much easier. This leads us to another point of the treatment of aneurysms, viz. the time of operation.

III. TIME OF OPERATION

While the necessity of operation is generally agreed upon today, the problem of the most favorable time for operation has not been settled until now. Even on the strength of the experience of World War I, STICH warmly recommended early operation of the pulsating hematoma, while he sees no urgency to operate the fully developed aneurysm particularly if there is no imminent danger. At all events, it is a fact that no time should be lost by using the compression treatment. As I mentioned before, even the formation of the collateral circulation is not much furthered by it, its damage is greater than its use in most cases, since during the lost time, symptoms may occur, which we are most anxious to prevent in case of arterial aneurysms, such as embolus, gangrene, and particularly the formation of callosities, which complicate the operation considerably. If you have seen the extensive formation of callosities of the fully developed aneurysm again and again and are aware of the difficulties they cause by involving the nerves and other surrounding areas, you will not wait till the sac has fully developed and will operate when the callosities are not yet so pronounced. Besides the formation of the collateral circulation, it is also the danger of infection which will decide the time of operation. We are of the opinion that a sufficient collateral circulation will develop within 3-4 weeks thereafter even the fresh granulation tissue and the soft scars are replaced by callous and cicatricial tissue (HERLYN). For this reason, this moment has been regarded as the most suitable time for operation so far. It was recommended also by LEXER. He made a difference between early and late operation, stipulating for early operation that infection had not yet set in and for late operation that it had disappeared again. If an operation was necessary between these two stages, he spoke of an emergency operation. Now V.HABERER has pointed out that, in contrast to his experience during World War I, he has changed his opinions as regards temporal indication for operation. He ascribed this to very intense inflammatory symptoms which set in very early after injuries of the vessels and require an extraordinarily long time for involution. Many months after the wound had been inflicted, he had observed, as he said, fresh inflammation chiefly in the lymph nodes in addition to the old inflammation foci. In the case of an arterio-venous aneurysm between the carotis communis and vena jugularis, which he operated 4 weeks after the injury, the operation had to be stopped because of serious chronic and acute inflammatory processes.

These inflammatory symptoms, which have evidently become more serious since the last war, can be explained only by the changed type of arms, particularly by the explosive missiles used by the Russians, but also the above mentioned increased flat trajectory of

rough missiles, which may cause great damage to the tissue and form large cavities in spite of the smallest entrance hole of the bullet. The geographical character of the theater of war may afford some explanation. Choosing the time for operation, one has to decide either to operate soon and to risk the danger of an infection owing to the still existing acute inflammation, or to wait and then find the operation complicated by callosities, which are difficult to deal with, and injured nerves. But as regards the danger of a late septic hemorrhage, even a serious infection of the aneurysm cavity does not contraindicate an immediate operative intervention. Only the method of operation (ligature, suture, transplantation) depends on the circumstances. In case of the rapid growth of an aneurysm, particularly if there is the danger of rupture, the conditions of the wound are not taken into consideration. As our observations have been made with the patients of a hospital in the homeland, early operation had to be considered but rarely. It must be regarded as absolutely indicated, however, for the pulsating hematoma or the state of primary formation of the sac , if no serious infection need be reckoned with (STICH, REHN, V.HABERER, WILDEGANS, KILLIAN).

If possible, we performed late operations only 2-3 months after the wound had healed. After this period, the danger of infection is largely eliminated (in case of war-injuries, latent infection may always occur) and there is a fair prospect that the suture will be durable, which is always the objective. If suture is not possible or even not necessary, ligature in the callous tissue is not too difficult. On the strength of the experience of the last war, one will accordingly double the period of delay for the late operation of arterial aneurysm and wait 2-3 months instead of 4-6 weeks, as was usual until now. In case of arterio-venous aneurysms, the time of operation is not so important as with the arterial aneurysm, particularly if there are no dangerous symptoms. For this reason one will wait for the most favorable aseptic conditions, which promise a healing per primam.

IV. OPERATIVE TECHNIQUE - GENERAL CONSIDERATIONS

Though I mentioned above that, in the operation of aneurysms, surprises must always be reckoned with and any typical method is therefore often impossible, there are certain rules which must be observed during the operation. As in all other interventions, it is aimed at preserving or restoring first, life; second, the limb; third the functional efficiency. This means that, if possible, methods of operation should be used which comply with these requirements. The objective of aneurysm operations accordingly is the restoration of normal circulation. For this purpose, two methods are available: vascular suture and transplantation of veins (in special cases, the transplantation of an artery may be considered, too). Where these methods are inapplicable or unnecessary, there is ligature as another method. Certain arteries for instance can be ligated without any concern, such as the arteria hypogastrica, arteria glutaea, arteria carotis externa and maxillaris, arteria meningea media, the small arteries in the lower arm, radialis and ulnaris, arteria profunda brachii and interossea. But even in the leg below the knee, disorders after ligature have been observed in vessels, the ligature of which has been thought safe.

Though vascular suture and transplantation of veins must not be considered too lightly, one ought to consider in dubious cases whether a ligature can be risked or whether a better method might be used. Various circumstances must be taken into account, such as the age of the patient, the condition of the vessels, arteriosclerosis, and even the time. Early ligature certainly yields less good results than late ligature, on the other hand, ligature of arterial aneurysms is, in most cases, more dangerous than that of arterio-venous fistulae. By means of arteriography and other examination signs, we are in a position to ascertain in some cases a sufficiently developed collateral circulation even before the operation, and during the operation there is available the LEXER-HENLE-COENEN symptom which allows us to draw conclusions concerning the collateral circulation. This test permits us to assume an adequate collateral circulation, if a jet of arterial blood still flows out of the peripheral end after the afferent artery has been pinched off. Also the MOSCOWICZ symptom and the KOROTKOFF symptom are useful for testing the collateral circulation. HOTZ recommended deep incisions into the toes or fingers as the only safe method as a test of the amount of the hemorrhage after the ends of the vessels have been pinched off. We think the LEXER-HENLE-COENEN test is most reliable, while the other tests seem to be less reliable. For instance, the skin can be adequately supplied with blood, while there are ischemic zones in the interior of the limb, particularly in the muscles. It is a well-known fact that the muscles are particularly susceptible to damage by a deficient blood supply. So if there is reason to suspect that ligature will cause any damage, one of the ideal methods for the treatment of gunshot aneurysms , vascular suture or transplantation of veins, must be used. It was occasionally doubted whether suture should be preferred to ligature (SCHOERCHER). But even World War I has shown that more necroses appear after ligature than after suture (FRANZ). In addition to the technical problems, which are not simple, the opponents of vascular suture hold that a thrombosis often appeared at the place of suture, which obliterates the free passage of the blood through the vessels, as in the case of ligature. In addition to that, a recurrent aneurysm might possibly occur at the place of suture. This is possible, but extraordinarily rare. V. HABERER has observed it once among 182 vascular sutures, and we, too, have observed but one recurrence among our patients, but in that case the vascular wall had been seriously injured before due to the considerable strain, which the aneurysm had exerted on the vessel during 25 years (Case D 39). The advantage of suture, even if a thrombosis develops sooner or later, lies in the fact that the gradually developing thrombus allows time and opportunity for the development of the collateral circulation. The ischemic symptoms accordingly are considerably fewer than in case of ligature, where the circulation is interrupted all at once. After compiling several statistical tables, FRANZ arrived at the result that suture is three times better than ligature, and most of the other authors also conclude that vascular suture, in the long run, yields better results than ligature. As for the methods of suture, the lateral suture and the circular one are to be considered. As already mentioned by STICH, no special instruments are required. We used, however, special needles for vessels with particularly fine paraffin silk, as otherwise, there will be easily a late hemorrhage out of the puncture canals, as shown by experience. For this reason,also REHN had a special needle made for the vessels. A repeated suture of the puncture canals narrows the lumen. When not operating in bloodless field, we use, if necessary, the HOEPFNER clips to pinch off the ends of the vessels, but secure the

vessels previously by twisting a moistened band around them which is technically not difficult. Illustration 19 shows an instrument developed by REHN for this purpose and other clips and hooks used by him during vascular suture. The disadvantage of the HOEPFNER clips consists in their being somewhat unwieldy and their slipping off easily, so that it is often necessary to see to it that they are properly fixed. Through their own weight, the clips have a considerable pulling effect on the vessel. For this reason, particularly the assistant must see to the cautious handling of these clips, especially if there are incidents, e.g. a hemorrhage. One is apt to pull on the clips or on the loops around the vessels, which is an additional damage to the vessels. But any rough handling must be avoided during vessel operations. Even pathologico-anatomical observations enjoin the absolutely necessary careful handling of the HOEPFNER clips. Careless handling may even annul the success of a laborious operation.

AMICH published two cases in which a post-mortem had been conducted and one linical case, in which after " a few seconds" application of the elastic HOEPFNER-STICH artery clips provided with thick rubber coats, serious, chiefly sharp edged injuries of the arterial intima and media occurred with subsequent thrombotic obstruction of vessel or perilous hemorrhage from vascular rupture. In both cases, which were operated by experienced surgeons, the success of the operation was frustrated, and the arterial damage would have been a fatal complication, if the original disease had not already reached a near fatal stage.

As regards the mechanism of the injury, it was interesting in these cases, according to AMICH, that a force acting on a large area had caused a sharp separation of the tissue (as if cut with a knife), in addition to extensive but less evident injuries by pressure. This process is explained by the extraodrinary elasticity of the arterial wall, which springs wide apart at the moment of the trauma, but snaps together again after the clips have been removed and thus shows, in its state of rest, the picture of a fine, sharp separation of continuity. The outer layers of the wall apparently have a greater power of resistance than the inner ones, though they are directly exposed to the pressure of the clips. Illustrations 20,21 and 22 show the circumstances of a case, in which the artery clip had been applied to the carotid artery for one minute only (Illustrations according to AMICH)

These detailed arguments show sufficiently that the HOEPFNER clips must be handled with caution. As they, yielding to their own gravity, easily slide off the vessel, the operating surgeon is tempted to apply them with heavy pressure. This must be avoided. The pressure of the clips need be only strong enough that the circulation is just interrupted. An adequate immobilization or the assistant's holding them will prevent the clips from slipping off.

After the application of 2 or 3 supporting threads, we make the circular vascular suture with single sutures, in contrast to most of the other descriptions, according to which there is a continuous suture between the supporting threads. All layers are pierced, and intima is laid on intima. If the suturing is made at rather narrow intervals, about 1-2 millimeters, a blood proof suture will result; if there is, in spite of that, a late hemorrhage from the one or the other puncture canal, this hemorrhage may be staunched in almost every case within a few minutes by the application of

Illustration 19 could not be reproduced with the facilities available.

Illustration 19

Instruments for blood vessel operations as used by REHN. Deschamps with branches and hooks for arterioversion (of the intima).

Illustration 20

Arteria carotis communis slightly enlarged a. secretion thrombus b. red stagnation thrombus pointing towards the heart, c. distinct sharp separation of the inner wall.

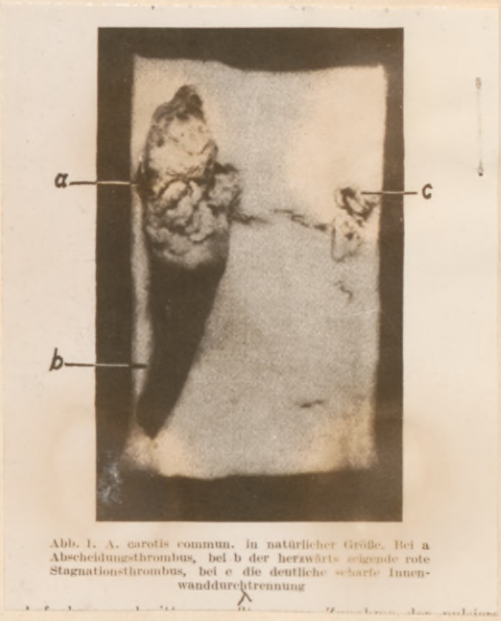


Abb. 1. A. carotis commun. in natürlicher Größe. Bei a Abscheidungsthrombus, bei b der herzwärts zeigende rote Stagnationsthrombus, bei c die deutliche scharfe Innenwanddurchtrennung

Illustration 20

Abb. 2. Sechsfache Vergrößerung. Elastica-van Gieson. Schnitt durch die in Abb. 1 erkennbare Thrombushaftstelle. Die durchtrennte und durch die Blutströmung abgehobene Intima- und oberste Mediaschichte im Thrombus festgehalten

Illustration 21

Six times enlarged. Elastica van Gieson. Transverse section of the place where the thrombus recognizable in Ill. 20 is attached. The intima and uppermost media-layer separated and detached by the hemorrhage are detained in the thrombus.

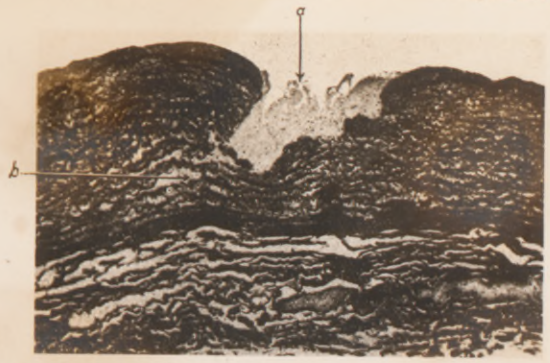


Abb. 3. 70fache Vergrößerung. Elastica-van Gieson. Schnitt durch die in Abb. 1 neben dem großen Thrombus liegende scharfe Verletzungszone. Bei a klaffende stufenförmige, von frischen Fibrin- und Plättchenmassen erfüllte Verletzung. Weiter peripher bei b, hier nur undeutlich sichtbar, Eintritt von roten Blutkörperchen in die traumatisch erweiterten Interstitien

1209

Illustration 22

70 times enlarged. Elastica van Gieson. Transverse section through the zone of sharp edged injury next to the large thrombus represented in Illustration 20. a. gashing gradual injury filled with fresh masses of fibrin and platelets, b. more to the periphery, only indistinctly visible here, penetration of red blood corpuscles into the interstices which are traumatically enlarged.

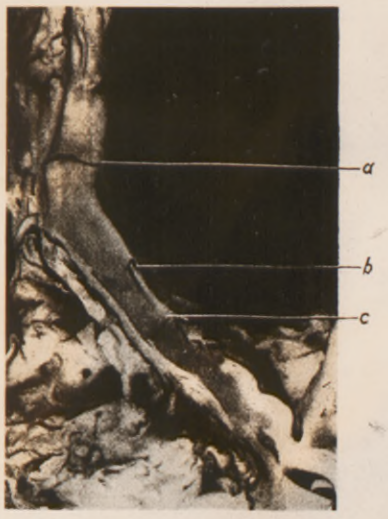


Abb. 4. Rechte A. carotis commun. in natürlicher Größe. Bei a, b und c sind deutlich die scharfen Klemmenverletzungen erkennbar

Ill. 23

Illustration 23

Right arteria carotis communis in natural size, a, b, and c, distinctly indicate the sharp edged injuries caused by the clips.

slight pressure on the suture. If it is not necessary to resect large damaged pieces of the artery at the ends, the suture can be made in most cases without any considerable tension. If a larger defect arises, however, the vascular tubes must be widely exposed to both sides. Lateral branches are spared if possible, and BIER believes that their dissection is never necessary. In this way, a defect of several centimeters can be bridged over and the suture can be made without any considerable tension, which is assisted by a corresponding flexion of the joints. Thus, the suture can be well made with a certain tension, and V.HABERER has applied extension without any damage immediately after vascular suture in three cases of aneurysms of the femoralis with attendant fracture of the femur, though KILLIAN advises favoring the ligature in case of fractures caused by gunshots. This cannot be absolutely approved, for if a good reduction is possible and an exact immobilization may be attained, which is quite possible, even in certain cases of fractures caused by gunshots, by use of the marrow nail according to KUENTSCHER, suture can be risked without any concern. In another case, V.HABERER, after resection of 5 centimeters and circular suture, observed that the femoralis had been torn off, not at the place of suture, but above it in the area where a HOEPFNER clip had been applied. This is one more warning against careless handling of this instrument during the operation. The advantages of the circular suture, even when made with tension, have doubtless been overestimated on the strength of the experience of World War I. Though clear patency could be often attained immediately after the operation, arteriography showed to an increasing degree that the suture became obstructed after a certain period. This is doubtless connected with the fact that a thrombus forms at the place of suture, which obstructs the vessel. But even if patency is preserved, blood supply in the periphery is reduced in the artery under tension, which, in this case, behaves as an india-rubber tube and is narrowed in its diameter. According to RÖHN, the POISEUILLE rule can be applied to such an artery according to which the volume of discharge decreases as the square of the reduced diameter. In considering a circular suture, another point of view seems important to me. This is the condition of the artery itself. Some vascular surgeons intimate again and again that the vessels, after injuries caused by gunshots in this war, are sometimes remarkably fragile and that to such a degree as V. HABERER had not observed in World War I. Since such brittle vascular walls with soft, flaccid spots are quite liable to burst, they are less suitable for suture than an arteriosclerotic vessel. We too, have often observed, chiefly in case of arterial aneurysms, remarkably damaged arterial walls. For these reasons, it is advised to be careful in performing the suture and to judge the outcome with a critical attitude, for in spite of the indisputable advantages of the circular suture as contrasted to the ligature, obstruction at the place of suture will sometimes arise. If the circular suture is too narrow, another circumstance may be responsible for the obstruction of an artery. Thus, DRESCHER describes a case, in which, after suture of the arteria femoralis, no blood came out of the peripheral section, even after puncture incision. After a powerful probe had been centrally introduced without meeting any resistance suggesting a thrombus, an intense jet of blood gushed forth upon the withdrawal of the probe. After the suture performed in a bloodless field, the peripheral section again remained without any pulse and the test with puncture incision and probe was repeated with the same result. The subsequent suture of the puncture incision was not performed in a bloodless field, and patency was retained. The only convincing explanation of this process is that an eddy formed at the much narrowed place of suture, which caused a reversal of the current, a phenomenon which is sometimes observed even in the natural bed of a river. The danger of such a narrowing with

formation of a bend and narrowing is even greater in case of an "almost circular suture" than in case of a truly circular one. In case of aneurysms attached to the wall, you will often observe that you have a gaping slash before you, after the sac has been removed, while the back wall of the vessel is intact. If you try to obtain an almost circular junction by suture and leave the back wall untouched, patency and arterial pressure will result, it is true, but a poor transmission of the pulse wave results on accout of the bend and narrowing. For this reason, the wholly circular suture is to be preferred in such cases.

