PARALYSIS OF THE MUSCLES OF THE ABDOMINAL WALL DUE TO INJURY TO NERVE TRUNKS DURING OPERATION.*

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This condition has been spoken of as a form of ventral hernia. Inasmuch as it concerns the belly it is ventral, but I do not see that the term hernia is the most appropriate. Gould's Medical Dictionary defines hernia as being "a tumor formed by the protrusion of the contents of a cavity through its wall." It cannot be said, I think, that the contents of the abdomen are protruded through the wall as a sequence of this lesion.

The case I wish to ~~repeat~~ is that of a woman, perhaps thirty-five years old, rather less than five feet high, who weighs about one hundred and seventy pounds, with, as I found, on operating, between two and three inches of fat upon the abdominal wall between the skin and the fascia covering the flat muscles. On account of a neglected appendicitis I was obliged to make an incision oblique in direction, running parallel with, and starting opposite to the middle of, Poupart's ligament, extending upward and outward into the lumbar region of the abdomen. Just how extensive this cut was I am not able to indicate; the scar in the skin is now eight and one-quarter inches long. After a rather trying time the wound healed and the patient went

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to Europe. She returned in the fall, and, coming to me, stated that two supporters which she had had made did not serve the purpose in a satisfactory manner. Upon making an investigation I found that owing to obesity it was difficult to be exact, but as far as I could ascertain there has been no particular yielding of the scar. There appears to be no ventral hernia at the site of the incision. But changes of a very different sort have taken place — the whole right side of the muscular abdominal wall seems to have yielded in all its diameters, vertical, oblique and transverse. The right side of the abdomen appears to contain pretty much all of the intestinal contents. The condition will be best understood by recalling the changes which are witnessed in Bell's paralysis of the face, where the tissues of the paralyzed side are dragged to the sound side, the mouth, chin and median line tissues showing off the deformity after a notable fashion.

Of course the explanation is not far to seek. In making the extensive incision enough of the nerve trunks which supply the right side of the abdominal muscular apparatus were divided, and, as the wound healed by granulation and from the bottom, these severed trunks have had no chance later to pick up ends, and thus to re-unite, as it is stated they sometimes do. The abdominal wall muscles of the right side, paralyzed by the loss of nerve-supply, yielded to the pull of the sound muscles in the left side, and to the bulging tension exercised by the soft abdominal contents, and for a termination we have the greater part of the mobile abdominal contents contained in the swelling right side of the belly. Owing to

circumstances, needless for me to specify, I was not able to make a new extended examination of this case, such as the use of electrical tests, to determine what muscles and what amount of muscle was affected. Nor could I investigate the amount and degree of dermic sensory disturbance. Nor was I able to note the effect of induced muscular action of the sound muscular structure in exaggerating the deformity.

There was nothing noted by palpation or percussion to suggest that anything other than intestinal structures — mesentery and omentum were contained in the bulging right side of the belly. There were no evidences of fluid, and there certainly was no circumscribed mass, such as a tumor would form.

The reason why the supporters which the woman had used had failed was easily to be perceived; they were not wide enough vertically when applied to furnish the lifting support needed in the lower part of the belly, and to supply at the same time the girdle-like pressure which was demanded above the umbilicus.

In submitting the case to Ford & Co. to be fitted I was able to make a suggestion which appeared to work very well when put into practice. It was this: The bandage when applied to the median anterior abdominal wall had to be quite wide (I have not the dimensions) in order to meet the difficulty developed by the defects found to exist in the old supporter. The supporter was made wide enough to permit of continuous application from the extreme lower part of the hypogastric region below, to the median portion of the epigastric region above.

Of course it needed a great deal of shaping and fitting to ensure neat and accurate application over this extensive area. And when this was done it was impossible to continue the supporter around where it was to be applied to the lumbar region of the back, in the same width, and to get at the same time the compressive force applied in two directions by the one apparatus. In order to remedy this difficulty and to fit the two kinds of pressure, the expedient of splitting the bandage in its long diameter at its ends was resorted to. The supporter was divided at each end in its long axis for about one-third its length, thus leaving the middle third undivided, when it was to be applied to the anterior and bulging portion of the abdominal wall. By applying and lacing of the inferior portion first, the support of a lifting character was applied to the lower part of the abdominal wall. By applying the superior portion exactly over the inferior around the lumbar region of the back, the girdle-like action was brought into play; and when made and thus applied this supporting bandage was found to work very well.

