

ON MOMBURG'S METHOD OF ARTIFICIAL ANÆMIA
BY SUPRAPELVIC CONSTRICTION.*

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For more than thirty-five years Esmarch's artificial anæmia, produced by elastic constriction of the extremity to be rendered bloodless, has been the common possession of surgery. It is pertinent to ask,—why did not Esmarch apply his simple and effective method to the abdominal aorta? His invention of an aortic compressory testifies that he was aware of the desirability of some procedure to control this vessel. Grave theoretical objections must have discouraged him from taking the last logical step—the application of simple elastic constriction to the waist of the patient. In a letter dated November 24, 1903, directed to Momburg, he still fears the effect of the rubber band upon the gut, but he hopes that his correspondent may succeed in proving the safety of the procedure. Esmarch's objections were shared by those surgeons who, by various proposals, endeavored to solve the problem of aortic compression. Modifications of the tourniquet were proposed and abandoned. McBurney practised digital compression of the vessel through an abdominal wound, a plan which has given good results in the experience of a number of surgeons, including myself. Yet the objection of adding the dangers of laparotomy to those of an amputation at the hip-joint, for instance, could not be ignored. The need of a reliable and convenient form of hæmostasis in this very operation was further emphasized by the invention of the pin method of Wyeth, which, in spite of grave drawbacks, has found enthusiastic advocates.

Ribera¹ has recently maintained the priority of his claim

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to the procedure now known as that of Momburg. As far back as 1893 he has used in exarticulations of the thigh the elastic band applied in the shape of a spica, the circular turn of the apparatus being placed around the waist. In 1898 he perfected his method by placing one turn of the constrictor, not over the inguinal fold, but by applying it along the intergluteal depression. With the aid of this plan, he successfully performed fifty-four exarticulations of the thigh, with ten deaths. While giving credit to Ribera for what is due to him, we cannot accept his point of view. Momburg's and his procedures are not identical, the former possessing the indubitable advantage of greater simplicity.

Momburg's first communication on the subject appeared in the *Zentralblatt für Chirurgie* on June 6, 1908, containing the report of two successful cases. In one of these, Professor Bier of Berlin removed, for sarcoma of the acetabulum, one half of the pelvis, together with the lower extremity. At the meeting of the Deutsche Gesellschaft für Chirurgie, held in April, 1909, Momburg reported on 34 cases.² In December of the same year he added the report of 200 cases.³ Thus we see that the procedure has met in Germany with a rapid acceptance.

Let us now see what the procedure is. The patient is placed in Trendelenburg's position. The end of a piece of soft rubber tubing, having the thickness of the index finger and the length of about four feet, is passed through under the back of the patient, to be grasped by the hand of an assistant who stands at the other side of the operating table. The tube is then stretched to the utmost, and, thus stretched, is passed by the surgeon midway between the border of the ribs and the iliac crests across the abdomen to the other hand of the assistant, whose duty it is to maintain the tension. The free end of the tube is now led back under the patient by the surgeon and is again put to the stretch, the assistant in the meanwhile gradually releasing the bight of the stretched tubing, which now firmly encircles the waist. While this is being done, another assistant places a finger upon the femoral

artery to ascertain the moment of the cessation of the pulse. Observing the same steps, two, three, or more, turns of the tubing are exactly superimposed until the femoral pulse disappears. In slim individuals two turns will suffice; in fat or muscular ones, as many as six may be necessary. As soon as the femoral pulse is suppressed, the ends of the tube are crossed, to be secured by forceps or ligature. After this is done, constrictors are applied to the thighs below Poupart's ligaments, and to the legs below the popliteal spaces. The reasons therefor will be later explained. Should exarticulation of a lower extremity be contemplated, the considerable quantity of blood contained in the vessels can be saved by preliminary elevation; or, if no counterindications exist, by the application of a pure gum bandage from the toes up to the groin. The immediate effect of the constriction of the waist upon the appearance of the patient is grotesque in the extreme, indeed almost shocking. The proportions become truly wasplike, but we may be reassured by the knowledge, that this appearance alone does not imply any danger. It is true that the exhibition of a considerable tension is necessary to interrupt the blood current in the aorta, but most of this tension is used to overcome the resistance of the abdominal parietes,—only a small fraction being needed for the actual compression of the vessel.