Because of the difficulties which sometimes arise when suture is performed, above all because suture is impracticable in some cases, another method of restoring normal circulation conditions must be mentioned :transplantation of veins. As already described by STICH, an arterial defect of 5 centimeters can be eliminated by suture by appropriate mobilization of the vascular ends by appropriate position of the joints (extreme flexion). For this reason, he as well as other authors (BIER, V. HABERER, ORTH) hardly ever used transplantation of veins in numerous vascular operations. Since transplantation is, in addition, dependent on many other conditions (aseptic conditions), it was not used in our operations, though we took it into due consideration in individual cases. But then, either ligature could be performed safely or there was no security for an aseptic healing. At all events, our results listed below show that we have renounced transplantation of veins without any considerable loss. We by no means intend to undervalue the transplantation of veins, It is doubtless one of the ideal methodsof operating an aneurysm.

During World War I, about 50 transplantations of vessels were made after the preliminary work of CARREL, STICH, LEXER etc. During this war, the method has been used more frequently, and HERLYN performed 50 transplantations among 300 operations of aneurysms.

HERLYN chooses the place from where the transplant is taken according to the tasks it has to fulfill: 1. The vein must be able to stand the arterial pressure. A vena jugularis transplanted into an arteria iliaca burst 21 days later and caused a new aneurysm; 2. The vein must have the appropriate diameter, so it is better to transplant the vena femoralis than the vena saphena magna; 3. The transplant must completely bridge over the defect. Since it has the tendency to contract, it must be taken somewhat longer; some winding does not matter; 4. In order ot obtain satisfactory circulation - conditions, it is best to implant it in the sense of the stream, so that the valves do not obstruct, though even implantation in the reverse does no harm.

On the whole, technique and postoperative treatment are the same as in case of vascular suture. REHN also points out that, in order to prevent the troublesome sticking together of the venous walls and to adjust the lumen to the arterial calibre, it is suitable to fill the transplant with paraffinum liquidum to somewhat more than arterial thickness, i.e. tightly, immediately after the removal under application of two elastic clips. Some minutes afterwards, the limp venous walls will tighten and thus, they can be better handled and sutured. Frequent rinsing of artery and vein with paraffin goes without saying. In this way, REHN was able to cover a 15 centimeters long defect of the high femoralis and external iliaca by transplantation of veins.

For the sake of completeness, another ideal method of operation is mentioned by which normal circulation can be restored. This is the transposition of one end of an arterial branch at a place of division, an idea put into practice at the arteria poplitea by A. HOFMANN, at the arteria carotis by REHN, and at the arteria cubitalis by HERLYN.

Besides these methods which remove the aneurysm and restore, or at least try to restore, normal circulation, there are methods removing the aneurysms but renouncing the restoration of normal circulation. In this case, the danger of a disorder of blood-supply is, of course, considerably greater, since a central and a peripheral ligature is always made after the extirpation of the sac.

Whilst these methods almost always prevent the danger of a recurrence, the danger of a recurrence is greater with the methods of aneurysm treatment as briefly described below. For this reason, they are used only in exceptional cases and are, therefore, emergency methods.

The more palliative method of trying to control the aneurysm by artificial strengthening of the wall, e.g. using a pedunculated lobe of the fascia lata, is practically of no importance today. On the other hand, we must have recourse in some cases to one of the following methods which try to heal the aneurysm by reduction of blood supply, by contraction of the wall, or by introduction of foreign bodies into the sac.

1. Gradual constriction of the afferent artery above the aneurysm by autoplastic material.

2. Ligature of the aneurysm.

3. Ligature below the aneurysm-sac, viz. between tumor and capillaries, and ligature above the aneurysm, viz. between tumor and heart, without touching the sac itself. This applies to those very serious cases, where one cannot approach the afferent vessels (intrathoracic subclavia aneurysms, anonyma aneurysms) or where one cannot approach the efferent vessels (aneurysms of the carotis interna, located high, near the base of skull).

4. The method of MATAS, who used 3 kinds of aneurysm repair:

   a) the obliterating method, in which the sac is opened and both the two main arteries and all joining secondary branches are sutured from the inside,

   b) the restoring method: incision of the sac, suture of the arterial hole, turning in of the sac by gathering suture;

   c) reconstructive method: opening of the sac, the hole of the artery is closed by plastic from the adjoining part of the aneurysm sac, the aneurysm sac is again turned in by gathering sutures.

No reliable facts are known of results obtained by introduction of silver-wire or gilded wire into an inoperable aneurysm in connection with electrolysis. These non-radical methods of operation may be justified in desperate cases as a final attempt for healing, particularly in case of purely arterial aneurysms; in case of arterio-venous aneurysms, no positive result can be expected.

During the operation of arterio-venous aneurysms, the most important thing is the absolute separation of artery and vein, if a recurrence is to be prevented. To this purpose, one approaches the afferent and efferent vessels if possible through sound tissue and places a small ribbon loop around them. If there is only one fistula, it is prepared in an exposed position as far as possible and only then incised. The holes of the vessels are closed by suture. We wish to emphasize particularly the exact often toilsome and wearisome preparation of the fistula in an exposed position. In doing so, one will often succeed in preserving the artery and vein to a large extent, and defects in the vascular walls actually occur only in the area of the slit of the fistula. We believe that by this exact preparation we, in contrast to other authors (HERLYN), were so successful in using v[illegible] suture and could renounce the transplantation of veins since we avoided greater defects by the preparation. If there is a sac which is not rare, it is also suitable to prepare the sac in an exposed position as far as possible without incising it, after placing a ribbon loop around the vessels. One is astonished again and again at the considerable hemorrhage which occurs if the sac is prematurely incised; voluntarily or involuntarily, though loops have been placed around the afferent and efferent vessels. This hemorrhage in most cases arises from congested veins or unexpectedly large arteries flowing into inapproachable secondary sacs, or into the principal sac at a place where it is not yet exposed. After preparation of the sac, it is important to emphasize this once more, to arrive at a perfect separation between artery and vein at their juncture. Simple ligature of the afferent and efferent main vessels, which seems to be sufficient at first sight, actually is not sufficient to prevent a recurrence, since, at the juncture, the vein sucks the blood out of the artery and thus - having the same effect as a narrowing of the artery - has particularly fostered the formation of a collateral circulation prior to the operation.

When the connection between artery and vein is severed, one can, if no difficulties arise, extirpate the sac or proceed according to the methods of MATAS described above. FRANZ writes that he never extirpated the sac. As for ourselves, we have almost always extirpated it. This has the advantage that in case of possible suppurations, which must always be reckoned with in war injuries, secretion will stop more rapidly.

In addition to that, the question of a bloodless field appears important. It doubtless facilitates the intervention considerably in many cases and prevents a large loss of blood, which must not be considered lightly, since the operation of an arterio-venous aneurysm often lasts several hours. On the other hand, the bloodless field also has its disadvantages. In spite of adequate exposure of the leg, in which one had better not include the aneurysm itself because of the danger of carrying thrombi, one often does not succeed in operating in a bloodless field because of venous stasis, and this

complicates orientation. Sometimes one is even temporarily compelled to give up operating in a bloodless field. Another disadvantage is the fact that one cannot palpate the thrill any longer. If the aneurysm is located on one of the smaller branches without any distinct sac, it is very difficult to discover it, sometimes even impossible, particularly if the arterio-venous fistula has not been positively proven previously. In some case, and they are the most difficult ones, such as aneurysms of the large cervical vessels and intrathoracic aneurysms, no bloodless field can be obtained. Also within the SCARPA's triangle and in case of aneurysms of the iliaca externa and interna, it is impossible to obtain a bloodless field. Whoever, therefore, is not practiced in operating an aneurysm without a bloodless field, will meet with particular difficulties in these cases.

V. TREATMENT BEFORE AND AFTER OPERATION

As mentioned before, we consider it suitable to collect cases for aneurysm operation together at special clinics, since it has been proved that expert vascular surgeons obtain the best results. Thereby it is inevitable that the patients are in most cases informed of the dangers threatening in an aneurysm operation. For this reason, it is the surgeon's task to inform of a certain risk of the operation, but, on the other hand, to talk them out of fear of an operation and to point out the dangers of a non-operation. Since the patients are chiefly young, robust people, and, as experience has shown, the operation may occasionally last several hours, we have administered, as a preparation for the operation, 2 tablets of Bellergal and Luminalettes, 3 times a day, for about 8 days. This considerably reduces the sensitivity of the vegetative nervous system, so that we could manage with a comparatively small dose of nacotics (ether).

As mentioned before, the majority of our aneurysm patients were examined by an internist for possible cardiac disorders. If there were symptoms of a morbid involvement of the heart, particularly symptoms of insufficiency of decompensation, the heart was treated for about 8 days before operation with strophanthin-redoxon, though we were well aware of the fact that only the removal of the aneurysm could stop these symptoms. The area of operation was prepared in the usual way; if possible, we let infections subside. In case of arterial aneurysms not yet ready for operation, which progress without considerable complaint, the patient's request to be discharged until ready for operation is understandable. All the same, we advise hospitalization, for sometimes there is a rapid growth with danger of perforation or perforation itself, - which we have observed several times - with the dangers described above, which demand prompt intervention. In all events, such patients should be conscientiously instructed before they are discharged.

During every operation of aneurysms, but particularly of the large vessels, a serious hemorrhage may occur. For this reason, one or two blood donors must always be available, and it is suitable to keep everything ready to perform a transfusion of blood quickly.

In case of lengthy operations, even with slight loss of blood, transfusion has proved excellent to overcome the postoperative shock.

To relieve pain, we have chosen, in most cases, general narcosis with ether. In order to manage with smaller quantities of ether during lengthy operations, we have also used avertin as a basic narcotic in some cases, though the involved reduction of blood pressure may have a disagreeable effect in that the thrill may become considerably lower or even disappear during the operation. We occasionally have also used local anaesthesia, especially in case of operations on the throat, but in most cases additional ether narcosis had to be applied. With elderly patients, we have operated aneurysms of the lower extremities with spinal anaesthesia.

As regards postoperative treatment, the individual authors again and again emphasize the necessity of immobilizing the operative area. This is easily done with the extremities by means of plaster or splint bandages. On the lower extremities, the VOLKMANN T-splint is to be preferred to BRAUN's splint. This causes a relaxation in the large joints, which facilitates the blood supply on by-paths. For this reason, the limb must be placed in a relaxed position also after the ligature of a vessel. KINGREEN thinks that the lower extremities are better supplied with blood when the patient is lying on his belly, so he orders his patients to lie on their bellies after vascular operations on the legs. Since, particularly after vascular operations on the extremities, a considerable ischemia because of spasms may occur, we recommend, in addition to appliance of heat, repeated high doses of spasmolytics (eupaverin). In order to control the spastic condition, it is often necessary to eliminate the sympathicus through anaesthesia of the lumbar (possibly spinal anaesthesia) or dorsal sympathetics. We have used the injection of the sympathetics in numerous cases of postoperative disorders of blood supply and have always observed the best results, subjectively as well as objectively. Some authors even recommend immediate postoperative resection of the sympathetics in desperate cases; others perform it even before the operation, e.g. in case of ligature of the poplitea. SCHOENBAUER, for instance has observed danger of gangrene after spasm in two cases (arteria femoralis and arteria carotis). For this reason, even a resection of sympathetics on both sides was performed in the latter case. Even in case of cervical aneurysms removed by suture or transplantation some authors (REHN, HERLYN) demand a fixation of the head by means of plaster bandage. As for ourselves, we have been content in most cases with an ordinary bandage of the head and have observed no late hemorrhage nor any recurrence. All the same, it is advisable to immobilize the operative area.

Since in case of war aneurysms, we must always be prepared to operate within the area of a latent infection, the wounds were primarily sutured, with the use of plenty of Marfanil-Prontalbin powder, but a drain was put in for 48 hours. The surgeon must see to it that the drain is not placed at the level of the vascular suture. In order to prevent any lengthy suppurations of cavities, one should endeavor to close the cavities in so far as possible; if their walls are rigid, possibly with mobilization and adaptation of the muscles. If a splinter is removed at the same time or if there is the danger of its mobilization, tetanus serum must be administered previously. After primary healing, active and passive exercise may be started in a fortnight.

SPECIAL TREATMENT OF ANEURYSMS OF THE SINGLE REGIONS OF THE BODY WITH CONSIDERATION OF PARTICULAR INDIVIDUAL CASES AND RESULTS OF TREATMENT

I. CERVICAL AND CEPHALIC ANEURYSMS

In most cases of aneurysms of the cervical and cephalic region, operation is inevitable. Since there are no masses of muscles in this region, the aneurysm sac can grow without any considerable resistance and then exert a destructive influence on the surrounding area, particularly on the nerves. Chiefly the plexus brachialis, vagus and sympathicus, but also trachea, larynx, and thyroid gland are involved. Through inflammatory processes and formation of callosities, such difficulties may arise for the operation, that, in one case, even such an eminent vascular surgeon as is V. HABERER had to stop the operation, and among our own operations, there are two in which the aneurysm was operatively attacked from the outside and which persisted without any success whatsoever.

One more indication for operation is the usually harassing thrill and whizzing which the injured man nearly always feels and which is often so tormenting, that the patient gets hardly any sleep. Then the patients will urgently demand operation.

Cases in which the vessels of the thyroid gland are involved and which thereby lead to a general disease in the nature of a thyreotoxicosis, are particularly interesting and indicated for operation.

SYNOPSIS OF THE CERVICAL AND CEPHALIC ANEURYSMS.

Vessel	Number	Arterio-venous	Arterial
carotis communis	18	14	4
carotis interna	4	3	1
carotis externa	3	2	1
arteria vertebralis	1	1	-
truncus thyreo-cervicalis	3	3	-
arteria temporalis	1	1	-
Total:	30	24	6

RESULTS OF OPERATIONS OF ANEURYSMS OF THE CAROTIS COMMUNIS AND INTERNA.

The aneurysms of the common carotid were operated 14 times, these of the internal carotid artery 4 times; the methods of operation and their results are illustrated in the following table:

Common Carotid Artery

Method of operation	number	complete patency	narrowing	healed	died
Lateral suture	13	10	1	12	1
Circular suture	1	-	-	-	1

Internal Carotid Artery

Lateral suture	3	3	-	3	-
Ligature	1	-	-	-	1

Case A 4

Arterial aneurysm of the arteria carotis communis. Despite considerable formation of callosities (previous compression-treatment), the aneurysm sac could be satisfactorily prepared in an exposed position and the lateral slit, which was about 1½ centimeters long, could be closed by lateral suture without narrowing the vessel. Complete patency was ascertained. The operation was performed without any considerable loss of blood. Five hours after the operation, a hemiplegia was observed. The following day, a sudden respiratory arrest occurred, which caused death. The post-mortem showed extensive embolic involvement of the left arteria carotis interna from its entrance into the cranial cavity and of the left arteria cerebri media.

Case A 7

A 30 year old soldier, shot through the neck in June 1942. An aneurysm the size of a fist formed in the left side of the neck with slight damage to the plexus on the left and a distinct HORNER's syndrome (miosis, enophthalmus, ptosis). In the neck, there was, besides a completely healed scar where the bullet entered, an old non-irritant scar originating from a goitre-operation; the left side of the throat was distinctly protruded by a tumor about the size of an apple, which showed a discontinuous thrill. The operation was performed under ether narcosis. Since a thyroid operation had been made a few years before, a cross incision was made through the old scar just above the collar bone. The incision was widely extended to the sides and to the back and the sternocleidomastoid muscle severed at its insertion. After a difficult preparation, it was finally possible to expose the aneurysm sac from all sides. It had nearly the size of two fists. First the vena jugularis interna was doubly ligated above and below the aneurysm sac and then severed. Thereupon, the thrill ceased at once, though it was very distinct before. Only arterial pulsation was still felt in the aneurysm sac. Above and below the aneurym sac, which rested with its bulk on the carotid, the carotis communis was prepared by exposure, and a small ribbon was pushed under it, in order to staunch the hemorrhage better. It was then attempted to detach the aneurysm sac from the carotis communis, particularly from behind. During this process, the aneurysm burst wide open and an extraordinarily violent hemorrhage of an artery occurred, though the carotid was tied off above and below the aneurysm. The source of that hemorrhage could not be clearly detected. The hole in the artery was very hard to find. Eventually, it was possible to suture a slit in the vena subclavia and to staunch the hemorrhage, after two thirds of a circular suture of the arteria carotis communis had been performed. Thereafter, the arteria carotis

communis pulsated again; the place of suture was patent according to palpation. Somewhat higher and at the back, beside the vertebral column, there was another arterial hemorrhage, though not a considerable one. This must have come from the arteria vertebralis. The hemorrhage was staunched by ligating that vessel. The hemorrhage being staunched, a respiratory arrest occurred, while the heart continued to beat distinctly. Artificial respiration was immediately applied but it was no longer able to reestablish respiration. A transfusion of blood had been made before. Despite adequate cardiac stimulants, arrest of the heart and death occurred.

This case is instructive in many respects. First, the question of how to make the incision. In order to expose the large cervical vessels, we made, as is usual, a longitudinal incision into the front edge of the sternocleidomastoid muscle and thus gained a good general view of the whole area. It is often inevitable to transsect the sternocleidomastoid muscle at its sternal end. In this case, the old goiter operation scar suggested where to make the incision, and some authors (KULENKAMPFF) always use the straight cervical incision in case of carotid aneurysms. As regards these aneurysms, KULENKAMPFF raises the question whether to expose the fistula by separation of the two vessels in case of arterio-venous aneurysms or to choose the "safer way": to ligate the vein above and below the aneurysm, so that only a small sac remains which closes the hole, as it were, through the short remaining piece of vein.

KULENKAMPFF recommends this way as the safe one. This proposal seems to be convincing at first, if one sees from our case what difficulties the staunching of the hemorrhage and the closing of the slit may cause. But our case also shows, and other cases prove, that this is no safe method for definitive removal of the aneurysm and for prevention of recurrences. We know that this remaining "small sac" may contain the mouths of arteries and veins which are originally completely unimportant but may lead, later on, to extensive formation of aneurysms. Only the absolute separation of artery and vein is a safe protection, and all other methods are to be used only as emergency measures. Also in our case, the thrill disappeared all at once after ligature and dissection of the jugular vein above and below the aneurysm sac. As further preparation showed, also the vena subclavia and the arteria vertebralis were affected by the aneurysm, so that ligature of the vena jugularis alone certainly would not have resulted in a permanent healing. For this reason, ours is a particularly complicated case, for it hardly ever occurs that two important arteries of the body are involved in an arterio-venous aneurysm. Thus, HERLYN, describes a case with an arterio-venous aneurysm of the carotis communis and subclavia, in which he ligated the subclavia and applied a circular suture to the communis. BAETZNER also describes the case of an arterial aneurysm with involvement of the carotis communis and the vertebralis, which was operated by REHN. This was a case of operating a recurrence, since only the carotis communis had been ligated centrally to the aneurysm before. So a recurrence was inevitable and was even liable to occur very soon, since, in consequence of the carotid being ligated, more blood was supplied to the vertebralis.