Support applied after some such fashion is the only remedy which I propose to apply in this case, but it has occurred to me that it is possible that in a more recent case it might be found advisable to attempt to obtain a restoration of function to the damaged motor nerves by dissecting out the nerve ends and making the attempt to suture them.

In the discussion which followed the reading of this paper it was said by one speaker that these nerve trunks were too small to permit of sutures being suc-

cessfully carried out. But I have read somewhere the statement that nerve-trunk tissue is the only one in the human body which has to any appreciable extent the capacity of reproduction — actual reproduction after destruction — reproduction shown to exist not only by restoration of function, but also by anatomical demonstration. The account stated, in addition, if I quote it properly, that a reproduction of a nerve-trunk to fill a gap had been noted one inch long. The clinical evidence that some such restoration of function may come to pass is sufficiently abundant and convincing, in view of the frequency with which the operation of neurectomy has been known to fail when applied as a remedy for neuralgia. Besides it still remains to be ascertained that the joining of nerve-trunks for the purpose of obtaining restoration of function necessitates the actual maintenance in contact of the divided ends, which we deem to be essential in other sutured tissues. In view of the power of reproduction claimed for nerve-trunk fibre, may we not expect something of the kind to take place if we put the separated ends in the immediate vicinage of each other, where they seem to be too small for actual needle-and-thread work? Of course, it is to be understood that this is done before hopeless degeneration has set in. And it is also to be mentioned that what I have said is conjectural, but the assumption that any nerve-trunk is too small for union to be brought about is also conjectural.

The diagnosis of this lesion is worthy of some consideration. As is the case with Bell's paralysis of the face, mistake will usually be due either to want of

knowledge or to superficial examination. Bell's paralysis can be easily confounded with disease implicating the second branch of the fifth pair, and I have known this mistake to be made. I will now venture, that quite a proportion of the medical men in active practice who read this article will be unable to make the distinction between these two paralyses offhand. There are several varieties of pathological lesions which can be profitably considered in this relation. The conditions which occur to me as needing consideration are:

I. Ventral Hernia.

II. Atrophy of the muscles of the abdominal wall, general and symmetrical;

III. Tumor, lateral, of the abdomen, fluid, solid or mixed.

As I have already intimated, lateral paralysis of the muscles of the abdominal wall cannot be mistaken for any other condition with which I am familiar, provided its characteristics are borne in mind. The motor nerve supply appears to be common to the two obliques transversalis, and to the rectus, and the changes are due to the relaxation of these former muscles, and are presumably in extent in direct proportion to the amount of damage inflicted upon the nerve-trunks.

Before taking up the anatomy of this disorder I wish to say something about those pathological states which are allied to it.

First, as to ventral hernia. I would submit that the term can conveniently be applied to all hernias to which a specific name has not already been given. This will exclude all forms of inguinal, femoral, umbilical, perineal, etc.; it will include all forms of protrusion at irregular sites,

and pretty much all forms due to injuries and operations. A number of years ago Dr. B. F. Joslin, Jr., read an article before this Society reporting a case of ventral hernia, actuated in this by the idea that he was making known an unusual and rare case. He based this supposition, he said in his article, upon what he found in some English work on surgery, wherein the author said that ventral hernia was so rare that a case of it was a surgical curiosity. If this were so at that time, it is not so now. And I think I am in position to say that in all probability the statement made by the English author was inexact for pretty much any time.

I know that among the soldiers of the United States army during the war of the rebellion I met with quite a number of cases of ventral hernia, and it seemed that as far as concerns the origin of these cases they could be divided into two classes with reference to cause. One class, located in the median line, was held to be congenital, as the subjects stated that they were there as long as they could remember. I held them to be due to defects of development. The other class were irregular in location, and were associated usually with a history of injury, certainly at times not associated with scar of the dermic surface. Not infrequently these were said to have followed bruises of the wall. Conjecturally, I assumed in these cases that subcutaneous wounds and lacerations had taken place. During my service as examining surgeon of pensions, from 1877 to 1885, I saw a good many more ventral hernias, and then I also noted that they were attributed by their owners, almost without exception, to injuries, gun shot or other, re-

ceived while serving in the army or navy. Since I ceased, in 1885, to be an examining surgeon pretty much all of the cases of ventral hernia which have come before me have been the result of operations upon the abdominal wall. And here again I could divide them into two classes:

I. Those due to the insertion of a scar into the muscular wall of the cavity;

II. Those due to the yielding of cut surfaces, which having been united, usually by suture, have later separated over perhaps quite a wide area, generally linear in kind at first, producing at times quite an extensive gap in the parietes of the cavity. These hernias are still being produced in goodly numbers.