Originally Momburg applied the constrictor in the horizontal decubitus. Not in one case has there followed herefrom any injury to the intestine. Theoretically, the fear seemed to be justified that a distended gut might easily be ruptured by too great pressure of the rubber band. A number of animal experiments, however, and experience with man, have demonstrated this to be unfounded. Nevertheless, Momburg now advises the use of Trendelenburg's posture, thus to cause, previous to the application of the constrictor, the recession of the intestines upon the diaphragm.

The immediate effect of the procedure is: first, the circular approximation of the abdominal parietes to the third and fourth lumbar vertebræ; secondly, the compression of the

aorta against the spinal column; thirdly, the compression of the root of the inferior mesenteric, and perhaps the spermatic arteries. Sometimes,—and this depends on anatomical variation,—a lesser or greater number of the branches of the superior mesenteric artery are also compressed. At other times, even the trunk of this vessel may become occluded, a circumstance of great importance, as will be later shown. These conditions insure a faultless artificial anæmia of the entire pelvis and its contents, and of both lower extremities. The greatest advantage of the method, however, is that the constrictor does in no manner encroach upon the field of operation, be that inside or outside of the pelvis, on the genitals, or the extremities. Momburg indicates the manner in which *absolute* anæmia of the pelvis may be secured. This is done by first rendering bloodless the lower extremity of the side on which the operation is to be done by elastic bandaging from the toes up to the groin. This is followed by the occlusion of the aorta at the waist. Then the elastic rubber bandages compressing the lower extremity are removed and, the patient's pelvis being raised, the legs are placed in the dependent posture, permitting all the blood still contained in the pelvis to gravitate to the extremities. But this advantage is only a seeming one, as the procedure takes much time, the saving of blood is inconsiderable, and one great advantage is lost thereby,—the indication of the situation of the smaller and smallest vessels given by the exuding of a drop of blood from their cut orifices.

As soon as the operation is finished and all the vessels have been secured by ligatures, the rubber band encircling the waist is removed. Directly after this the other rubber ligatures embracing the thighs and legs are untied one by one. The object of this is the gradual extension of the scope of the circulation, and the avoidance of a too sudden demand upon the efficiency of the heart's muscle. By this switching on of one segment of the circulatory system after another, the readaptation of the heart to the changed conditions is gradually effected.

As to the applicability of the method, the following may be said: All surgery in and about the pelvis has by it been divested of its greatest danger,—the uncontrollable loss of blood. This loss, even from oozing alone, has always been so considerable as to constitute a real danger, and has often deterred us from interfering with growths involving the pelvic skeleton. On account of the advantages it offers, gynecology has immediately appropriated the new method in dealing with cancer of the uterus, where radical procedures, such as Freund's for instance, are being adopted with increasing frequency. Neuhaus⁴ reported five cases in which Mackenrodt operated with the aid of Momburg's constriction. His procedure began with a transverse abdominal incision above the symphysis pubis. The intestines were made to recede upon the diaphragm in extreme Trendelenburg's position, after which the elastic tubing was applied, thus avoiding their compression. If the gut was attached to the pelvic organs by adhesions, these were liberated previous to the application of the tubing. To prevent prolapse of the intestine, this was carefully confined to the space above the constrictor by a system of cloth packings, so that only the uterus, its adnexa, the bladder, and the sigmoid flexure remained behind in the pelvis. These preliminaries disposed of, the extreme Trendelenburg's position was reduced to the amount needed by the operation proper. This author found the hæmostasis flawless. The site of each cut vessel was clearly marked by the exudation of a drop of blood, thus facilitating its closure. No sponging whatever was required. In fat or very muscular subjects, Mackenrodt recommends the slipping of a suitable gauze pad intraperitoneally between the rubber tubing and the aorta, a measure, by the way, much deprecated by Momburg.