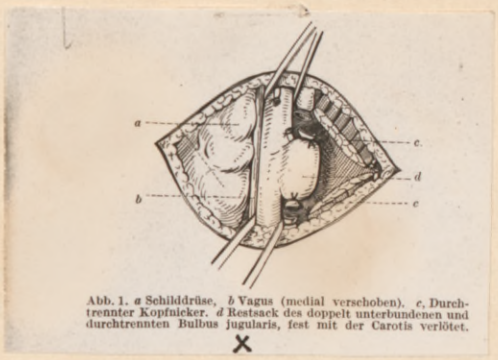


Abb. 1. *a* Schilddrüse, *b* Vagus (medial verschoben). *c*, Durchtrennter Kopfnicker. *d* Restsack des doppelt unterbundenen und durchtrennten Bulbus jugularis, fest mit der Carotis verlötet.

Illustration 24

a) thyroid gland
b) vagus(medially shifted)
c) severed sterno-cleidomastoid muscle,
d) remaining sac of the doubly ligated and severed bulbus jugularis, firmly agglutinated to the carotid.

As the post mortem showed in our case, there was, besides the operated aneurysm, another arterial aneurysm of the left arteria vertebralis apart from the operative area. This aneurysm had the size of a cherry. Death must have been caused not only by anemia through loss of blood but also by the shock effect and a damage to the respiratory center.

Case A 22 was another fatal case.

Arterial aneurysm of the left internal carotid of a 19 year old man, who had, shortly after his injury, a large retropharyngeal hematoma. Some otologist proposed "incision". After involution of the hematoma, an aneurysm of the left side of the neck was ascertained, after previous "punctures of glands" have had no success. Subjectively, there was ringing in the ears, difficulty of hearing and weakness of the voice, objectively paralysis of the left recurrent nerve and injury of the plexus (C3- C5).

On the ascending ramus of the lower jaw there was a healed operation wound. There had been a previous attempt to operate the aneurysm. The hole where the bullet entered was the size of a penny and fairly well healed. It was just beneath the lobe of the ear. Arteriography showed: arterial aneurysm, probably of the internal carotid, about $3\frac{1}{2}$ centimeters above the place of division with plum sized transverse aneurysm sac extending almost to the base of the skull. Medially close by the sac, there was a shell splinter of about 4:5 millimeters.

The operation started under local anaesthesia and later continued under ether, turned out to be a very difficult one. After holding the communis in a loop, the submacillary ramus was severed at the angle of the jaw and the proximal end was drawn upwards. Despite satisfactory general view created thereby, the aneurysm could not be adequately exposed, nor could the place of division, which was adherent to the sac and to the callous tissue. During further preparation, a serious hemorrhage occurred which could not be staunched even by ligature of the common carotid just below the place of division. Thereupon, the carotis interna was ligated once more high above, near the base of skull, the thrombotic masses were removed from the aneurysm sac and the latter was extirpated down to the artery. The ends of the aneurysm sac were sutured against each other. Thereupon the hemorrhage was controlled. Because of the seriously injured wall of the interna, the radical operation or extirpation of the sac with vascular suture was impossible. After the operation, a hemiplegia occurred. When the patient awoke from the anaesthetic, he suffered from a motor aphasia. In the course of the following day, the patient's state became aggravated and in the night, death occurred with the symptoms of an aspiration pneumonia.

Illustration 25

Arterial aneurysm of the internal carotid close by the base of skull above the place of division of the communis. Splinter beside the sac.

Because of some peculiarities, one more case of an arterio-venous aneurysm of the carotis externa and vena jugularis externa is briefly mentioned (Case A 23).

The arteriogram (see Illustration 26) showed the following picture: after injection of 15 cc. uroselectan into the percutaneously punctured left arteria carotis communis, the carotid could be demonstrated only as a feeble shadow stripe extending from the needle. Lateral to it, there are 2 contrast shadow bands the width of a finger, which correspond to the progress of the jugularis interna and externa. The arterio-venous fistula cannot be certainly located.

In contrast to the clinical and roentgenological findings, according to which an arterio-venous connection of the carotis interna and vena jugularis interna was expected, after separation of the jaw, and arterio-venous aneurysm of the carotis externa with considerable formation of callus was found, which did not permit any exact separation of the vessels. After ligature and incision of the markedly congested veins and the arteria carotis externa one finger above and below the arteria lingualis, the thrill disappeared. Some weeks later a slight thrill recurred, but without any symptoms of a tumor or congestion and without any considerable subjective complaints.

These cases are our failures in the area of the arteria carotis. All other cases ended with healing as regards the vessel; once a circular suture, 16 lateral sutures were performed. Adequate patency was obtained 13 times, while in 3 cases, there are no records concerning patency. There is one fatal case each after lateral suture, circular suture and ligature.

Gunshot aneurysms of the arteria carotis communis and carotis interna are a specialty because the course after their ligature is so varied. Many reasons are mentioned to explain this varied course, above all, the patient's age or a particular hypersensitivity of certain parts of the brain against the interruption of the blood supply. According to us, the structure of the ductus arteriosus Willisii is usually the principal influence on the further course after the failure of the large cervical vessels. REHN, too, points out these irregularities and peculiarities in the structure of the ductus arteriosus Willisii. Particularly the French literature has paid increased attention to the anomalies of this region of the circulatory system and, according to POIRIER: anomalies of Willisi!s hexagon (l'hexagone) are very frequent. For instance, an arteria communicans posterior of the carotid may not exist, which form both arteriae fossae sylvii or even both arteriae cerebri anteriori. Such irregularities involve serious dangers for the patient, if the carotid is ligated. Also a failure of REHN's warns us to give careful consideration to these anomalies. In that case, a lateral suture of the carotis interna had been performed, and the circulation had been interrupted only for 6 minutes. From this case, REHN deduces the clinical rule to reduce the period of absolute obstruction as far as possible, if the reconstructive methods are applied in the region of the carotis communis and interna.

Illustration 26

Arterio-venous aneurysm of the carotis externa and the vena jugularis externa. The needle lies within the artery; laterally two broad vessel shadows. (Vena jugularis externa and interna).

At the same time, one more aspect must be considered with arterio-venous aneurysms, viz. the postoperative change of circulation conditions, particularly the reaction of the vein. Even in case of ligatures of the carotid made for other reasons such as after fresh injuries, some authors ask that the vein be ligated, too, since thereby the blood will flow more slowly out of the respective half of the brain and the blood supply of the brain will thus be improved. Similar reflections have been made also in case of arterio-venous aneurysms. Thus, it has been ascertained several times, that the suction towards the heart of the vena jugularis interna in an arterio-venous connection with the carotis communis may be so strong, that this alone may lead to a cerebral anemia with its consequences. Anatomical findings do not confirm this assumption, as is emphasized also by JUNGHANNS. He did not find any corroboration of SUBBOTITSCH's rule (that the enlargement of the vein in the arterio-venous aneurysm is located toward the heart) the thickening of the vein, if there was any difference at all, always lay distal from the aneurysm. Here, arterial blood directed away from the heart, and venous blood, flowing towards the heart, meet in a whirl, producing thereby a congestion in the part of the vena jugularis interna away from the heart, that is to say towards the heart from the arterio-venous connection. JUNGHANNS always ligated the vena jugularis interna. As regards our cases, we always suture the vein at the same time if possible, in order to restore normal conditions. Also REHN supports venous suture, if possible, for the reason that in case of some arterio-venous fistulae, the venous system is particularly enlarged and overfilled. Sudden ligature of the jugularis interna, however, means a perhaps injurious change of pressure in the blood supply of the brain despite a favorable preparation of the way for the arterial blood.

The kind of blood supply to the brain is singular in comparison with other regions of the body. While, for instance, the hollow of the hand is supplied with blood from two directions, radially and ulnarly, by the formation of the arcus volaris superficialis or profundis, we find in the circulus arteriosus Willisii a ring of vessels, closed by anastomoses, which emerge from branches of the arteria carotis interna and the arteria basilaris, that is, we have not only a bilateral, but also a ventro-dorsal blood supply.

The question of what effect ligature of a large cervical vessel of the arteria carotis communis or the arteria carotis interna has upon this ring of vessels and therewith upon the blood supply of the brain, is not yet settled, though it is quite frequently necessary to ligate these vessels. Ligature is enforced chiefly by injuries of these vessels with perilous hemorrhages which cannot be staunched otherwise, particularly if vascular suture, which should be always attempted first, or transplantation of veins are impractical. Besides, aneurysms of that area as sequelae of these injuries, claim the interest of surgery in wartime. Because of intracranial aneurysms, these vessels have been ligated occasionally and frequently an inoperable tumor in the cervical region, such as a carcinoma of the thyroid gland, of the pharynx, or of the submaxillary gland, requires ligature because of marked adherence to the vessels.

Statistics of successes or failures after ligature of the large cervical vessels are limited and cannot be safely evaluated for this reason. Thus, RIESE has observed 2 cases with fatal termination after 8 ligatures of the arteria carotis interna, 8 fatal cases among 25 ligatures of the arteria carotis communis. HOTZ observed 5 cases of disorder of the brain among 6 cases of ligature of the arteria carotis communis, FRANZ none among 4 cases. TORRACA describes 6 cases of ligature of the carotid because of hemorrhage; in 5 of them death occurred. According to KOCHER, the danger of ligature of the carotis interna is great with people older than 30 years, with people older than 35 years, it is to be called almost a fatal mistake, except there is an indicatio vitalis. Thus, it cannot be denied that through ligature of the large cervical vessels, such damage can be done to the brain that death may occur rapidly or within a short time.

A preliminary condition for extensive elimination of the above mentioned damage is a well developed collateral circulation. The adjustment of blood supply in the brain is, therefore, of great practical importance, and the problem of blood supply to the brain was the subject matter of a great many treatises during the last decade. Though the physiology of this region is by no means definitely settled, a good deal of important knowledge has been gained during the last few years.

While BIER was still of the opinion that, as far as the brain is concerned, there are other rules valid for collateral circulation than those established by himself for the extremities, KRIEG was in a position to prove that these are largely valid even for the brain. The high sensitivity of the tissue causes the brain's standing somewhat apart, it is true, since "blood attraction" and "feeling for blood" of the brain is no longer efficient if the tissue is seriously damaged.

Besides this "feeling for blood" there is a series of other physiological facts which are important for knowledge of the blood-supply of the brain. As long as 10 years ago it was the common belief that the cerebral vessels were passive towards blood-pressure (HERING, HEYMANN). It was assumed that a greater or lesser blood supply was caused by an increase or decrease of the general pressure at the expense of other organs. The systematic anatomical recognition of the paths of the cerebral vascular nerves (research work of WOLFF, LOB, GOLLWITZER-MEYER and ECKARD (1935 W.and D. SCHNEIDER)) showed vasomotion of the cerebral vascular system. Of particular importance is the statement of GOLLWITZER-MEYER, ECKARD, that an irritation of the sympathicus causes a dilatation of the cerebral vessels and that, sympathically as well as parasympathically both halves of the brain are simultaneously innervated from one side.

In addition, cerebral mechanisms of compensation are important, particularly the meningeal reflex discovered by D. SCHNEIDER, which will be dissussed later.

As mentioned above, opinions concerning the consequences of ligature of one of the large cervical vessels still vary, nor is there any agreement as regards the direction of the blood stream after ligature of the arteria carotis communis. According to former opinions, maintained even today, in case of ligature of the arteria carotis communis, the interna is supplied by a retrograde blood stream from the externa, which is connected with the other side by a fair

number of anastomoses (PLOEGER, MORTON, JUNGHANNS). On the other hand, SIMONETTA thinks he is justified in assuming the opposite direction of the stream after ligature of the arteria carotis communis.

In order to clarify the complicated situation and the various contradictions, we have made several experiments. First, the problem was examined in some dogs*.

Order of Experiments:

In a dog, the arteria carotis communis was severed and a manometer introduced into both ends towards the heart and towards the head. Then, all vessels, except the arteria carotis interna and carotis externa, were ligated at the place of division of the carotid. Pressure in the manometer amounted to about 120 millimeters towards the heart, to 40 millimeters towards the brain, the latter pressure approximately corresponding to pressure in the circulus arteriosus. Further research showed that the arteria carotis externa plays a special part with regard to pressure and circulation conditions, for, if the arteria carotis externa was ligated a distinct increase of pressure immediately arose in the manometer inserted towards the head, while, if the ligature was removed, the pressure dropped to the original value (see, Ill. 27 a and b).

This shows that, after ligature of the arteria carotis externa, pressure in the circulus arteriosus Willisii, which is of decisive importance for the blood supply to the brain, increases to almost double the usual amount, but if the ligature is removed, the arteria carotis externa forms, as it were, a leakage for the circulus arteriosus, into which the blood is drained from the brain. Besides, one can safely deduce from the experiment that, in a dog, the blood streams from the interna to the externa after ligature of the arteria carotis communis.

We also can prove quantitatively the existence of this leakage caused by the considerably less resistance to pressure in the externa as contrasted to the interna. If, in our experiments (that is with the communis ligated), we let blood run out of the large cervical vessels, we observed that, in the unit of time, 10 - 20 times more blood streamed out of the externa than out of the interna. Thus, in one experiment, 6 cc. blood per minute streamed out of the interna, 114 cc. out of the externa; in another experiment 14 cc. out of the interna, 156 cc. out of the externa.

These results, however, can by no means be indiscriminately transferred to man. We have examined conditions here as well. Considering the fact that the human arteria carotis interna is considerably stronger developed in proportion than that of the dog, which is only of a few millimeters caliber, the above mentioned results obtained from a dog are to be expected in an increased degree, viz.

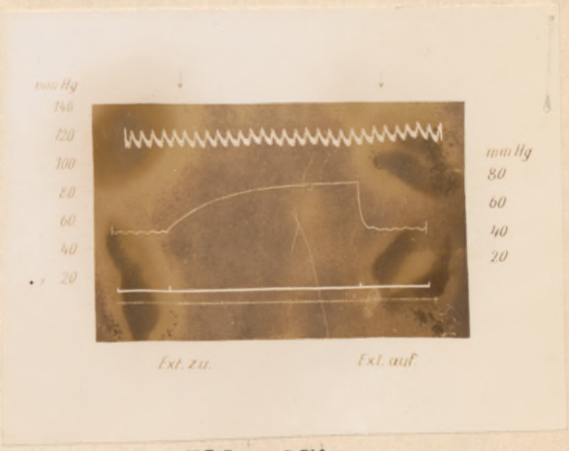
* The experiments were performed in the Physiologic Institute Giessen. I wish to express, also on this occasion, my gratitude to Director Prof. E. KOCH for his advice and support in this work.

Ill. 27a

Illustration 27 a b

a) After ligature of the arteria carotis communis, the blood flows in the direction of the arrow from the interna to the externa.

b) After ligature of the arteria carotis externa with closed communis, there is an increase of pressure to almost double values in a manometer inserted towards the head (from 40 mm Hg. to 75 mm Hg.)



Ill. 27b

Ill. 27c

Illustration 27c

With ligated communis, an injection of contrast medium is made into the arteria carotis interna. Demonstration of the area of the externa through reflux from the interna to the externa.

the outflow into the area of the externa takes place to an increased extent. At all events, the reflux from the interna to the externa could be roentgenologically confirmed.

If one injects contrast medium into the arteria carotis communis, it flows into the arteria carotis interna and externa and the supply areas of both arteries are demonstrated. But if one ligates the arteria carotis communis and then injects contrast medium, one will detect the principal part of the contrast medium in the area of the externa. This demonstration succeeded particularly well in Illustration 27c. In this case, an injection was made into the arteria carotis interna under slight pressure after ligation of the arteria carotis communis. The picture shows how the contrast medium is diluted, caught by the current and transported to the area of the externa.

This reversal of the blood stream direction has probably nothing to do with the "reflux" into the arteria carotis communis after aspiration of the arteria carotis interna, observed by MONITZ and KRIEG, since the injection was made there with great pressure with a patent communis, in our case only with slight pressure and with a ligated communis.

Our own experience with a corpse showed after injection of colored solution into the arteria carotis communis, which had been ligated before, that the fluid streamed to an increased degree into the area of the externa, it is true, but partly also into the area of the interna. So there is no previously determined draining-into the area of the externa exclusively.

This knowledge gained from man and animals suggests, therefore, the following theoretical conclusion: In order to avoid a reflux into the area of the externa after ligature of the arteria carotis communis and to stop the leakage opening in this area, it is necessary to ligate the arteria carotis externa as well.

This inference based on mere hydrodynamic considerations is furthermore confirmed by the sequelae of the meningeal reflex discovered by Dr. SCHNEIDER. It is caused by ligature of the arteria carotis communis or of the arteria carotis externa or of the meningea media, viz. whenever the meningea media is obstructed, too. On the contralateral side, the blood supply of the interna is increased by 70-80% also the vertebral arteries supply more blood. The consequence is a considerable increase of the amount of blood in the brain, which furthers the reversal of direction of the stream in the ligated arteria carotis communis and thus intensifies the leakage in the area of the externa. For this reason, also the reflex process, named meningea reflex by D. SCHNEIDER, urges the suitability of simultaneous ligature of the externa during ligature of the arteria carotis communis.

On the strength of our experiments with dogs and the observation in man, we think we are justified in summing up as a most important result:

The opinion first expressed by MORTON (1914), then by PLOECHER, according to which the blood flows from the arteria carotis externa into the arteria carotis interna after ligature of the arteria carotis communis, is untenable. On the contrary, a reversal of direction of the blood stream arises and the blood flows from the interna to the externa, the latter being a leakage into which the blood is drained from the brain. For this reason, it is suitable to

ligate, in case of ligature of the arteria carotis communis, the arteria carotis externa as well.

Although we have not yet been in a position to collect much experience in this field, in the interest of the importance and considering the contradictions still existing in this field, communication of the results obtained by us appears to be justified.

B. VERTEBRAL ARTERY ANEURYSMS

The aneurysm of the vertebral artery is one of the rarest gunshot aneurysms, since death occurs in most cases in which the vertebral artery is involved. Among 2235 gunshot injuries of the American War of Secession, only 2 cases of injuries of the vertebral artery are reported (OTIS, according to KRUEGER). BIER mentions only one case, V. HABERER, in his former treatises, did not mention any aneurysm of the vertebralis and only 2 in his latest list of 349 vessel operations. HERLYN reports 4 cases among 150 and BAETZNER 3 cases among 240. We have observed an aneurysm of the vertebralis only once, though in another case the carotid was involved in the aneurysm, and the post mortem showed another aneurysm of the vertebralis apart from the one of the carotid.