A mass of cicatricial tissue anywhere in the wall of the abdomen certainly is a weak spot. This is demonstrated by experience. And at this weak spot protrusion is apt to take place, particularly if the cicatrix penetrates all the layers, fascial as well as muscular.

Ventral hernia can always be distinguished from the lateral deformity produced by the motor paralysis described by the facts that the bulging or protrusion will take place at the site of the scar in hernia, whereas in paralysis it will be remote in its location.

Another condition which may be contrasted with lateral paralysis I have met with twice. The only way in which I can characterize it is to call it general symmetrical wasting of the muscular portion of the abdominal parietes. These two cases were each of them women who had borne a number of children. In each case the walls had lost entirely the substance and rigidity, tonicity, may I say, which is ordinarily found. Not only the

muscular substance, but also all adipose tissue seemed to have been removed, seemingly nothing but skin and soft fascial tissues covered the contents. The intestines, considerably distended, could be readily stimulated to rather rapid action by rubbing and manipulation with the fingers, until they would writhe and twist about in a fashion that was uncanny and almost shocking to behold, being so strongly suggestive of the presence of a serpent in the cavity. Nothing analogous has ever been witnessed by me in any case where by ~~action~~ I have exposed the intestinal tube.

Of these cases, I recall one very distinctly; the other more dimly; but when I saw the second case I was able to say that I had met with the condition before.

Both of these women wore bandages of muslin of their own devising and application, and neither of them came to me on account of state of the abdominal wall. In neither was there any great degree of hanging of the abdomen, a condition which has always been associated in my mind with a material amount of fat accumulation in the mesentery, omentum, or under the skin. I was not able to account for this general and symmetrical wasting of the abdominal wall, and I am now equally unable to explain it. Should similar cases have come to the notice of any of the readers of the Medical Era I would be glad to be informed, particularly so if any adequate explanation can be offered.

When it comes to the distinction of lateral paralysis from tumor of one side of the abdomen, the detection and circumscribing of the mass of the tumor will be the first step. This done, it will be

easy to determine that the umbilicus and median line tissues, if they go at all, will go to the side of the tumor location, and not to the opposite side, as is plainly the case in lateral paralysis.

The essential lesion being the fact that motor nerves are put out of function, the amount and extent of yielding of the muscles will depend upon the number of motor nerves damaged, and here the anatomy of these nerves becomes important.

It has been one of the common reproaches cast at our profession that it does not approximate to such position as would justify the term of an exact science being applied to it. Without really considering the question seriously, I have in my own mind rather resented this, and particularly with reference to anatomy. Several times, however, within the past few years I have had occasion to refer to standard works upon anatomy for information, specific and exact, about particular structures. The results of such references have been at times disappointing.

And in the matter of the relations of the motor nerves to the large abdominal muscles the manuals do not give exact information, as will be seen from what follows.

Gray says the lower intercostal nerves supply twigs to the abdominal muscles, mentioning the two obliques the transversalis, and the rectus; in another place he says that the abdominal muscles are supplied by the lower intercostals, and by the ilio-hypogastric and the ilio-inguinal.

Harrison Allen, "Human Anatomy of the Nervous System," says nothing about those nerves being distributed to the ab-

dominal muscles, nor does he give the destination of the lumbar branches.

Tilleaux, "Topographical Anatomy," states that the nerves of the antero-abdominal walls are derived from the five lower intercortals, and the two abdomino-genital; these are the ilio-hypogastric and the ilio-inguinal. He also says they "animate" the rectus.

Jestut, the latest French authority, p. 714, Vol. II., goes into the description of the nerves supplying the abdominal wall in more detail, and he gives a plate of their ramifications. He says that the sixth and seventh intercostals furnish branches to the external oblique and to the rectus. Of the eighth, ninth, tenth and eleventh intercostals he says they give branches to the large abdominal muscles; also that branches from them go to the rectus. He figures the twelfth intercostal as doing much the same thing, and as going into the substance of the rectus and supplying the portion of the lower belly, which is midway between the umbilicus and the pubes. His plate represents the ilio-hypogastric as supplying the part of the inferior belly of the rectus from this area to the pubes. In addition, he states that the ilio-hypogastric gives branches to the flat muscles. Of the ilio-inguinal he says it partakes of the distribution of the preceding and also that it finally sends branches to the abdominal muscles, and also that the genito-crural sends twigs to the transversalis.