Useful as Momburg's procedure has been found in surgery and gynecology, nowhere has its life-saving value been more signally proven than in obstetrics. It is true that a number of the first trials by Rieländer⁵ resulted in failures. In two cases of placenta prævia the application not only

failed to check the hemorrhage, but was shortly followed by the rise of the pulse to 136, and by deep collapse, which immediately ceased upon the removal of the elastic band. Rieländer states, that, though the tubing was applied with the utmost force, the femoral pulse remained nevertheless clearly palpable. With the disappearance of the collapse, the pulse returned to the normal rate. Axhausen's⁶ explanation of Rieländer's experience seems to be reasonable. He attributes the failure of hæmostasis, and the collapse, to *insufficient arterial compression*. While these vessels remained partly patulous the corresponding veins were certainly occluded, thus producing an engorgement of the intestines and lower extremities by the backing up of the blood, and a dangerous cerebral anæmia. This assumption is rendered extremely probable by the disappearance of the collapse after the removal of the tubing.

In marked contrast with Rieländer's failures are the successes in twenty-five cases of grave post-partum hemorrhage observed by Sigwart,⁷ and in sixteen similar cases by Weber.⁸ Sigwart states that after the adjustment of the elastic tubing, with two exceptions, the cessation of the hemorrhage was immediate and complete, and was, in most instances, followed by a prompt contraction of the uterus. Where contraction was not immediate, it never failed to occur directly after the removal of the constrictor. In two cases the hemorrhage was not checked by the application of the elastic tubing, and had to be controlled, in one case by packing and in the other by hysterectomy. Though no anæsthesia was used, the women complained very little. The radial pulse rate became slower, its quality smaller,—returning to normal after the removal of the tubing. The course of the childbed was normal. Twice, when the cause of death was not hemorrhage, post-mortem examination demonstrated no abnormality of the abdominal organs, notably the gut. Sigwart is so convinced of the great value of the method, that he warmly recommends its use in post-partum hemorrhage to general practitioners, obstetricians, and even to midwives.

Weber reports that in all of his sixteen cases of post-partum hemorrhage the application of Momburg's constriction was immediately and invariably effective. The placenta was spontaneously expelled by an energetic contraction of the womb, which remained unchanged after the removal of the band. He adds that in over forty other cases, where post-partum operations were done under Momburg's anæmia, the method was ineffective three times. In these cases some hemorrhage was observed, though the femoral pulse was suppressed. He discusses his and Rieländer's failures, and suggests as an explanation in the latter's cases, a slipping of the aorta from the eminence of the spine. We have seen that Axhausen has furnished a better explanation. As to Weber's own failures, the slipping out of the grasp of the rubber band could not have taken place, since he states explicitly that the femoral pulse was suppressed. It is more probable that anastomosis between spinal vessels and those of the pelvis may have established a collateral circulation. Weber observed no bad systemic effects; pulse and respiration remained unchanged, no vomiting occurred, and the child-bed showed no change from the normal.

For how long a time can aortic compression be exercised without detriment? We know that in the dog, *f.i.*, even short compression of the aorta is followed by serious paralysis of the hind extremities. Fortunately, for anatomical reasons, nothing similar occurs in man. Heretofore the measure has been safely applied for the duration of two hours and twenty minutes. This signifies that in man aortic compression does not differ in its effects from the effects of the compression of the peripheral arteries. Probably it can be extended to three hours without serious damage,—a circumstance of inestimable value in certain emergencies. In post-partum hemorrhage,—or in injuries with excessive hemorrhage caused by accidents in war, on railroads, in mines, or factories—preliminary hæmostasis can readily be secured by the simple means of elastic constriction. Thus time will be gained for the transportation of the patient to a hospital or other place,

where safe, expert, and definitive surgical relief may be had.