Different methods have been described for exposing or ligating the vertebral artery. Its ligation is one of the most difficult because of the vessel's lying so deep and its peculiar course, and KLEINSCHMIDT writes in KIRSCHNER's science of operation: Since in its whole second section, the vessel can hardly be exposed, the vessel can be ligated only in either the first or the third section. Thus, the vessel is divided into three sections. Section 1, extends from the origin to the entry into the transverse process of the sixth cervical vertebra, the second section runs through the canalis transversarius and the third in the regio suboccipitalis. Even in the vertebralis, anomalies are not altogether rare, e.g. arising elsewhere than from the subclavia, directly from the aorta, under the truncus thyreocervicalis or from the anonyma or carotis communis. For this reason, an operation in the first section may be rendered most difficult. The artery also may enter into the foramen transversarium VII instead of VI or into any other up to II.

As for the first section, the sternoclaidomastoid muscle and the carotid artery are pulled outwards and downwards, the thyroid gland and the medial cervical muscles towards the center and downwards. Then, one feels for the tuberculum caroticum (transverse process of the sixth cervical vertebra), the vertebral artery is right under it. In contrast to KLEINSCHMIDT, HERLYN thinks that access to the second section is possible and reliable. He put it into practice in 2 cases in the tract where the artery runs in the second to the sixth transverse process. The sternoclaidomastoid muscle is moved outwards with the cervical vessels. By blunt preparation and by moving the thyroid gland with its adnexae inward, one penetrates into the loose tissue surrounding the esophagus and the larynx. Then, one easily arrives at the vertebrae and transverse processes. These are pinched off and the artery is

exposed in its bone canal. As regards the third section, the posterior arch of the atlas must be found. The artery runs arched along the upper sharp edge of the posterior curve of the atlas. The artery can be palpated there.

These aneurysms may cause great difficulties diagnostically and therapeutically. In most cases, one assumes an aneurysm of the subclavia or carotid. By pressing the latter aside, one can eliminate an injury of the carotid. Even arteriography fails us here in most cases, though BAETZNER was in a position to confirm the diagnosis of a vertebralis aneurysm by elimination of an injury of the carotid through arteriography. He reports also concerning an aneurysm in the first section, where aneurysms are observed most rarely. The second and third sections are affected more frequently. Also in our case (Case A 30), the aneurysm was placed in the suboccipital part.

It was a case of multiple injuries of the head, chest, and arm, sustained on August 15, 1942. Even 8 days after the injury a rustling was perceived in the left side of the head, which, in the course of months, increased to an intolerable degree and considerably disturbed sleeping. The left ear was almost completely deaf. Behind the mastoid process, there was a protuberance the size of a thumb-tip over which a distinct thrill was palpable and audible. Arteriography showed (Ill. 28) an aneurysm sac the size of a walnut near the base of the skull, which is projected right on the atlas in the lateral picture.

During the operation under general anaesthesia performed on July 22, 1944, the aneurysm sac was exposed by indentation of the sternocleidomastoid muscle and partial severing of the splenius capitis and the semispinalis capitis, which was very difficult, since numerous small veins join it. The aneurysm sac had partially destroyed the periosteum of the tabular part of the occipital bone. For this reason, when the periosteum was moved, considerable hemorrhages from small apertures in the bones occurred, which were staunched by compression. The aneurysm sac was as thin as paper in some areas, particularly where it was attached to the bone. The transverse process of the atlas was exposed, and it was observed that the pedicle of the aneurysm was about one finger's width above it and ran in a direction toward the front of the cervical vertebral column. The aneurysm was doubtless supplied from the vertebralis, the latter was ligated above the posterior atals arch. Since it was impossible to work one's way farther on, ligatures were made on the aneurysm sac itself and distally to it, and the sac was extirpated. Thus, no recurrence occurred. It would have been a mistake to be satisfied with a central ligature of the vessel supplying the aneurysm, since the vertebralis is supplied with blood also from the periphery, which causes continued blood-supply or a recurrence. In the further course of the case, there was a serous secretion moderately mixed with blood, but the wound healed well. Even after weeks, no more thrill occurred, there was only a slight feeling of giddiness after exertion, sometimes headaches. The patient was discharged as fit for service under certain conditions.

a

b

Illustration 28

Aneurysm of the vertebral artery near the base of the skull with aneurysm-sac the size of a walnut

C. ANEURYSMS IN THE REGION OF THE TRUNCUS THYREOCERVICALIS.

We have observed this kind of aneurysm three times. If these are distinctly developed and arteriography does not help to locate them, one will always think first of an aneurysm of the large cervical vessels, and then one will be astonished at finding the large cervical vessels unchanged during the operation. Then, one should not be satisfied with the diagnosis of "pseudo-aneurysm", but look for an aneurysm of the vessels of the thyroid gland.

Also in one of our cases (A 29), the operation was begun under the suspicion of an arterio-venous aneurysm of the carotid, but no arterio-venous connection could be found in the area of the carotis communis. On the other hand, a capsular vein of the thyroid gland was enlarged to nearly the thickness of the small finger and showed an intense thrill. After ligature, the vein was severed. The arteria thyr. inf. was as thick as a pencil. After its ligature, the thrill at the thyroid gland ceased at once. It was therefore ligated and severed. Marfanil-Prontalbin, subcutaneous suture. Suture of the skin.

But this case was interesting even in another respect. Before the operation, the injured man had distinct symptoms of BASEDOW's disease, which were manifest by an enlargement of the thyroid gland, particularly on the right side, excitement, inner restlessness, trembling of the hands, and increased appetite. All these symptoms disappeared after the operation. Thus, this is one of the cases where a thyrotoxic state developed as a sequel of an arterio-venous aneurysm in the region of the thyroid gland. SAUERBRUCH observed two similar cases with exophthalmus, trembling of the hands, nervous restlessness, symptoms which gradually developed as a sequel of an arterio-venous aneurysm, once between the carotis communis and the vena jugularis interna, and once between the jugularis interna and the carotis externa. We can explain these symptoms only by the fact that the increased arterial blood supply to the thyroid gland caused an enlargement of the struma with BASEDOW's syndrome. For this reason, these complications are one more absolute indication for operation.

II. ANEURYSMS OF THE CHEST AND UPPER EXTREMITIES.

Even today, the introthoracic aneurysms have not yet lost their terror, since a hemorrhage out of the large arterial trunks may be fatal within a few seconds. For this reason, one endeavors, in case of an intrathoracic aneurysm, to find the best possibility of preventive blood control by suitable ways of access, if location and extent of the aneurysm permit. To this purpose, several approaches to these vessels have been mentioned which afford a better general view than the rest of the methods of li-

gature. Even if we had no aneurysm of the anonyma among our cases, we repeatedly had to expose the area of the thorax in case of aneurysms of the subclavia with large sacs, e.g. in a case where several ribs had been partially destroyed by the pulsating aneurysm sac.

Illustration 29 shows the extrapleural exposure of the anonyma and of the arcus aortae according to KUETTNER.

One begins with a longitudinal incision just below the jugular with a 5-6 centimeters long cross-section and lays back a triangular flap together with the pectoralis major. After subperiosteal resection of the cartilage of the left second rib and severing of the back periosteum of that rib, one carefully puts one's finger medially under the sternum and carefully detaches the pleura. The left sternal margin is pried off up to the middle of the sternum from the insertion of the third rib to that of the first. The cartilage of the first rib is also resected.

The arcus aortae is now only covered by thin layers of tissue, which are severed by blunt dissection. The places of origin of the anonyma of the carotid artery and of the subclavian artery are now exposed. Special heed is to be paid to the vena anonyma sinistra and to the left vagus, which run downwards above the origin of the left subclavia. While exposing the arteria subclavia, one must consider, on the one hand the difference between right and left, on the other hand, the question whether the artery should be exposed above or below the clavicle. We do not wish to enter into particulars of the different methods, but it is emphasized that a good general view must be demanded especially for the subclavia during the operation of aneurysms. V.HABERER thinks operations of the subclavia the most difficult of all vascular operations, and we know that failure of the subclavia will frequently cause gangrene or grave ischemic disorders. The performance of the incisions and the technique are partly shown in Illustration 29 and 30. Resection of the medial two thirds of the clavicle or temporary exarticulation with sawing in the middle are the methods used most often. LERICHE recommends, instead of this method of exposure, the median splitting of the sternum, because the vessels lie more medially than laterally, more behind the sternum than behind the clavicle. In his 50 removals of the thymus, he has found out that it is easy to get into the anterior mediastinum and to press the thymus forwards, as well as to expose safely the first portion of the left carotid and of the subclavia. LERICHE advises the use of local anaesthesia, lest the veins are much dilated.

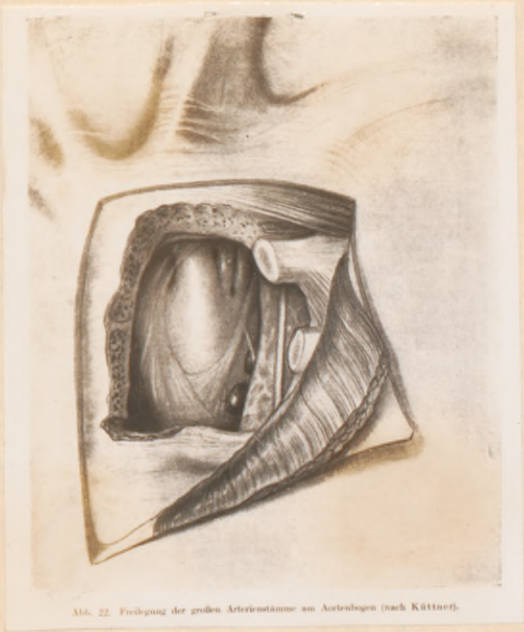


Abb. 22. Freilegung der großen Arterienstämme am Aortenbogen (nach Küttner).

Ill. 29

Illustration 29

Extrapleural exposure of the anonyma and the arcus aortae (KUETTNER)

Illustration 30 a and b

Performance of incisions and technique of exposing the subclavian artery with partial resection of the clavicle and of the upper ribs.

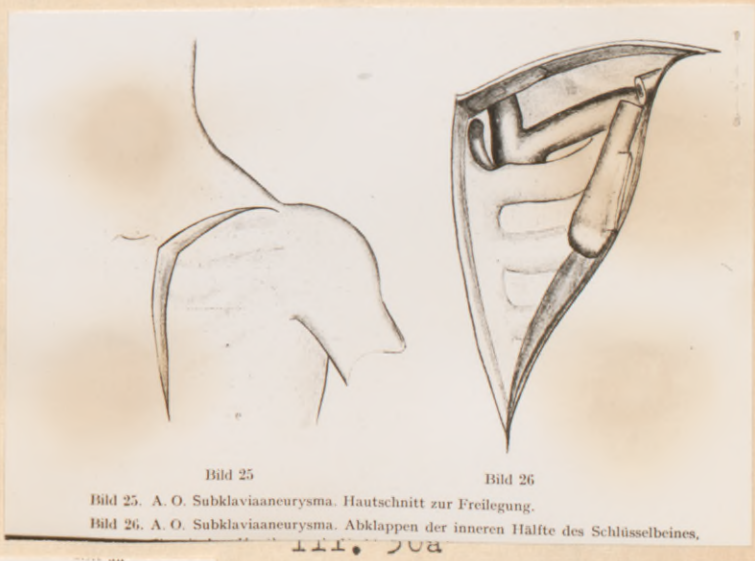


Bild 25 Bild 26

Bild 25. A. O. Subklaviaaneurysma. Hautschnitt zur Freilegung.
Bild 26. A. O. Subklaviaaneurysma. Abklappen der inneren Hälfte des Schlüsselbeines,

Ill. 30a

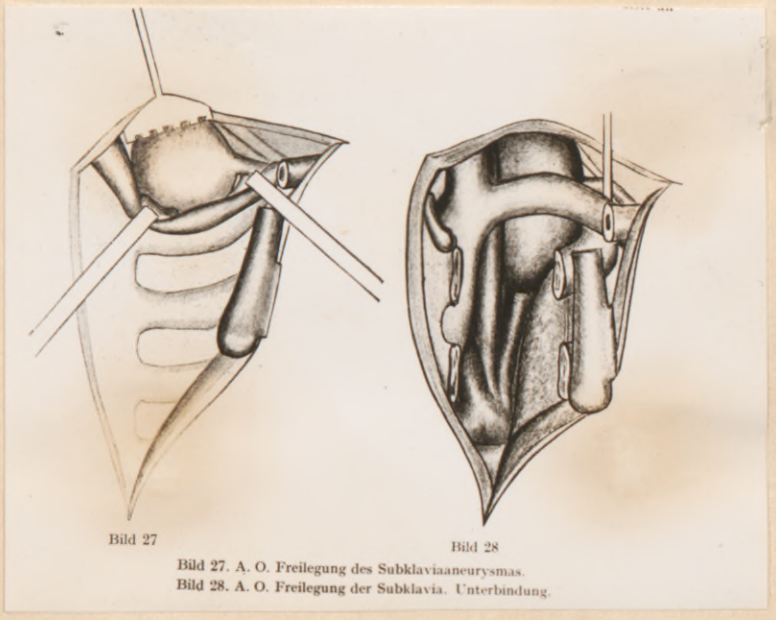


Bild 27 Bild 28

Bild 27. A. O. Freilegung des Subklaviaaneurysmas.
Bild 28. A. O. Freilegung der Subklavia. Unterbindung.

Ill. 30b

SYNOPSIS OF THE ANEURYSMS OF THORAX AND ARM

Vessel	Numbers	art. ven.	art.	operated	spontaneous healing	recurrence
subclavia	18	10	8	14	1	-
axillaris	14	6	8	12	-	-
brachialis	11	8	3	9	1	-
profunda brachii	1	1	-	1	-	-
cubitalis	6	3	3	5	1	1
ulnaris	2	-	2	2	-	-
radialis	2	1	1	2	-	-
Total	54	29	25	45	3	1

The methods of vessel operation and the results of the 14 operations of the subclavia are shown in the following table:

Method of operation	Total	discharged as		Death
		Healed	with disorders of the circulation	
Lateral suture	10	3	4	-
Circular suture	2	1	1	-
Ligature	2	-	1	1

This shows that we have performed vascular suture in the majority of the cases, since ligature involves the great danger of gangrene, as mentioned before.

Illustration 31 affords a synopsis of the possibilities of ligature and the dangers connected with it in the arm according to ANDREE (On injuries of arteries and their subsequent treatment. Dissertation, Goettingen, 1940).

SYNOPSIS OF THE POSSIBILITIES OF LIGATURE ON THE ARM

Ligature of the arteria anonyma causes violent disorders of blood supply, The arteria subclavia on the left side may get sufficient collaterals from the cervical and thoracic vessels.

Between truncus thyreocervicalis and arteria circumflexa scapulae: in case of ligature, preservation of the arm is endangered.

Between arteria circumflexa scapulae and arteria circumflexa humeri: supply of the arm is guaranteed, though disorders of blood supply and functional disorders are to be expected.

Between arteria circumflexa humeri and arteria profunda brachii: ligature becomes more critical. It must be endeavored to preserve the vessel.

From the arteria profundadownwards: ligature is without dangers as regards preservation of the arm, though functional disorders may be expected; there is no danger as for ligature of the single branches of the arteries of the arm below the elbow.

Among our cases, we have observed no gangrene and only one case with fatal termination. Among 30 operations on the subclavia, V. HABERER had 4 cases with fatal terminations, that is 11,1% while during World War I, mortality amounted to 23.4% with the French, to 20% with the English. Worth mentioning is the comparatively high percentage of disorders of the circulation (6 times). This is perhaps caused by the fact that in case of aneurysms of the subclavia, as well as those of the brachialis, the nerves are either directly injured themselves or seriously affected by the aneurysm. In case of these aneurysms, larger nerves, sometimes nearly the whole plexus, are involved in the aneurysm sac and sometimes form part of the sac wall. One is then compelled to make a cautious neurolysis. Twice we had to perform a regular nerve suture. These severe injuries of the nerves will easily cause neurotrophic disorders, which will be influenced particularly unfavorably by a deficient blood supply. In one case with a postoperative median paresis, an additional, rather serious causalgia set in.

In such a case, both with neurotrophic disorders and disorders of blood supply, novocain block of the cervical sympathetics has an excellent effect, which we could observe again and again. In very grave cases, we even recommend to sever the preganglion dorsal sympathetic, which we did in numerous cases also because of other disorders of the blood supply.

Case B 10

Injury of the left shoulder with formation of an aneurysm on 30 August 1943. Ligature of the subclavia in a field hospital, which led to grave disorders of the blood supply. On March 2, 1944, the cervical sympathetic was

Übersicht über die Unterbindungsmöglichkeiten am Arm.

Unterbindung der Arteria anonyma hat schwerste Ernährungsstörungen zur Folge. Die linksseitige Arteria subclavia kann ausreichende Kollateralen über die Hals- und Brustgefäße erhalten.

Zwischen Truncus thyreocervicalis und Arteria circumflexa scapulae: Die Erhaltung des Armes ist bei Unterbindung gefährdet.

Zwischen Arteria circumflexa scapulae und Arteria circumflexa humeri ist Versorgung des Armes gewährleistet. Allerdings sind Durchblutungs- und Funktionsstörungen zu erwarten.

Zwischen Arteria circumflexa humeri und Arteria profunda brachii wird die Unterbindung bedenklicher. Die Erhaltung des Gefäßes ist anzustreben.

Von der Arteria profunda abwärts ist die Unterbindung bezüglich der Erhaltung des Armes meist gefahrlos, jedoch sind Funktionsstörungen zu erwarten. Die Unterbindung der einzelnen Unterarmäste kann unbedenklich erfolgen.

Illustration 31

(Description see beginning of article on page 53).

severed, which caused a distinct improvement of the blood supply and of mobility. The increase of heat of the hand and the fingers was distinctly perceptible both objectively and subjectively.

Case B 15 was the only fatal case after operations in this region:

The arterio-venous aneurysm of the 29 year old injured man led to marked symptoms of congestion with distinct delineation of the veins in the area of the back, of the thorax, and of the arm, then, violent additional nerve-pains occurred. Even before the aneurysm was exposed to any considerable extent, an intense-hemorrhage set in, the slit at the place of the anastomoses was the longest one ever observed, about 8-10 centimeters long. Though subsequent ligature of the subclavia was a success, and the slit in the vein could be sutured, death occurred despite two transfusions of blood. Continued hemorrhage with status thymicus lymphaticus was assumed to be the cause of death.