Sappey, another French author, coincides in the main with Jestut.

Quain, Schafer and Thane, Vol. III., part II., p. 309, figures the sixth intercostal as sending branches to the anterior abdominal wall behind the upper part of

the rectus. It is to be borne in mind that the rectus arises from the cartilages of the fifth and sixth ribs, but this area will probably never be attacked by the surgeon, and these branches are so small as to be unimportant. The seventh is portrayed as going to the wall in the upper part of the epigastric region, the general drift of the direction of branches being ascending. The eighth nerve acts the same at a lower level, the general tendency being to ascend. The ninth occupies the next space, which reaches nearly to the umbilicus, the branches being horizontal in their gross direction. The tenth in its area envelops the umbilicus. The eleventh and twelfth descend much more rapidly as they reach to the lower parts of the abdominal wall.

Quain's plate corresponds most closely with the results obtained by Dr. Seward in his dissection, but Quain's descriptions are brief and unsatisfactory.

The following account of nerve-distribution has been prepared for me by Dr. J. Perry Seward, from recent dissections:

"The nerves that may be severed in lateral abdominal and lumbar incisions are the lower six intercostal nerves and the two divisions of the first lumbar nerve, the ilio-hypogastric and ilio-inguinal. A brief practical description of their course and distribution may aid in determining the direction of incisions calculated to avoid them.

To begin below, we can promptly rule out of the discussion the lumbar nerves. The ilio-inguinal is only in danger near its origin, as it crosses the anterior surface of the quadratus lumborum muscle. It then passes between the transversalis and internal oblique

muscles, so close to the iliac crest as to be amply protected. In the abdominal wall it is so near Poupart's ligament as to be safe in abdominal operations. The muscular distribution is very slight, limited to a few fibres of the internal oblique near the iliac crest.

"The ilio-hypogastric from the middle of the outer border of the quadratus lumborum traverses the abdominal wall between the transversalis and internal oblique, running obliquely downward and inward. In the greater part of its course it is divided into two parallel trunks, a half inch apart. Its distribution is a matter of dispute at the present time, the point at issue being whether it supplies any of the lower part of the rectus abdominis. In five dissections undertaken to determine this point, the writer traced the nerves to the outer border of the sheath of the rectus, between the middle and lower thirds of the section extending from the umbilicus to the os pubis. In two subjects it could there be plainly seen to enter the superficial fascia over the hypogastrium. In three cases the nerve was lost in the aponeurosis, and its final distribution undetermined. But in no dissection could any trace of it be found within the sheath of the rectus. Gray's description, therefore, which limits its distribution to the skin over the hypogastrium, is probably correct, although no rule of nerve distribution can be considered absolute.

"It is therefore the course of the lower six intercostal nerves that must be considered with a view to the prevention by their preservation of paralysis. In the thoracic wall they occupy a position close to the lower border of their respective

ribs, between the internal and external intercostal muscles. They continue their course toward the median line of the abdomen, resting upon the anterior surface of the transversalis muscle. This latter muscle takes part of its origin from the posterior surfaces of the six lower costal cartilages. The nerves, therefore, pass between the cartilages and the transversalis to reach the abdominal wall. Their direction varies, for they radiate from the edge of the subcostal angle.

"The seventh intercostal nerve, after passing behind its cartilage, runs upward and inward close to the cartilages, to a distribution in the rectus. It is so near the thoracic wall as to be in little danger of section. The eighth nerve diverges decidedly from the side of the subcostal angle, while the ninth has an almost horizontal course, only slightly upward. The tenth, eleventh and twelfth intercostal nerves increase the obliquity of their course from above downward. They are usually found dividing soon after they leave the ribs into two trunks, which take a parallel course about a half inch apart. Each pair of nerves is separated by about an inch and a half.

"Upon reaching the sheath of the rectus the nerves penetrate the aponeurosis, and continue their general direction behind the muscles, the lower nerves, particularly the twelfth, bending slightly more downward. At a point an inch or less from its outer edge they enter the muscle and are distributed in its substance.

"The operator may therefore expect to find a series of nerves lying between the internal oblique and transversalis muscles radiating from the extremities of the

ribs to the linea semilunaris. They vary from a half inch to an inch and a half apart. Their distribution being both muscular and cutaneous, it is in the highest degree desirable to preserve them from injury, particularly since they are too tenuous to permit suture after section.