The question, "Is the method safe?" can be answered in the affirmative as to young and healthy individuals with a sound circulatory system. Elderly persons with a damaged heart form the exception. Rimann⁹ observed, after the removal of the constriction, distinct diastole of the pulse where the band had been applied for twenty minutes. Rimann and Wolff¹⁰ reported observations of the serious effect of the use of Momburg's methods on elderly patients with cardiac lesions. In the case of a woman forty years of age, who had no valvular trouble, but a weak pulse, extirpation of a rectal cancer was done with aortic constriction. Measurements of the brachial blood-pressure were made. Within fifteen minutes after the application of the rubber tubing, the pressure sank from 115 to 85 millimetres, and in ten minutes more to zero. Immediately after the removal of the tubing it rose to 75, and gradually, within the time of twenty minutes, to 100 millimetres. During the following night energetic stimulation was repeatedly required. Twenty-four hours after the operation marked lateral dilatation of the heart, systolic murmur at the apex with accentuation of the second pulmonary sound were observed; in short, mitral insufficiency had developed. In addition to this, for twelve days the pulse remained arrhythmic and irregular, needing the exhibition of digitalis. Animal experiments instituted by these authors for the study of the effect of Momburg's constriction have shown that as in man, so in animals, the occlusion of the aorta and inferior mesenteric vein has little influence upon the action of the heart. The moment, however, that the superior mesenteric artery also was blocked, there followed, within 26.2 seconds, gradual rise of the blood-pressure by 21.2 millimetres on an average. After the removal of the rubber tubing, within 6.5 seconds, the pressure dropped on an average by 40.8 millimetres. The explanation of these facts seems to be that the sudden reduction of the area of circulation caused by the exclusion of the aorta and the inferior mesenteric, together with that

of the superior mesenteric arteries, produced an increased resistance which had to be overcome by an augmented effort of the heart. This effort again was the cause of a considerable amount of cardiac fatigue which on the removal of the constriction manifested itself, even in healthy and young persons, by the rapid sinking of the blood-pressure. Whenever a worn out and damaged heart muscle is made to undergo this effort, it may become directly insufficient as soon as the greater strain is put on, that is, while the constricting tube is still *in situ*; or, having overcome this initial strain, it may fail when, on the removal of the rubber band, the excluded portions of the circulation are switched on,—and this for the reason, that the sudden extension of the circulation from the restricted to the normal area constitutes in itself an additional demand upon the energy of the heart,—especially a heart previously enfeebled by disease and by the unusual effort thrust upon it by Momburg's method. This is why he so strongly advocates the use of subsidiary elastic ligatures applied to the extremities preceding suprapubic constriction. By successively untying these subsidiary ligatures one after another, the area of circulation is gradually widened, and the heart is gently led back to its normal functional output of energy.

By studying the histories of the cases heretofore published by numerous authors, marked divergence of the behavior of the heart is a marked feature. In most instances we meet with the statement that during and after the application of the elastic band no irregularity of the cardiac function was observed. But in a respectable number of the cases well-marked cardiac depression followed the removal of the constrictor, even in young and healthy individuals,—an alteration, however, which had no dangerous features and was of a passing character, easily overcome by ordinary stimulation. These differences may receive an anatomical explanation. Individual variations exist regarding the height at which the superior mesenteric artery passes from the aorta. A high branching off of this vessel means this, that its trunk

would not be embraced in the grip of the rubber constrictor, and hence that the action of the heart would not become much disturbed. Conversely, a low site of the root of the superior mesenteric artery would necessarily result in the compression of this vessel, and would, even in healthy young individuals, lead to passing anomalies of the heart action. The graver forms of heart insufficiency would, on the other hand, be the rule in cases of cardiac or vascular disorders, especially where a low site of the trunk of the superior mesenteric artery made its compression unavoidable. Therefore, whenever possible, due selection of cases should be made, and in the presence of marked arteriosclerosis, myocarditis, or valvular lesions, even when well compensated, Momburg's procedure should not be employed except under most stringent necessity, and as a last and desperate resort.

Attentive search in the American periodical literature reveals the absence of an account of even a single application of this important addition to the technic of hæmostasis. Its value to the surgeon in the injuries and maladies of the pelvis, to the gynæcologist, and especially to the obstetrician and general practitioner called upon to deal with emergencies accompanied by excessive loss of blood, is undeniable, hence it seemed proper to put on record the following observation made by the author of this paper.