In case D 5, we once observed a postoperative pleural empyema as a further complication: Injuries by shell splinters on March 8, 1943 had led to an arterial aneurysm of the subclavia. The formation of the tumor and its growth may be seen from illustration 32 a and b. In addition to the danger of perforation because of late hemorrhage, the complaints on swallowing and the painful pressure on the plexus brachialis made an operation necessary. Arteriography, performed 3 weeks before the operation, showed an aneurysm sac the size of 2 fists in the area of the subclavia (Ill. 32c). The operation showed that the aneurysm spread to the place of origin on the arcus aortae, so we had to perform an extensive exposure with removal of the uppermost ribs. During the attempt to expose the arteria anonyma, the carotis communis, and the subclavia by blunt dissection, the pleura burst on its left side. Because of the enormous formation of sac and callosities, the anatomical conditions were very intricate. The pleura was sutured again, and it was managed to extirpate the sac and to suture the arterial slit of 1 centimeters length. The pulse wave passed well and the pulse of the radialis was satisfactorily palpable. The wound healed secondarily following pleural empyema, which required a resection of the ribs.

No functional disorders of the arm or the hand occurred.

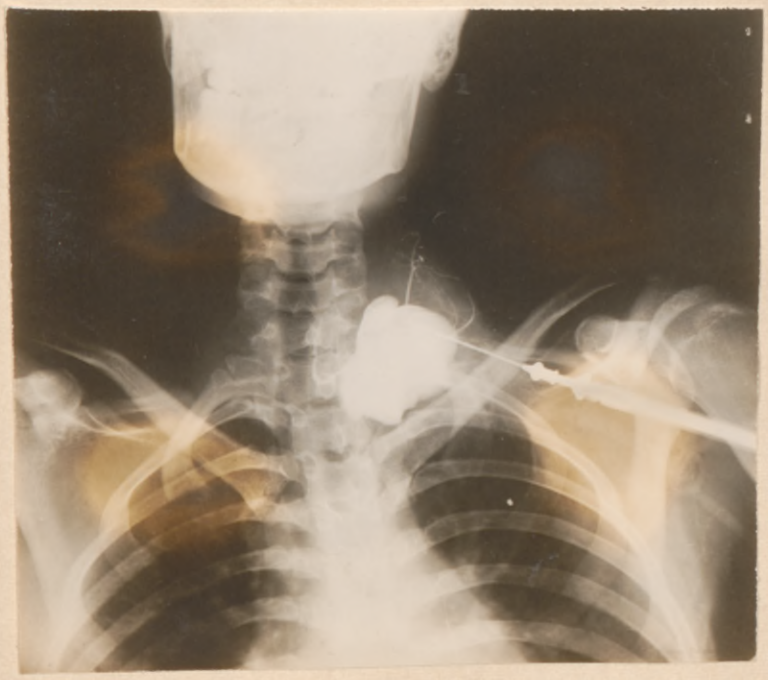
Ill. 32a

Arterial aneurysm of the subclavia.

Illustration 32b could not be reproduced with the facilities available.

Ill. 32b

The same case after rupture of the sac, danger of perforation.



Ill. 32c

Illustration 32c

Arteriogram of the same case

Illustration 32d

The same case 6 months after the operation

We have postoperatively observed decubital tumors or marked injuries of blood supply three times after lateral suture and once each after ligature and circular suture, while, in another case of circular suture, good permeability and complete healing was attained.

The following table shows the results of the aneurysm cases of the upper extremities, of which 3 cases have been operated.

Vessel	Total	lateral suture	circular suture	ligature	turn.in of sac	heal.	heal. with circ. disord.	recurrence
axillaris	12	2	7	2	1	7	4	-
brachialis	9	3	4	2	-	7	2	-
prof. brach.	1	-	-	1	-	-	1	-
cubitalis	5	3	1	1	-	2	2	1
ulnaris	2	-	-	2	-	2	-	-
radialis	2	1	-	1	-	2	-	-
Total	31	9	12	9	1	20	9	1

It is remarkable in this table, that there are the same numbers of ligatures and lateral sutures, and that the circular suture is predominant. Circular suture is the kind of vessel operation that has yielded next after ligature, the most unfavorable results, we think that can be explained by the fact that the arteria axillaris in 7 cases, the brachialis in 4 cases and the cubitalis in one case, were either completely shot off or destroyed to such an extent that only circular suture or ligature were still possible. All the same, the results are satisfactory. 9 cases of circular suture showed no disorders of the circulation at all, in 2 cases slight disorders of the circulation are reported, in one case, there are no data. In 4 cases, in which a postoperative arteriography was made, failure of the vessel was observed, it is true, but a good collateral circulation had been formed.

While ligature of the arteries of the forearm passed without any disorders, there were grave disorders of nutrition with restriction of mobility and temporary occurrence of decubital tumors in one case each after ligature of the large vessels (twice axillaris, twice brachialis and once cubitalis).

Further arteriographies of aneurysms of this area show conditions before and after the operation.

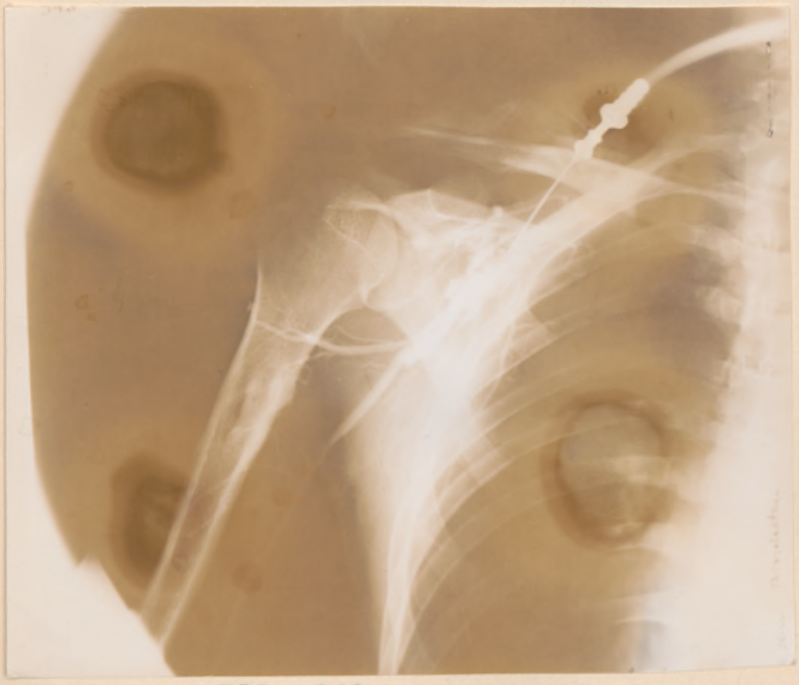
Illustration 33

Case Bl. Aneurysm sac of the size of two fists in the area of the subclavia at its juncture with the brachialis. 2 broad vessel shadows (veins) are to be seen in the lateral lower section.

Condition 10 weeks after the operation. Normal picture of the vessels. The fistula is removed, no narrowing of the vessels after lateral suture.

Illustration 34a

Case B 39. a. Arterio venous aneurysm of the brachialis on the level of a healed gunshot fracture with distinct enlargment of the vessel.



Ill. 34b

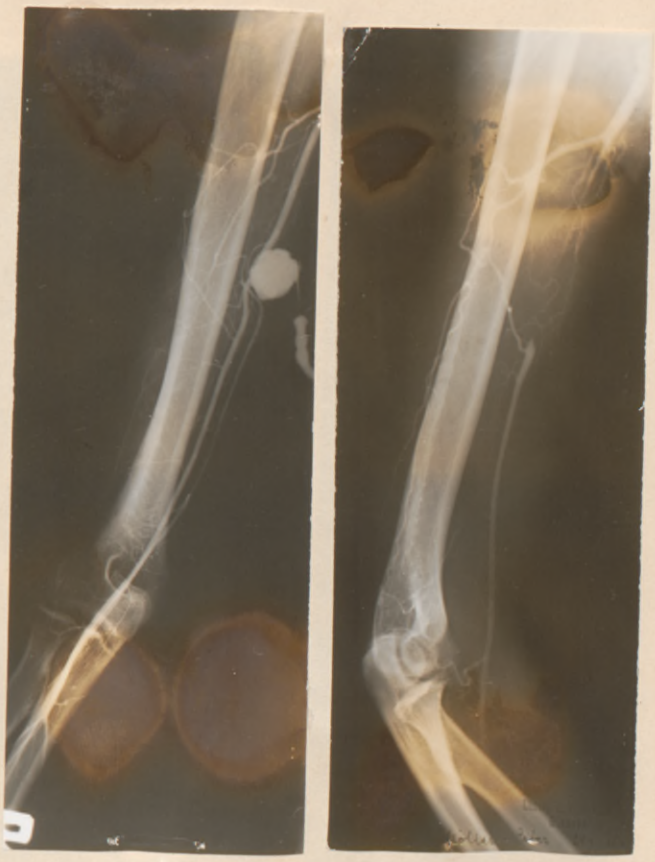
Illustration 34b

After lateral suture good permeability. In the area of the subclavia para-arterial contrast medium.

Illustration 35 could not
be reproduced with the
facilities available.
(a and b)

Illustration 35

Case B 31. a. Arterio-venous aneurysm of the brachialis with formation of a small sac of the artery and considerably enlarged vein.
b. Control arteriography 24 days after the operation. In the area of the fistula a slight sac with free permeability persists, no delineation of veins, fistula removed.



a b

Ill. 36

Illustration 36

Case B 43.

a. Arterial aneurysm of the art. brachialis with sac the size of a walnut.

b. Control arteriography six months after the operation (circular suture). Failure of the brachialis (9cm) with good collateral circulation.

Ill. 37

Illustration 37

Case B 21

Arterial aneurysm of the brachialis with formation of a sac of the form of a heart (as on playing cards)

a b

Ill. 38

Illustration 38

Case B 45

a. Arterio-venous fistula of the cubitalis

b. Condition after lateral suture of artery and vein, fistula removed, tiny eversion at the place of suture.

a b

Ill. 39

Illustration 39

a. Arterial aneurysm of the cubitalis with 2 sacs.

b. Condition after lateral suture and extirpation of the sac with failure of the artery at the place of suture. In the soft parts, longitudinal shadow-streak (old contrast shadow).

Illustration 40

a. Arterial aneurysm of the art. ulnaris with gunshot fracture of the ulna.

b. Condition after removal of the aneurysm by extirpation of the sac and ligature.

a b

Ill. 40

a.

b

Illustration 41

Case B 54

a. Demonstration of the fore arm vessels beginning with the cubitalis, with arterial aneurysm of the radialis.

b. The same case with arterial aneurysm of the common carotid with onion-peel-like stratification.

a b c

Illustration 42

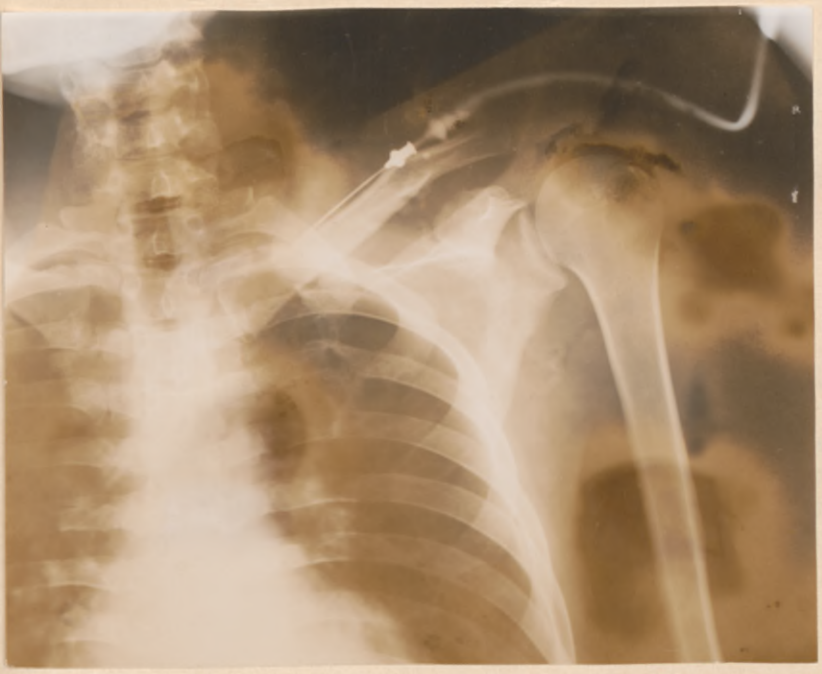
Case B 52

Arterial aneurysm in the area of the arcus volaris caused by iron splinters.

a. Mycotic-embolis arterio-venous aneurysm in the area of the forearm (art. radialis). Arteriography shows the different phases of blood circulation.
first stage: arteriography performed from the cubitalis. While ulnaris and interossea are demonstrated well, the radialis is filled only up to the arterio-venous connection, where a sac is distinctly formed.

b. second stage: Radialis represented distally from the arterio venous junction by collaterals: only now is the formation of the arcus volaris complete. There is no blood supply to the fingers, thus atrophy of the bones.

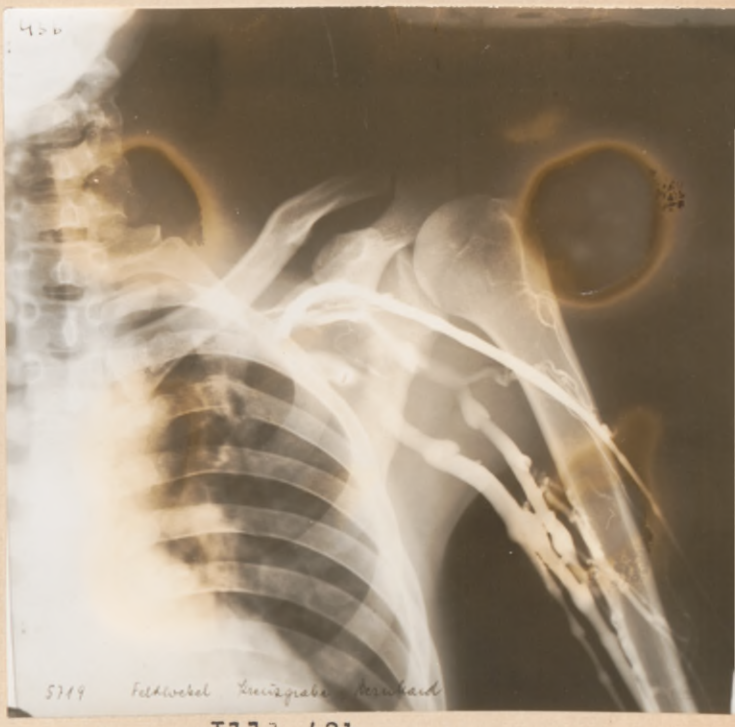
c. third stage: A later picture shows very slight representation of the finger-vessels, also the heavily filled venous convolutions. Operation with extirpation of the blocked veins and removal of the arterio-venous union by ligature of art. and vena radialis.



Ill. 43a

Illustration 43a

a. Arterio-venous aneurysm of the subclavian with formation of a sac and enlargement of the vein.



Ill. 43b

Illustration 43b

Venography of the same case shows enormous enlargement of the vein in the area of the basilica and cephalica with distinct representation of the valves. Gunshot fracture of the 4th rib.

Even without arteriography, an aneurysm may sometimes be ascertained reontgenologically, if there are calcifications, as in our Case B 17, Ill. 44 a and b.

Illustration 44 a and b could not be reproduced with the facilities available.

Illustration 44

Calcification of an aneurysm sac with an arterio-venous aneurysm of the subclavia. Because of calcification, the sac can be recognized without contrast medium.

III. ANEURYSMS OF THE ABDOMINAL VESSELS

Since the aneurysms of the retroperitoneally situated art. iliaca ext. must often be approached transperitoneally, they were included in the discussion of the abdominal aneurysms, particularly since there are in most cases simultaneous intraperitoneal injuries. While, during both World Wars, aneurysms have been observed of all major and intermediate arteries of the outer parts of the body down to the art. temporalis, maxillaris, mammaria, radialis and ulnaris, aneurysms located intraabdominally were observed very rarely. This is easy to understand with the big vessels (aorta, iliaca comm. and ext.), since a fatal hemorrhage will at once result. Though the danger of bleeding to death is not so great if smaller or medium abdominal vessels are injured, it is much more serious than in case of an artery of the same calibre in the extremities, for the abdominal artery discharges its blood into the free abdominal cavity, and there is practically no resistance of the surrounding soft parts. Thus, a fatal hemorrhage may occur even in these cases, or an early operation is required, because of the danger of the artery's bleeding empty or because of concomitant injuries. These may be the reasons why traumatic aneurysms are seldom developed. Intrahepatic aneurysms, or aneurysms of the hepatic vessels, are still observed most frequently.

Synopsis of the Abdominal Aneurysms

Vessel	Numbers	arterio venous	arterial	Method of Operation	Result
Iliaca comm.	1	1	-	extirpation of fistula	recurrence
Iliaca ext.	6	6	-	3 times circ. suture 3 times later. suture	1 amputation
art. mesent. sup.	1	1	-	lateral suture	healing

We have observed two cases of pure abdominal aneurysms, one of the iliaca communica and the other of the arteria mesenterica superior.

The aneurysm of the art. iliaca comm. has been described in detail in Case C 1. During a later examination in April 1946, a recurrence was observed. There was an extraordinary intense continuous rustling in the abdomen with a distinct systolic tumult like the sound of a drum. The noise could be noticed from the arch of the ribs down to the tip-toes. Besides, there was a considerable congestion of the veins in the area of the left leg, of the left buttock and in the inguinal area (Ill. 45 a and b).

Illustration 45a

Ill. 45 a and b. Congestive and trophic disorders in the left leg, considerable varices in the area of the left buttock with arterio-venous aneurysm of the abdominal aorta just below the level of division.

Ill. 45b

In the leg below the knee, there were the beginnings of trophic disorders of the skin, and a considerable swelling of the whole leg. Subjectively, mainly complaints of impairment of gait. There were no complaints of pain in the abdomen itself or of the intestinal organs (heart, lungs).

Since these symptoms evidently kept increasing and endangered life, one more operative intervention was planned despite the great danger connected with it. MATAS and LERICHE have undertaken the problem of the aortic aneurysmsand the latter has indicated a way to expose the aorta behind the peritoneum which ensures previous staunching of the blood. He proceeds as in case of lumbar sympathectomy and thus approaches both iliacae and the bifurcation of the aorta from behind through the peritoneum without any considerably loss of blood.

In 1940, MATAS reported the first successful ligature of the abdominal aorta as treatment of an aneurysm syphiliticum. By means of gauze trips, he performed a double ligature proximally from the aneurysm. 17 months later, death occurred by "galloping" consumption. The aorta had recanalized itself in a narrow lumen. Before the operation a collateral circulation had developed above and behind the aneurysm. But since ligature of the aorta is nearly always fatal, one even tried ligating the aorta, for instance with fascial strips. Even ensheating the artery with cellophane was attempted in an experiment, which caused an enormous irritation of the tissue and puts a constricting ring of scars round the vessels (PEASE). Since this process cannot be checked, obliteration will occur, as a rule. Whilst at the arcus aortae, considerable improvement of the aneurysm was attained by palliative methods, e.g. operation according to BRASDOW-WARDROP, conditions are more unfavorable in case of aneurysms of the abdominal aorta, since only a radical operation promises healing.

The second case (C 8) concerned a 27 year old man who had been wounded three times. The second wounding on 19 August 1943 by shell splinter in the area of the right loin led to a rupture of the liver, therefore laparotomy. The wound healed without any serious consequences. Almost 2 years afterwards, a distinct thrill appeared in the middle of the belly above the navel. There were no remarkable complaints except a slight feeling of pressure. Objectively, a well healed longitudinal scar of the laparotomy was found in the upper belly of the lean patient. In the linea alba right above the navel, a distinct thrill was to be felt, which did not increase in intensity after deep pressing nor spread to a larger area. The continuous rustling was imperceptible both at the iliaca vessels and in the back.

Heart and lungs showed virtually no finding of disease. The same applied to the graph of the cardiac sound and the record of the sound of the aneurysm. (These examinations were made by Prof. WEBER, Bad Nauheim, whom we sincerely thank here also.) A radioscopy of the stomach showed a splinter the size of a small bean in the area of the gastrohepatic omentum. The urine was normal. A test of the liver function conducted with sugar showed no abnormal values.

Though these examinations had settled that the arterio-venous aneurysm did not affect the aorta, and probably no gastric artery, only an operation could clarify the situation. The operation was performed under general anaesthesia. Approach was made through the old

scar. One felt an intense thrill everywhere over the back wall of the abdominal cavity, most distinctly at one place, where also a splinter could be felt, and that was in the area of the duodenal arch and behind the mesocolic attachment. The descending duodenum was examined. The gall bladder was imbedded in scars, but was intact. The portal vein was enlarged almost to the width of a child's arm. After turning up the transverse colon, the upper jejunal and the lower duodenal sections were exposed. Thus, it was possible to expose an arterio-venous fistula about 1½ centimeters wide between the arteria mesenterica superior and the vena mesenterica superior. The art. mesent. sup. was tied above and below, then the fistula was carefully exposed and severed. Lateral suture of the art. mesenterica sup. was possible without narrowing the lumen. In the wall of the vein, there was a bean-sized splinter, which was removed. Lateral suture of the vein was accomplished without any hemorrhage worth mentioning. Marfanil-Prontalbin powder. Peritonealization of the area of operation. Suture of the abdominal wall in three layers.

The postoperative course occasioned concern on several points. First, a postoperative penumonia occurred, which subsided rapidly by sulfonamide treatment. The sixth day, an icterus set in with distinct yellow coloring of the skin and the sclerae. The urobilinogen in the urine was distinctly increased, the TAKATA-ARA reaction was positive, the test of the liver function made with grape sugar yielded almost normal values. At the same time, there were rather violent at times colic-like pains in the belly, the leukocyte count was much increased (17000). A pleural and an abdominal puncture yielded negative results. The wound of operation healed primarily. The icterus subsided a few days later, but since the pain in the belly aggravated a reoperation was decided upon. At the place where the splinter had been an abscess was found which discharged thick matter. Thereupon the fever subsided, the patient felt well and the further course of healing was normal.

The icterus which appeared as a sequel of the operation, doubtless indicated an injury of the liver. Its origin cannot be certainly explained. As the pneumonia subsided comparatively rapidly, it should not be held responsible. It is much more probable that the icterus set in because of the changed circulation conditions caused by the operation of the aneurysm. It is a well-known fact that the liver, being abundant in vessels, is of the utmost importance for the circulation. Situated immediately before the right heart, it can absorb immense quantities of blood as a reservoir-like sponge and retain them if necessary (by contraction of the hepatic veins). Thereby, it prevents the heart's being overcharged with blood and thus regulates the circulation. Probably for this reason, the changes of the heart we are accustomed to finding in cases of arterio-venous aneurysms near the heart, did not occur in our case. The liver is supplied through the art. hepatica, while the principle supply of the blood it has to work up according to its function, enters through the portal vein. Before the aneurysm was removed, conditions were changed in so far, as the liver certainly received more arterialized blood than usual through the channel of the portal vein. This was evidently compensated less in an enlargement of the liver, than rather in a portal vein enlarged nearly to the width of a child's arm and relatively of a lighter red color than usual,

The removal of the aneurysm now restored the normal conditions of the circulation. This caused a sudden change of blood supply to the liver. If one considers that the liver had already been damaged in its functional efficiency by the previous rupture and was perhaps at the limit of its normal efficiency, one may assume that a temporary dysfunction of the organ occurred after the operation because of the necessary adaptation (increase of urobilinogen, positive TAKATA-ARA) and that also the icterus may thus be explained.

When the injury was inflicted, the arterio-venous union evidently did not cause any considerable bleeding or the rupture of the liver was predominant so that the injury of the vessels was not noticed during the first laparatomy. Only in the course of months did the objective and subjective symptoms, because of the changed conditions of the circulation develop.

So ours was a case of a genuine traumatic aneurysm of a large intestinal artery. These cases are decidedly rare. LANG describes a traumatic aneurysm of an artery of the wall of the large intestine in consequence of the affect of blunt force. In the seventh week after the accident, the arterial aneurysm burst into the intestine and caused a fatal hemorrhage. V. SCHROETTER found only 220 aneurysms within 10 years among 19300 autopsies of the Vienna Pathologico-anatomical Institute, without differentiating their origin, among them only 3 of the abdominal aorta, 4 of the splenic artery, 1 each of the art. coeliaca, renalis, and mesenterica superior. There are no data as regards the frequency of traumatic origin. GILMOUR and McDONALD describe a case of gunshot aneurysm of the aorta located between the art. mesent. sup. and the right side of the diaphragm, in which the lumen of the mesent. sup. was closed by a thrombus, but in which there was no communication with a vein nor any aneurysmatic change of the wall of the mesent. sup. Our case obviously seems to be the first and only arterio-venous gunshot aneurysm of the art. mesent. sup. known until now, probably the first arterio-venous aneurysm of this kind altogether.

IV. ANEURYSMS OF THE BUTTOCKS AND OF THE LOWER EXTREMITIES.

This category of aneurysms is the most frequent, among them, the aneurysms of the arteria femoralis are predominant, as shown in the following table:

Synopsis of Aneurysms of the Legs and Buttocks

Vessel	Numbers	arterio-venous	arterial
arteria femoralis	41	36	5
arteria prof. femoralis	5	4	1
arteria poplitea	17	13	4
arteria tib. ant.	7	7	-
arteria tib. post.	5	3	2
arteria peronea	2	2	-
arteria glutaea	2	1	1
Total	79	66	13

The predominance here of the arterio-venous aneurysms as contrasted to other regions of the body is remarkable, which permits the conclusion, at least as far as the art. fem. is concerned, that a high percentage of the pure injuries of the femoralis bleed to death, while in case of arterio-venous aneurysms, the blood pressure at the injured place decreases by partial diversion of the arterial blood into the vein and the shell of soft parts can effect the isolation of the injured place. Even if an arterio-venous aneurym may lead to no considerable functional disorders for years and decades (see cases 39 and 29), just these very cases show that operation is indicated, as has been mentioned before. The 35 operations of the art. fem. performed by us had the following results:

Method of Operation	Numbers	Freely permeable	Narrowed	Healed	Circulation disorders
lateral suture	25	23	2	13	12
circular suture	4	3	-	4	-
ligature	6	-	-	2	4

In 15 of these cases, a postoperative arteriography was made, which yielded the following results:

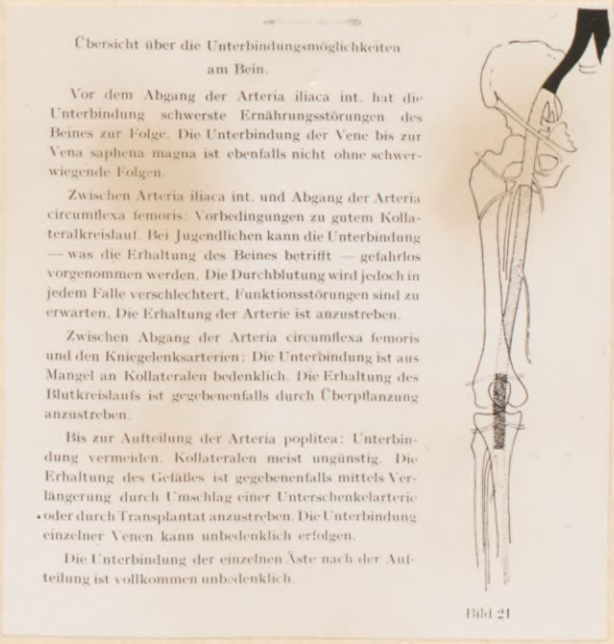
Postoperative Arteriography

Method of Operation	Failure	Narrowing	Permeability
lateral suture	1	2	6
circular suture	1	-	2
ligature	3	-	-

Among our 25 cases of lateral suture, 14 times complete healing and efficiency of the leg were obtained. Among the 11 disorders of circulation, there was only one really serious involvemen while all the rest caused only slight impairment of the efficiency of the leg and they mostly improved in the course of time. The 2 cases of failure of the artery after lateral suture, as ascertained by postoperative arteriography, are surprizing, since in both cases no considerable narrowing was caused by the suture immediately and the blood passed smoothly. But the failure led to no unfavorable sequelae. In one case (Case D 28), where there was a 17 centimeters long failure of the femoralis with the development of a good collateral circulation, trophic tumors healed and the damage to the nerves improved.

Among the 4 cases of circular suture, one failure was ascertained in a postoperative arteriography, three times there was smooth permeability directly after the operation. All 4 cases remained clinically without vascular disorder.

We performed 5 of the 6 ligatures, one case was ligated elsewhere. Among these cases, there is also case D 39 (Aneurysm of the first World War, see page 18).



Übersicht über die Unterbindungsmöglichkeiten am Bein.

Vor dem Abgang der Arteria iliaca int. hat die Unterbindung schwerste Ernährungsstörungen des Beines zur Folge. Die Unterbindung der Vene bis zur Vena saphena magna ist ebenfalls nicht ohne schwerwiegende Folgen.

Zwischen Arteria iliaca int. und Abgang der Arteria circumflexa femoris: Vorbedingungen zu gutem Kollateralkreislauf. Bei Jugendlichen kann die Unterbindung — was die Erhaltung des Beines betrifft — gefahrlos vorgenommen werden. Die Durchblutung wird jedoch in jedem Falle verschlechtert, Funktionsstörungen sind zu erwarten. Die Erhaltung der Arterie ist anzustreben.

Zwischen Abgang der Arteria circumflexa femoris und den Kniegelenksarterien: Die Unterbindung ist aus Mangel an Kollateralen bedenklich. Die Erhaltung des Blutkreislaufs ist gegebenenfalls durch Überpflanzung anzustreben.

Bis zur Aufteilung der Arteria poplitea: Unterbindung vermeiden. Kollateralen meist ungünstig. Die Erhaltung des Gefäßes ist gegebenenfalls mittels Verlängerung durch Umschlag einer Unterschenkelarterie oder durch Transplantat anzustreben. Die Unterbindung einzelner Venen kann unbedenklich erfolgen.

Die Unterbindung der einzelnen Äste nach der Aufteilung ist vollkommen unbedenklich.

Bild 21

Illustration 46

Synopsis of the possibilities of ligature in the leg.

Before the division of the arteria iliaca int., ligature will cause the most serious disorders of blood supply to the leg. Up to the vena saphena magna, ligature of the vein too, will lead to grave sequelae.

Between the arteria iliaca int., and the parting of the arteria circumflexa femoris, preliminary condition to a good collateral circulation. As regards juveniles, ligature can be performed without danger as far as the preservation of the leg is concerned. Blood supply, however, will be impaired at all events, functional disorders must be expected. Preservation of the artery must be attempted.

Between the branching off of the arteria circumflexa femoris and the arteries of the knee-joint; ligature is precarious for want of collaterals. If necessary, maintenance of the circulation is to be endeavored by transplantation. Up to the bifurcation of the arteria poplitea: avoid ligature. Collaterals are unfavorable in most cases. Preservation of the vessel must be attempted if necessary by means of prolongation by turning of an artery of the leg below the knee or by means of transplantation. Ligature of single veins can be safely performed.

Ligature of the single branches after the division is absolutely safe. Synopsis of the possibilities of ligature in the leg with the different degrees of danger (according to ANDREE).

After the operation (in 1943), the patient felt well at first. 2 years afterwards, again had drawing pain in the right thigh, painful knocking and swelling from the middle of the thigh to below the knee. The arteriogram showed a considerable enlargement of the vein with arch-like medial displacement (see Ill. 47). Another operation on January 29, 1946. Masses of blood coagula were removed. The proximal stump (it was a case of a burst arterial aneurysm) was ligated. The peripheral stump did not bleed any longer. Secondary healing with tendency of the leg to swell.

In another case (D 17), we were forced to ligate, because a late bleeding occurred with the development of a pulsating hematoma in consequence of getting out of bed too early following a lateral suture of the femoralis, which had been done for an arterio-venous aneurysm. Even here, no grave consequences remained.

One ligature was made because the artery was destroyed to such a degree that a suture was impossible, and once, the peripheral end of the vessel did not bleed at all, though a sufficient collateral circulation was to be supposed.

An explanation for the fact that these cases led to no radical symptoms of failure is that the ligatures were performed below the profunda femoralis, i.e. in the second and third fourths of the thigh. A ligature above the profunda, within Scarpa's triangle, will take, as a rule, a much more unfavorable course. According to HEIDRICH's statistics, gangrene occurred in 21.8% of the cases, whereas gangrene set in only in 10.7% of the cases ligated below the profunda. Also V. HABERER found this rule confirmed and obtained the best results during operations on the femoralis in the adductor canal. On the other hand, ligature of the femoralis is again more dangerous in its lowest section, after its egress out of the adductor canal. Some surgeons think of this section as already belonging to the poplitea, which explains that these operators then had better results with ligature of the poplitea and that different opinions as to the dangers of ligature of the poplitea could arise.

The following illustrations show some of our cases before and after the operation.

Case D 4

On 15. VIII. 1944, removal of an arterio-venous aneurysm in the area of the femoralis by cutting of the fistula and lateral suture of the artery and vein which had a $\frac{1}{2}$ centimeter long slit.

Several weeks afterwards, thrill occurred again. Another operation on October 9, 1944: A communication between a secondary branch of the prof. fem. and the vena femoralis. No more thrill after ligature of the secondary branch. Control arteriography after 8 weeks : fistula removed. Slight narrowing at the old suture site (49b). There had obviously been a double fistula, one between the art. and vena femoralis, the other between a secondary branch of the profunda and the vein.

Illustration 47 could not be reproduced with the facilities available.

Illustration 47

Aneurysm recurrence of Case D 39, see also page 19 and Ills. 8 and 9. Swelling of the soft parts by hematoma with displacement of the dilated vein 2 years after the operation of the aneurysm, 27 years after the injury was inflicted. The artery is thrombosed proximally to the place of ligature and palpable in a length of about 25 centimeters as a hard cord of the thickness of a finger.

Ill. 48a

Illustration 48a

a. Threefold aneurysm sac of the femoralis.

Ill. 48b

Illustration 48b

Good permeability after lateral suture. As arteriography apparently hit a secondary branch, the femoralis and the profunda are represented only faintly.

Illustration 49 b, could not be reproduced with the facilities available.

a b

Ill. 49

Illustration 49

a. Arterio-venous fistula between art. and vena femoralis, about 20 cm , above the knee-joint.

b. Fistula removed. Slight narrowing at the place of suture.

Illustration 50 a and b could not be reproduced with the facilities available.

Illustration 51 a and b could not be reproduced with the facilities available.

Illustration 50

Case D 27

a. Arterio-venous fistula with big aneurysm sac and splinter.

b. After removal of the fistula and after lateral suture, distinct narrowing at the place of suture but good permeability.

Illustration 51

Case D 43

a. Arterial aneurysm at the transition of the art. femorali into the poplitea.

b. Failure of about 10cm of the main artery after circular suture with good development of a collateral circulation.

Ill. 52

Illustration 52

Case D 32

Failure of the main artery after ligature of the artery and vein (operated elsewhere) bridged by collateral circulation.

Illustration 53 b could not be reproduced with the facilities available.

a b

Illustration 53
Case D 30

Arterio-venous aneurysm of the femoralis with formation of a sac and badly healing ulcera cruris. Rapid healing after operation.

Shows the sac in situ during the operation.

V. ANEURYSMS OF THE ARTERIA PROFUNDA FEMORIS

Hemorrhage or aneurysms of the prof. fem. in most cases make a clinical impression like those of the femoralis, and only by aid of arteriography can the true conditions be ascertained preoperatively. Since the profunda may be very variable in its course and origin, it is often difficult to locate it. Its origin may be from the femoralis right under the lig. Pouparti, or even 11 centimeters lower. Its origin is usually 4-6 centimeters lower. It may originate from both the medial and the lateral periphery. By the fact that also the two circumflexae femoris often arise from it, it virtually supplies all muscles of the thigh with blood (FRANZ). So we have endeavored in our cases to avoid ligature, which we performed only on a secondary branch. The disorders of the circulation after this injury (3 times lateral suture, once circular suture) were negligible. V. HABERER, who otherwise enthusiastically recommends suture, thinks that aneurysms of this artery should be ligated and that suture should be used only in exceptional cases. He did not observe any gangrene.

Case D 63 shows that injuries of the profunda may become dangerous and even lead in rare cases to a fatal hemorrhage in the muscles of the thigh.

A few days after the injury by shell splinters, gradual swelling of the thigh developed in the area of the injury accompanied by violent pain. A swelling of the size of a man's head results with a dimple scar where the bullet entered (Ill. 54a). At first, rustling and thrill in the rhythm of the pulse is audible and palpable which gradually disappears, so that a vascular noise and pulsating can no longer be ascertained. In this state arteriography (Ill. 54b). The art. fem. is pressed medially in a large arc, by the existing tumor of the soft parts (quiet hematoma). With its origin in the prof. fem., there is a filled aneurysm sac the size of a walnut, right beside a shell splinter. Ill. 54c shows the condition after excision of the hematoma, with preservation of the secondary branch of the profunda by lateral suture, normal circulation conditions.