Louis Damashoffsky, 21 years old, married, admitted to the First surgical division of Mt. Sinai Hospital, March 1, 1909. Had no syphilis. Four months before admission, noticed swelling on inner side of thigh just above the knee-joint, which has since gradually increased in size, and was causing dull and inconstant pain.

Physical examination: Short, stout, and muscular habitus; good general condition. Heart and lungs normal. Liver cannot be felt; not enlarged. Edge of spleen can be felt one finger below costal border. Marked enlargement of lower one-third of femur, especially on the internal aspect; swelling not tender; over it skin of normal color and temperature; tumor is smooth and hard, of uniform consistency, not painful on

pressure, and immovably attached to the underlying bone. Extension of knee normal; flexion somewhat limited.

Diagnosis: Medullary sarcoma of thigh.

Operation: March 6th. Disarticulation of the thigh under Momburg's artificial anæmia. Nitrous oxide and ether anæsthesia of good character. In the supine horizontal position of the patient, a soft rubber tube was passed under and around his waist under great tension, three full turns being superimposed. At the completion of the third turn the femoral pulse disappeared. The waist had become so reduced, that it could be almost comprised in the circumference of two outstretched hands. There was no change in the appearance of the patient, nor was there any immediate change in the character of the pulse or the respiration. A racquet shaped incision with its handle on the trochanter then encircled the thigh immediately below Poupart's ligament. The skin was dissected well up above Poupart's ligament and on the gluteal aspect; the inguinal lymphatic glands were exposed so as not to leave any of them behind; the hip-joint was invaded from the front and disarticulated. Then all the soft parts were cut through close to the pelvis. The hemostasis was absolute. Each vessel was carefully tied, and then the rubber band was removed from the waist, where it had been in situ for twenty-six minutes. No further ligatures were needed; drainage and suture of the wound. The operation was truly a bloodless one. The pulse, eighty-four at the beginning, rose gradually to one hundred and sixteen towards the end of the operation, its quality remaining excellent to the moment after the removal of the constrictor. Then there was a sudden drop in tension, very noticeable, though not alarming. A camphorated ether injection improved it somewhat. The facial expression did not change, nor was there any noticeable rise in the rate of the respiration. Anæsthesia had lasted forty-seven minutes. Fifteen minutes after the operation the pulse had risen to one hundred and twenty-four and had become thready, so that a saline intravenous injection of 800 grammes was administered with marked effect. The patient vomited twice directly after the operation, the pulse rate still rising, till it reached its maximum twenty-two hours after the operation at 164 beats per minute. The temperature had also steadily risen from the normal standard to 103.4° F., which figure was reached also twenty-two hours after the operation.

The pulse had remained fairly good after the saline injection, needing little further stimulation, and the patient spent the first night comfortably with the aid of seven minims of Magendie's solution. No heart murmurs were observed. Twenty ounces of urine, somewhat concentrated, but otherwise normal, were drawn by catheter twenty-four hours after the last preceding evacuation.

March 7: Milk punch with whiskey was given and retained. From midnight between March 7th and 8th, the temperature rate showed a steady decline, reaching the normal standard on the morning of March 10th. The pulse rate also showed a tendency to diminution, but the descent was slower, eighty-four beats per minute being first observed on March 18th. The last catheterism was done on March 11th; the first stool was passed after an enema on the same day. Chemical test for blood in the feces gave a negative result. From this time on, the course of the after-treatment was uneventful; the wound with the exception of the drainage track, had healed by the first intention. This was also closed by the end of May.

The pathologist's report declared the growth a medullary osteosarcoma, the inguinal glands being in a state of hyperplasia with no malignancy.

In February, 1910, the patient was re-admitted to the medical side of the Hospital with sarcoma of the lung, to which he succumbed in the course of the month of March. At the site of the operation no relapse could be detected. No autopsy was secured.

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