Thus, first a pulsating, then a quiet hematoma arose at a place of predilection, viz. where the artery is surrounded by strong muscles. This state will be caused whenever the internal pressure of the hematoma and the resistance of the displaced tissue counterbalance each other. The thrombotic tumor presses against the afferent artery, and the vein may be compressed, too. Congestion and pain result. The fact that in our cases the pulse of the dorsalis pedis was still distinctly palpable though more feeble than on the opposite side, led to the clinical conclusion that there was some injury of the profunda, a fact, which is mentioned because in most of these cases, a participation of the femoralis is considered first. This was confirmed also by arteriography, which refuted even one more opinion supported until then. In literature, the opinion is supported that, in case of a quiet hematoma, a thrombotic blocking plugs the place of injury of the vessel, thus causing a complete separation of the

Illustration 54a

Arterial aneurysm (quiet hematoma) of the profunda femoris with dimple at site of entry of the bullet; distinct swelling.

Ill. 54b

Illustration 54b

Ant. femoralis pressed medially in a wide arc by the dissecting tumor of the soft parts (quiet hematoma). With its origin in a main branch of the prof. fem. there is a filled aneurysm sac the size of a walnut, right beside a shell-splinter.

Illustration 54c

Condition after excision of the hematoma with preservation of the secondary branch of the profunda by lateral suture. Normal circulation conditions.

hematoma from the artery, which renders the hematoma quiet. As also SCHROEDER was able to show in some pictures, the vessel always retains some, even if slight, communication with the hematoma, some blood always flows from the artery into the blood-cavity, and that in most cases into a small section of the hematoma directly adjoining the arterial injury.

VI. ANEURYSMS OF THE ARTERIA POPLITEA

Even if statements concerning the occurrence of gangrene after ligature of the poplitea still vary very much (15-80% according to FRANZ), it is agreed upon, that ligature of this vessel is very dangerous and therefore should be avoided if possible. Besides, practice shows that the statements of anatomists concerning a favorable development of collaterals from the artry of the knee are not borne out. One assumes that in the tight tissue of the knee joint, the development of collaterals is more difficult than in the muscles. Even an injury of the vena popl. alone may lead to gangrene.(FRANZ). According to HEIDRICH's statistics, gangrene occurred in 37.2% of the cases after ligature. Even if matters stand somewhat more favorable in case of aneurysms because of the possibilities of better development of collaterals, we can rely on this in only very few cases, for instance, if arteriography shows a good collateral circulation even before ligature. But since good blood supply and functional efficiency of the leg below the knee and of the foot after ligature are more or less a lucky incident, one should always use one of the ideal methods during operation of an aneurysm of the poplitea. For this reason, we intentionally never applied ligature in our 14 cases , but 11 times lateral suture, 3 times circular suture. Twice, an amputation had to be performed but in one case, ligature could not be made responsible for it. This was

Case D 60.

Injury inflicted on July 26, 1942 by shell splinter, which remained in the body, An arterial aneurysm developed with pronounced paralysis of the peroneus and extensive trophic disorders in the foot and the toes. Arteriogr phy, made on January 27, 1943 (Ill. 55a) showed an arterial aneurysm of the poplitea the size of a chicken's egg, with compression of the artery and good development of a collateral circulation. During the operation on February 2 , 1943, the aneurysm sac, which was at least as large as a chicken's egg was exposed freely and the afferent and efferent artery visualized. The ischial nerve clung to the sac and had to be isolated. It turned out that the artery was largely destroyed and that a lateral suture was impossible. About 3-4 centimeters of the artery had to be resected, and a circular suture was performed with the

a

b

Illustration 55

Case D 60.

a. Arterial aneurysm of the poplitea; there are distinct collaterals making a circuit around the aneurysm beside the main artery above and below the aneurysm sac.

b. Failure of the poplitea, after circular suture with sufficient development of a collateral circulation, so that the vessels of the leg below the knee are well filled.

knee-joint bent. Thereafter, a distinct pulsation was ascertainable in the peripheral arterial stump. The preparation showed a large aneurysm sac which was crossed by a still patent vessel (vein). The vessel was severed outside the aneurysm sac with the use of cords of connective tissue for ligature. The extensive destruction of the artery beyond the aneurysm sac was remarkable and required a resection. Besides the before mentioned reasons (infection etc.) which we hold responsible for the fragile condition of the artery, it is certain that the compression treatment made for months elsewhere had some part; that treatment had not only not been useful but had rather been injurious. Control arteriography made three weeks afterwards (Ill. 55b) showed a filling defect of the poplitea of 6 centimeters.up to close above the division of the tibialis ant. and post. The defect was bridged over by well developed collaterals, hence good filling of the vessels of the leg below the knee.

The arteriogram corresponded to the clinical course. Immediately after the operation, the foot was cold and cyanotic and there were no pulses of the foot, caused evidently by vascular spasms, but then a good blood supply to the foot was obtained by injection of the sympathetics and doses of eupaverin. The dorsalis pedis was easily palpable. The trophic tumors improved in a remarkable way. Since the neurologist held that the nerve disorders were caused by the formation of a scar in the hollow of the knee, a neurolysis of the ischiadicus and a tenotomy of the Achilles tendon because of pes equinus were performed on October 6, viz. 8 months after the aneurism operation. Subsequently, an empyema of the ankle joint developed which led to amputation of the leg below the knee. This amputation, therefore, cannot properly be considered as a sequel of the aneurysm operation.

Also the second case which led to amputation took an unfortunate course in so far as an arterial aneurysm of the poplitea had to be operated because of the danger of a perforation. The sac, the size of 2 fists was excised, the slit closed by lateral suture. Good patency. On the 12th day, the wound had to be revised because of a late hemorrhage. The suture had opened at the foul, putrescent injury. Despite this, vascular suture of the fragile artery was attempted once more, and the pulse of the foot was again readily palpable. At last amputation in the thigh, because of gangrene of the foot. Pathologico-anatomically, there was observed a circumscribed phlegmonous putrescent invasion of the muscles in the surroundings of the place of suture. In the poplitea itself, there was a small thrombus at the place of suture above the place of division, which led to an absolute closing of the vessel.

Illustration 56 could not be reproduced with the facilities available.

Illustration 56 a and b

(Case D 50).

a) Arterio-venous aneurysm of the poplitea with intense aneurysmatical enlargement of the artery and distinct enlargement of the vein.

b) State after removal of the aneurysm by circular suture of the poplitea 4 months after the operation. Moderate narrowing at the place of suture. The former considerable arterial enlargment by the aneurysm still exists proximal to the fistula, but there is smooth permeability.

So the infection, to which the suture became a victim, was the cause of the unfortunate termination. Deducting the first case amputated because of an ampyema of the ankle joint, we have only one amputation among our 14 cases, or 7%. In all other cases, the leg below the knee and the foot were preserved with good eficiency.

VII. THE ANEURYSMS OF THE LEG BELOW THE KNEE AND OF THE GLUTEAL REGION

Ligature of the vessels of the leg below the knee (art. tib.,post., ant., and peronea) has been considered as safe until now and thus performed as chosen treatment of that place. I have mentioned above the damages as seen by BAETZNER after ligature of the art. tib. post., and we failed once too after ligature of the art. tib. ant.

Case D 68

This case was a secondary operation. Only a small aneurysm sac was removed, during a previous aneurysm operation performed abroad in which no fistula had been found. There were intense disorders of the circulation, besides causalgic pain, so that a second operation became necessary. Artery and vein were ligated above and below the thrill, which ceased thereupon. In the next few days gas gangrene developed, which probably was furthered by a throttling circular strap of adhesive plaster. It was necessary to amputate in the thigh, thereafter rapid healing.

Once we have observed a recurrence, once a temporary postoperative damage to the peroneus. In the rest of the cases, there were temporary disorders of the circulation, which, however, could be improved so much by adequate bandaging, that the patients became fit for service, if no other serious injuries of the bones or nerves made this impossible from the first.

Illustrations 57 and 58 (Case D 74), and Illustration 59 (Case D 72) show aneurysms of the different vessels of the leg below the knee.

Illustrations 57 a and b, 58 a and b, and Illustration 59, could not be reproduced with the facilities available.

Illustration 57

Case D 74

a. Arterial aneurysm of the art. tibialis post. with development of a sac.

b. Failure at the place of suture after removal of the sac and lateral suture.

Illustration 58

a. Arterio-venous aneurysm of the art. peronea with distinct enlargment of the artery above the fistula. The peronea has almost the same calibre as the poplitea.

b. Control arteriography after operative removal of the fistula shows the art. peronea considerably thinner than before the operation, as compared to the other arteries of the leg below the knee. At the level of the splinter, the peronea is interrupted (ligature during the operation) at an angle, an enlarged secondary branch goes down from the place of ligature.

Illustration 59

Case D 72

Arterio-venous aneurysm of the tibialis ant. with the formation of a double sac and distinct enlargment of artery and vein proximal to the fistula.

VIII. ANEURYSMS IN THE GLUTEAL AREA

Both the aneurysms of the gluteal arteries and the hemorrhages out of the large vessels of the gluteal area (art. glutaea sup. and inf.) are judged quite differently in the literature. Though ISRAEL proposed, even in 1905, to ligate the place of origin of these vessels, viz. the art. hypogastrica, because of the difficulties of staunching the blood in the injured area, every now and then (KRISCHE and FRISCHBERG) the aneurysm of the gluteal area are operated at the injured place. Even if the glutaeus maximus is opened widely, ligature of the vessels is difficult, even impossible sometimes, particularly in case of aneurysms, for it is often hardly possible to approach the vascular stalk of the art. glut. sup. or inf. centrally from the aneurysm sac. Similar conditions will arise in case of bleedings when the blood spurts forth out of the pelvis from under the bone. Then, one must first make ligature practicable if necessary by removal of the bone. These difficulties make one understand why most of the authors choose the simpler method of ligature of the hypogastrica for the treatment of the gluteal aneurysms, particularly since it will be successful in many cases. But if one wishes to take no chances, one must approach the aneurysm also at the place of injury after ligature of the hypogastrica, which must therefore be called the method of selection. The operation may be performed in one or two sessions. Very frequently, the symptoms of the aneurysm, particularly the thrill, disappear after ligature of the hypogastrica, but they may again set in afterwards, which happened also in our case.

Case D 1 and 1a

Injury inflicted on November 23, 1942; laying bare the art. glut. at its place of egress because of an arterio-venous aneurysm. Intense interlacing prevents free exposure of the aneurysm sac. The afferent and efferent vessels are ligated. Ligature extends even into the pelvis, but thrill and pulsation reappeared a few days afterwards. For this reason, ligature of the art. hypog. on May 31, 1943 after which pulsation and thril disappear, one week later on, however, a thrill is ascertainable again. This case thus proves ligature of the hypogastrica with removal of the aneurysm to be the only safe method, which was no longer possible, since the patient had to be transferred to another hospital.

In the case of an arterial aneurysm of the art. glut. (Case D 2), ligature with extirpation of the sac led to rapid healing. As frequently with aneurysms of this region, a serious damage to the ischiadicus had arisen, which rendered a nerve suture necessary.

IX. PSEUDOANEURYSMS

At times, one observes symptoms, particularly noises of the vessels, which may feign an aneurysm where there is actually no injury of the vessel. Then we are justified to speak of a so-called pseudo-aneurysm. According to the experimental research work of FRANZ, the causes of the vascular noises of arterio-venous aneurysms, are a change of speed of the blood stream (speed noises) or a narrowing of the track (noise of stenosis). Such noises are, however, occasionally observed in the human body even if there is no aneurysm or tumor, and difficulties may arise in the explanation of that noise, if, on the other hand, there is the possibility of a vascular injury because of a gunshot wound of this area. Even in World War I, such cases were described, and we have met some cases of pseudo-aneurysms, too:

A 33 year old soldier was wounded by shell splinter in the left thigh. Penetration and issue of the bullet in the area of the left flexure of the groin or the left hip. Wounds healed without complications. The leg was shortened by 3 centimeters. Distinct pulsation in the left flexure of the groin with distinctly audible noise, which increased during systole, on the right side normal conditions. The roentgenogram showed a medial fracture of the neck of the femur. For suspicion of an aneurysm arteriography which showed normal conditions of the vessels without any symptom of an aneurysm (Ill. 60). Evidently the medial fracture of the neck of the femur with twisting of the head of the femur had caused a displacement of the art. fem. to the front, the thus formed narrowing led to the noise of pulsation and suspicion of an aneurysm.

In another case, a 20 year old soldier had been wounded by a shell splinter in the right shoulder. Immediate paralysis of the arm and hemathorax had followed. Some months afterwards, an aneurysm was diagnosed for the first time. Under the lateral part of the clavicle, a well healed scar of the size of a penny with pulse synchronal thrill was observed. Arteriography of the subclavia showed a normal arteriogram, so did arteriography of the art. vertebralis; but on both sides there was a pronounced development of cervical ribs; the venous pressure had normal values. In this case the aneurysm was feigned by the anormally (cervical ribs) and by scar bands or callosities in the area of the old wound.

Illustration 60

Pseudoaneurysm as sequel of a displacement of the femoralis after fracture of the neck of femur.

Abb.1
Pseudo-Aneurysma infolge
eines medialen Schenkelhals-
bruches.

Vascular noises of such an intensity that they make one think of an aneurysm do not rarely lead to operation in order to confirm the diagnosis. Operation then will reveal the cause of the vascular noise, for instance cicatricial changes of the gunshot canal with constriction of the artery, callosities of the vessels, pressure by masses of callus etc. If, during the operation, one finds no cause at all of the origin of the noise and if the noise persists during the operation, it is highly probably that there is a genuine aneurysm after all, the thrill of which is conducted very far and which is heard more distinctly at a remote place for anatomical reasons. One can be easily deceived in such cases, and in one of our cases, (Case D 70), only a second operation led to final healing, the first operation with ligature of the art. tib. ant. having made the thrill disappear temporarily. In these cases, one must think of a communication between an arterial and a venous secondary branch, and one should endeavor to find it. The methods of examination described above, particularly arteriography, oscillometry, and measuring of the venous pressure, may be of decisive importance for the differential diagnosis between genuine and pseudo aneurysm.

COMPARISON OF THE ANEURYSMS OF THE FIRST

AND

SECOND WORLD WARS

COMPARISON OF THE ANEURYSMS OF THE FIRST AND SECOND WORLD WARS

A comparison of the aneurysms of the first and the second World Wars has been made in only a few points by some authors. Thus HERLYN reports that he made general inquiries among operated patients of World War I and received 43 answers, which showed that ligature leaves behind greater complaints than the more conservative methods. WILDEGANS and PHILLIPIDES have recently found, in individual cases of the last war, similar changes as we have observed in the case described on page 18. WILDEGANS described a gunshot aneurysm of World War I in a woman which had persisted through 25 years. In place of the fistula, a considerable cicatricial stenosis developed which led to a sac-like dilatation and sinuosity of the afferent artery femoralis and to an extraordinary general congestion of the veins. In the case mentioned by PHILLIPIDES, the arteriogram of an arterio-venous aneurysm of a 50 year old patient of World War I showed a greatly enlarged vein and a false aneurysm at the level of the fistula. By inquiry and later examinations of aneurysm patients of the first World War, we have tried to make a comparison of the aneurysms of both World Wars possible (NUDING). 17 cases of aneurysms of World War I have already been described by GUNDERMANN in the "Report of War Surgery of the Giessen Clinics concerning the first 5 Months of the Present War". A comparison of the aneurysm cases of the first World War treated at our clinics with those we have observed now yielded interesting results as regards distribution, cause of origin etc. The following table is a synopsis of the vessel-injuries from 1914 to 1918 and of their location, numbers, kind of aneurysm and cause:

Place of the aneurysm	Total	art.	art. ven.	shell splint.	inf. gun-shot	spontaneous or other injury
art. carotis comm.	1	-	1	-	-	-
art. interna	1	-	1	1	-	-
art. subclavia	3	2	1	-	-	1
art. axillaris	5	3	2	-	1	-
art. brachialis	9	7	2	3	1	-
art. cubitalis	3	3	-	1	1	-
art. ulnaris	5	5	-	-	2	-
art. femoralis	11	7	4	2	7	1
art. poplitea	2	-	2	-	-	-
art. prof. fem.	1	1	-	-	1	-
art. cir. fem.	1	1	-	-	-	-
art. tibialis	5	5	-	-	2	-
art. peronea	1	-	1	-	-	-
art. interosseadors.	1	1	-	-	-	-
Total:	49	35 71,43%	14 28,57%	6 21,73%	15 65,22%	2

A comparison table of the war 1939-45 shows the following figures:

Seat of the aneurysm	Numbers	art.	art.ven.	shell-splint.	inf. gun-shot	spontaneous or other injury
art. car. comm.	18	4	14	13	4	-
art. car. int.	4	1	3	3	1	-
art. car. ext.	3	1	2	3	-	-
art. vertebralis	1	-	1	1	-	-
art. temporalis	1	1	-	1	-	-
trunc.thyreocerv.	3	-	3	2	-	-
art. subclavia	18	8	10	10	6	2
art. axillaris	14	8	6	4	7	3
art. brachialis	11	3	8	6	3	2
art. prof. brach.	1	-	3	1	-	-
art. cubitalis	6	3	3	2	2	2
art. radialis	2	1	1	-	-	1
art. ulnaris	2	2	-	2	-	-
arcus volaris	1	1	-	-	-	1
art. iliaca comm.	1	-	1	1	-	-
art. mes. sup.	1	-	1	1	-	-
art. iliaca ext.	6	-	6	1	2	-
art. glutea	2	1	1	-	2	-
art. femoralis	41	5	36	23	13	-
art. prof. fem.	5	1	4	2	1	-
art. poplitea	17	4	13	11	2	-
art. tib. ant.	7	-	7	5	1	-
art. tib. post	5	2	3	3	2	-
art. peronea	2	-	2	2	-	-
Total:	172	46 26,74%	126 73,26%	97 56,40%	44 25,58%	11 6,40%

A comparison of these tables shows that the proportion of arterial and arterio-venous aneurysms is considerably changed. 1914-18, 71,43% of the cases were arterial aneurysms (now 26,74%); 28,57% arterio-venous aneurysms (73,26% in this war). Besides, there is a considerable change as regards the cause. While during the first World War, 65,22% of the cases were caused by infantry missiles and 25,58% by shell splinters; in this war, the percentage of shell-and bomb-splinter cases amounted to 56,40%, as contrasted to 27,49% infantry missiles. Among the present arms, therefore shell-splinters cause an aneurysm most frequently, with the infantry-missiles following at a great distance, whilst the hand-weapons (swords, knives etc.) play practically no part any longer. The shell-splinters (rough missiles) are more liable to cause a simultaneous injury of artery and vein, which explains the increase and the predominance of arterio-venous aneurysms.

Comparison of observations of the Giessen clinics during World Wars I and II, with the statistics of other authors with consideration of the single vessels.

Vessel	HERLYN 82 cases %	v.HABERER 318 cases %	GIESSEN 49 cases % (1914-18)	BERNHARD 172 cases % (1939-45)
art.car. comm.	5,0	7,86	4,0	10,47
art. car. int.	---	0,63	---	2,33
art. car. ext.	---	0,63	---	1,74
art. vertebralis	2,0	0,63	---	0,58
art. temporalis	---	0,31	---	0,58
art. max.int.	2,0	0,31	---	----
art.thyr. inf.	---	0,31	---	----
Truncus thyreocerv.	4,0	----	---	1,74
art. subclavia	9,0	14,46	6,1	10,74
art. axillaris	5,0	11,66	10,2	8,14
art. brachialis	17,0	5,34	18,4	6,40
art. prof. brochii	---	----	---	0,58
art. cubitalis	6,0	1,57	6,1	3,49
art. radialis	---	0,31	---	1,16

Vessel	HERLYN 82 cases %	v. HABERER 318 cases %	GIESSEN 49 cases % (1914-18)	BERNHARD 172 cases % (1939-45)
arcus volaris	---	----	---	0,58
art. ulnaris	---	----	10,2	1,16
art. iliaca comm.	---	0,31	----	0,58
art. mesent. sup.	---	----	----	0,58
art. iliaca ext.	---	3,14	----	3,49
art. hypogastr.	---	0,31	----	----
art. glutea	---	1,26	----	1,16
art. femoralis	2,2	26,10	22,4	23,84
art. prof. fem.	4,0	5,66	2,0	2,91
art. poplitea	16,0	10,69	4,1	9,88
art. tibialis ant.	5,0	1,88	10,2	4,07
art. tibialis post.	5,0	5,03	4,0	2,91
art. tib.ant.and post.	5,0	0,63	----	----
art. peronea	---	0,31	2,0	1,16
an.racemosum	---	0,31	---	----

Also surprising is the comparatively high percentage of aneurysms of the carotid from 1939 to 1946. In my opinion, this is no consequence of the kind of warfare (war of position) as is held by NUDING, but of the fact that patients with cervical aneurysms, because of their difficulties and dangers, are more likely taken to special hospitals than patients with the less dangerous aneurysms of the extremities.

COMPARISON OF MORTALITY OF THE FIRST AND SECOND WORLD WARS OBSERVED BY DIFFERENT AUTHORS

FRANZ computes in 1519 operations, 201 cases with fatal termination, that is 13,2%, though he includes fresh injuries of the vessels. STICH only reaches 7% in 1000 operations of aneurysms. Recently,

HERLYN reports a mortality rate of 4% among 82 cases, and V.HABERER had only 18 cases with fatal termination among 349 vascular operations. (5%). The following table shows our results of the late war (1939-1945).

Method of operation.	Totals	Healing	Death	Amputation	Recidivation
Lateral suture	81	75	1	2	3
Circular suture	26	23	1	1	1
Ligature	39	36	2	-	1
Ligature round	2	--	-	-	2
Suture round	1	--	-	-	1
Total	149	134	4	3	8

Since 5 of our 8 recurrences could be brought to healing by a second operation, the numbers of our aneurysm operations increases to 156, the numbers of healings to 139, there remain 3 recurrences, 3 cases of postoperative amputation became necessary. Thus, BERNHARD succeeded in reducing mortality to 2,7% in a by no means small number of aneurysm operations; if we include our recurrent operations, we even arrive at only 2,5%.

In this context, the successful operations of aneurysms treated at our clinics during World War I, appear remarkable. An inquiry sent to all 49 patients was answered by 34, 2 patients could be reexamined at the clinics. These 34 patients had been treated as follows: 28 ligatures, 3 lateral sutures, in one case suture of the aneurysm sac with ligature of the art. prof. fem., 2 patients were treated conservatively. Among the 28 ligatures, a necrosis had set in 2 times (tibialis post. and circumfl. femoris), and an amputation had to be made a few days after the operation.

8 patients died within the last 25 years; 3 of these became fit for service during World War I, and were sent to the front again, where they died in action 1917/18. Their families did not know about any complaints or sequelae of the vascular injury. One patient died in 1925 of the consequences of a gas-poisoning. These cases were ligatures of the art. fem., brach., tib. post and 1 lateral suture of the art. ulnaris. The other causes of death are with one patient "cerebral tumor, weakness after operation", one patient

died of the sequelae of a bladder disease; the cause of death of one patient is unknown, and one patient died in 1936 of "heart-failure". An epicritical judgement of the clinical record and the subsequent progress raised justified doubts concerning this diagnosis. Since the case is also interesting as a "late sequel of aneurysms", it is briefly mentioned.

> H.N., born March 17, 1891, was wounded in France on August 23, 1914, on the right side of the throat. At that time, the finding reported a distinct pulsation thrill and a swelling at the right side of the throat. During the following operation performed on the strength of the diagnosis of "arteriovenous aneurysm of the art. carotis comm.", the aneurysm sac was opened in the attempt to free it, which caused such a violent hemorrhage, that the carotis communis had to be ligated, and a tampon was applied to the aneurysm sac. In the further course, no symptoms of paralysis or of irritation on the part of the brain was observed. The patient complained only at times of most violent headaches, which he localized in the right half of the skull. The discharge examination on October 17, 1914 records a slight thrill above the upper end of the jugularis interna right under the right ear as still noticed.
>
> The further course is described as follows by the deceased's brother: The complaints connected with the vascular injury subsided in the course of time, for all he know. Thus, the patient was able to engage in sports, such as tennis , swimming, skiing etc. Later sequelae which are to be explained by the vascular injury were: swelling of the throat, intensified reddening of the affected half of the face and visible pulsation, but the patient was no more treated because of these symptoms. He drew a pension owing to his injury sustained in military service, but the amount of it is not known. On November 20, 1936, N., suddenly fell dead without having previously felt ill. Cause of death stated as heart-failure.

This finding and the sudden death suggest that a thrombus detached itself from the left aneurysm sac and that the cerebral embolism thus caused led to immediate death. It is highly probable, therefore, that there was an original causal connection between injury and death.

The following table gives information of the cases still alive.

Late Results of 23 Aneurysms of World War I.

Seat of the operated aneurysm	Numbers	Lig.	treatm. suture	conserv.	free from compl.	slight circ.	ser. disorder
art. subclavia	2	2	-	-	1	-	1
art. axillaris	2	2	-	-	-	2	-
art. brachialis	4	3	1	-	-	4	-
art. ulnaris	3	3	-	-	2	1	-
art. cubitalis	1	1	-	-	-	-	1
art. femoralis	7	4	1	2	2	-	5
art. poplitea	2	1	1	-	-	1	1
art. tib. post.	2	2	-	-	1	1	-
Total:	23	18	3	2	6 26,1%	9 39,1%	8

Thus, 26,1% remained without any complaints, in 39,1%, there are only negligible peripheral disorders of the circulation leaving the patient completely fit for work, and there are more serious sequelae in 34,8%. The pensions are fixed accordingly:

8 patients get no pension

11 patients are 30-40%, and

4 patients 40-80% (injured during war-service).

As regards the latter group, it is worth mentioning that in 2 cases, the respective extremity remained paralysed by a simultaneous nerve damage and a higher pension was awarded for this reason.

The stated complaints are the same with hardly any exception: pain in the injured limb if the weather changes, greater feeling of exhaustion after exertion, greater sensitivity for cold in cool weather, swelling

of the leg, chiefly after long standing, atrophy of the affected muscles and contractions appearing as a sequel of the injury. Only the two patients treated conservatively - both had arterio-venous aneurysms of the art. fem. - complained of graver sequelae, which got worse and worse in the course of time. Here is a clinical report as an example:

> On March 22, 1918, J.W. was wounded by a machine gun bullet. The bullet entered below the symphysis and came out somewhat lower on the outside of the right thigh. The right thigh was considerably swollen in its upper half. There was a distinct vascular thrill in the inguinal area, the right leg below the knee and the foot felt warm. On April 10, 1918, it was noted that the aneurysm has not grown and is now three times compressed for ten minutes every day above the Poupart's ligament. Since threre were no subjective complaints any longer, no operation was made and the patient was discharged on April 22.

W. now answered us as follows: In the first few years after the war, he had but few complaints and worked hard and much. Thereby, the aneurysm increased, and he developed pronounced varicose veins. On account of an examination by an official doctor, made in 1936, an impediment of his capability of earning his living of 40% was ascertained and the corresponding pension granted to him. Recently the suffering has become so much worse, that he frequently has to consult a doctor and his present state is almost intolerable.

A comparison of the success of suture and ligature in these cases is hardly possible, since suture was made only twice and each time caused disorders of the circulation.

These observations of aneurysms of the first World War are meant to complete the discussion of the above mentioned late sequelae.

S U M M A R Y

S U M M A R Y

221 aneurysms are reported, 172 of which have been observed during the late war, 49 during the first World War at the Surgical Clinics of the University in Giessen. Hereby, manifold experience as regards early and late sequelae and their treatment was gathered.

For the diagnosis and evaluation of the condition of the circulation before, during and after the operation, arteriography is highly important. The "percutaneous technique" is described for the single vessels. As we have observed during several hundred arteriographies, it is practically without danger and provides useful pictures. Advantages and disadvantages of the different contrast-media are discussed.

Measurements of the temperature of the skin, oscillometry and measurements of the venous pressure were referred to for diagnosis and evaluation of the conditions of the disease and yielded important knowledge. While in case of arterial aneurysms, there is a decrease in the temperature of the skin in the peripheral section as a consequence of deficient blood-supply, there was found in case of arterio-venous aneurysms, a distinct increase of the temperature of the skin distally of the arterio venous communication. These differences of temperature are not, as assumed formerly, only sequelae of a congestion, but they are caused by increased arterial blood supply evoked by the regulatory means of the body, partly central, partly sympathicotonic. This opinion is also confirmed by the enormous enlargement of the artery above the communication often observed in case of arterio-venous aneurysms, which is caused by the fact that the body tries to neutralize the fall of pressure occasioned by the draining of arterial blood into the veins. Not mere mechanical and hydrodynamic factors, but above all physiological factors cause these changes of the vessels in a reflex manner. Oscillometry, too, supports the same conclusions. In case of arterio-venous aneurysms, it always showed proximally of the arteriovenous junction, as a consequence of the increased arterial blood supply, a considerably rising oscillometrical index, which is characteristic of the arterio-venous aneurysm, while peripheral to the communication, the oscillometrical curve always showed a flattening as a sign of worse arterial blood supply.

Measuring of venous pressure also confirms these results, and a positive venous pressure is a certain symptom of an arterio venous union, which is important for differential diagnosis, e.g. in case of pseudo-aneurysms.

Beside these local peripheral effects illustrated by curves and pictures, serious central changes of the heart are frequently observed. Comparative examinations of arterio-venous aneurysms of the art. femoralis over a period of almost thirty years have been particularly interesting. Slowing down of the pulse, increase of blood pressure and diminution of the heart, when pressure is applied to the aneurysm, may be clearly seen from examinations and orthodiagrams of the years 1914 and 1942, at the same time the adaptability of the organism to pathologic conditions. As could be roentgenologically proved in several cases, a dilatation of the heart will occur even after a few months in case of arterio-venous aneurysms on account of over-exertion of the heart, which may even lead to decompensation and which will disappear within a few months after operative removal of the arterio-venous aneurysm.

Concentration of the aneurysm cases accumulated in wartime at special hospitals and their operative treatment by a few particularly experienced vessel-surgeons promises the best results and is therefore warmly recommended.

Spontaneous healing of an arterial aneurysm has been observed six times and proved by arteriography. In spite of that, absolute indication for operation remains because of the dangerous complications which will often set in even years afterwards.

The most favorable time for the operation depends on different factors. Early operation, 3-4 weeks after the wound was inflicted, is recommended for the pulsating hematoma, if there is no grave infection and if the development of a collateral circulation is to be expected and if rupture or hemorrhage do not enforce an earlier operation. Waiting 2-3 months has proved advisable because of the often very serious inflammatory symptoms observed in this war. Post operative infection has been rarely observed. In cases of arterio-venous aneurysms, one can wait nearly always for the most favorable aseptic conditions.

The ideal method of operation for the aneurysm is the vessel suture, which will restore normal circulation conditions. If this method is not possible or not necessary, ligature is considered, occasionally also vein transplantation or displacement of an artery. The palliative methods are emergency methods and not safe as regards healing and prevention of recurrences. Circular and lateral suture are described in detail, as well as the circumstances that may lead to failures. Though impermeability will often occur after circular suture, it should be preferred to ligature, since the gradual failure of the principal vessel will further the development of a collateral circulation.

8 abdominal aneurysms were approached operatively, among them 1 aneurysm of the iliaca comm. 1 arterio-venous gunshot aneurysm of the art. mesenterica sup., evidently the first of its kind, was brought to healing by operation. Interesting physiological particulars as to blood supply to the liver changed by the aneurysm before and after the operation were observed.

Aneurysms of the lower extremities, particularly of the art. femoralis, are most frequent in numbers, with five times as many arterio-venous aneurysms as arterial ones.

As postoperative arteriographies show, lateral suture yields the best results as regards permeability of the vessels (75%), but even in case of failure of the principal vessel through ligature or thrombosis, a sufficient functional efficiency has been obtained by collaterals, as a rule.

Among the formidable aneurysms of the poplitea (14) in which an ideal method of operation should be always undertaken, a gangrene once set in, because the suture was destroyed by an infection.

Ligature of the single vessels of the leg below the knee (art. tibialis ant.,post., and peronaea) is not always without dangers.

The safest way of removing the aneurysms of the gluteal area is the treatment at the place of injury with ligature of the hypogastrica.

Pseudoaneurysms and their differentiation against genuine aneurysms are discussed. Comparative statistics of the appearance of aneurysms in the different regions of the body shows a relatively high percentage in the area of the carotid among our patients as compared to the data of other authors.

A comparison of 49 aneurysms of the first and 172 aneurysms of the second World Wars shows a considerable increase of arterio-venous aneurysms during the last war; the percentage of vessel injuries caused by shell- and bombsplinters in contrast to infantry missiles has considerably increased, too.

Vicissitudes and late results of aneurysm patients of the first World War are described.

Among 156 aneurysms of the late war (39-45), which were operated by one operator, 4 cases with fatal terminations occurred. Mortality thus amounted to 2,5%. The failures were practically inoperable cases or inevitable complications, so that operation appears to have been indicated in any case.

Also the direct functional results have been outstanding with the technique applied, and postoperative amputation had to be made only very rarely because of infection.

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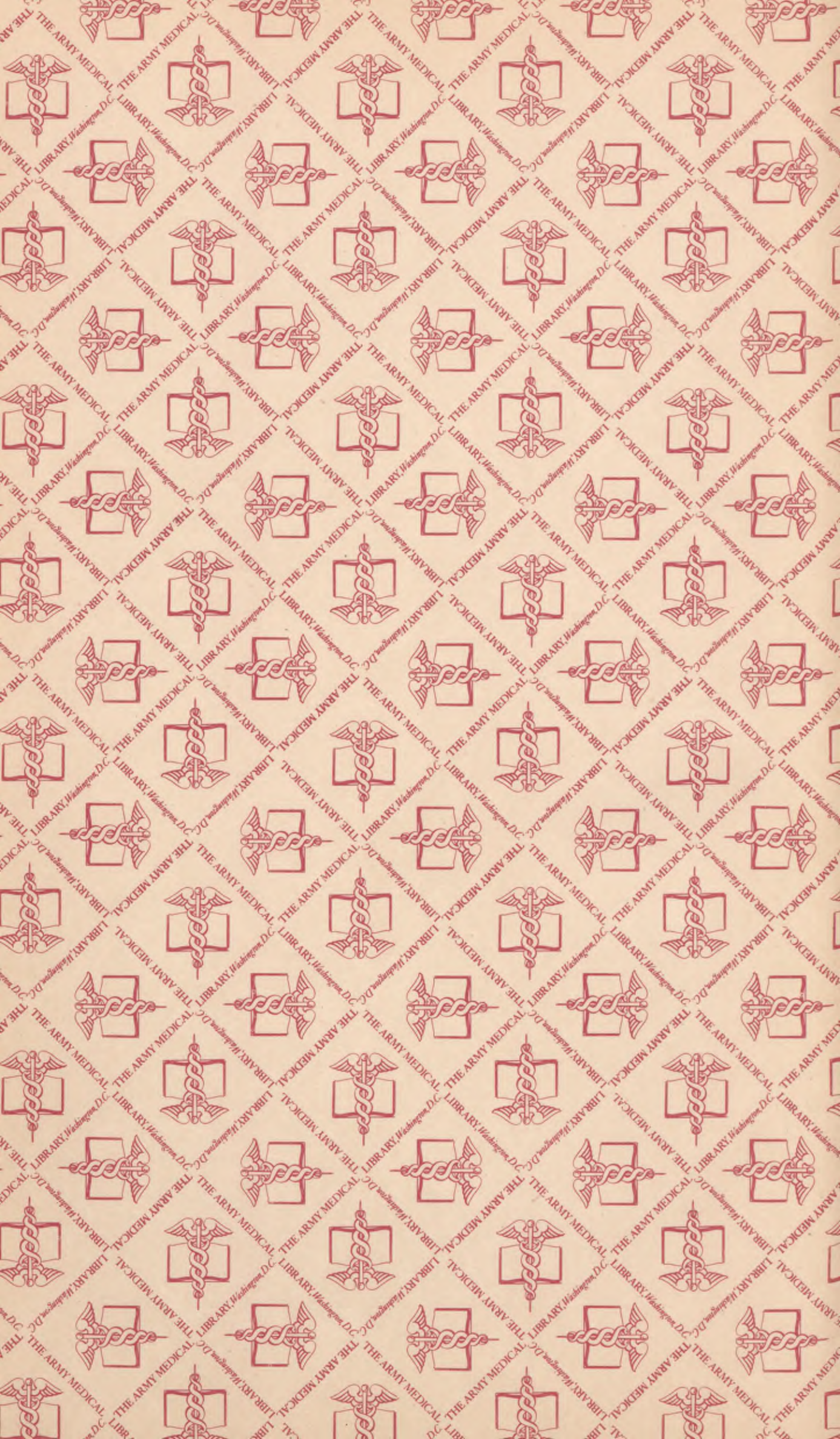
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