"The last intercostal nerve extends downward and inward from just below the anterior extremity of the last rib to the linea semilunaris opposite the middle third of the lower belly of the rectus. Below and behind this nerve all trunks exposed are cutaneous in distribution, except the ilio-inguinal, which hugs closely the iliac crest and Poupart's ligament."

It will be seen by Dr. Perry Seward's report that he ignores the sixth intercostal nerve as being out of the field; that the trunk of the seventh coursing upward and inward in so far under the shelter of the costal cartilaginous border as to be practically safe from injury; that the trunk of the eighth is really the only one that can be said to pass upward and inward in the anterior abdominal wall where it would be liable to be severed during operation; that the ninth is practically horizontal in its direction; while the rest of the dorsal nerves have a direction downward and inward, becoming less transverse as they descend to the twelfth, which enters the sheath of the rectus opposite the middle of the inferior belly of the muscle, which extends from the umbilicus to the pubes.

Consequently, I feel warranted in saying that above a line drawn horizontally forward from the tenth rib horizontal incisions will not sever more than one nerve trunk; and also that below this

line oblique incisions should not sever more than one trunk if suitably inclined after an increasing fashion in descending.

In the August number of the "Annals of Surgery" Kammerer, in speaking of the way in which he has operated for appendicitis, says that in two cases in which he made a vertical incision through the wall of the abdomen, located somewhat to the inner side of the linea semilunaris, in order that he might go through the rectus muscle, or pull it to the inner side and leave it intact, that he cut the branch of the ilio-hypogastric nerve which supplies that part of the rectus muscle and that in each case this was followed by atrophy of the corresponding portion of the rectus.

In the "Medical Record," Feb. 26, '98, p. 321, H. L. Hibbard, M. D., in a communication criticises Kammerer's conclusions, first, by saying that the nerve supply of the rectus is through the lower intercostals, and not from the ilio-hypogastric. He also rather implies that one of the liniae transversæ was taken for an atrophic spot in the muscle, and in addition he states that the ilio-hypogastric goes to the skin almost wholly, and to muscle not at all, or at least to a very slight extent.

By recent writers Kocher, a German, is credited with being the first to call attention to the probability of injury being inflicted upon nerve trunks in making sections of the abdominal walls, and writing with particular reference to gall-bladder operations, he advises that the incisions should be made in an oblique direction, but I find nothing to indicate the particular oblique in which he would

cut, whether it was to be inward and upward, or inward and downward.

In the January number of the "Annals of Surgery," 1898, Geo. Woolsey, Surgeon to Bellevue Hospital, has an article on abdominal incisions, from which I extract the following: "A most important and too often neglected element of the abdominal walls are its nerves, comprising the six lower dorsal, the ilio-hypogastric, and the ilio-inguinal nerves. Their motor portions pass for the most part between the internal oblique and transversalis muscles, which, together with the external oblique, they supply, and they pierce the rectus muscle to furnish its motor nerve supply. The direction of these nerves is of great importance, as pointed out by Kocher, in determining the direction of abdominal incisions, for their division causes paresis and atrophy of the muscles, weakens the abdominal wall, and predisposes to hernia. In the anterior abdominal wall their nerves pass downward and inward in the lower third (i. e., the eleventh and twelfth intercostal and the ilio-hypogastric and the ilio-inguinal) nearly transversely inward in the middle third (i. e., the ninth and twelfth intercostals) and upward and inward above (i. e., the seventh and eighth intercostal nerves.)" Recently I have had an opportunity to inspect the scar upon the abdomen of a young woman upon a nephrectomy, and later a ureterectomy was done on the right side. In her case there was no evidences of any damage having been inflicted upon the motor nerve trunks, although the scars, two in number, have a united extent at least as great as in the case reported by me. Starting from just

below the twelfth rib in the right lumbar region of the back, extending forward and downward with one slight interruption across the lumbar region of the abdomen, past the anterior superior spine to a point opposite the middle of Poupart's ligament, an entire compass of eight and a half inches. There are some anaesthetic areas, but no signs whatever of motor paralysis.

My case shows that an incision of over eight inches long, although oblique in direction, may inflict so much damage upon the motor nerve trunks of that side of the belly as to make it appear that pretty much all the abdominal muscles are paralyzed. While the other case shows that a scar equally extensive may be left by incisions which, although located in close proximity, apparently fail to produce any lesion whatever of the motor apparatus of the vicinity.

The two cases suggest the necessity for careful study of the location of the motor nerve trunks in carrying out operation into the performance of which section of the abdominal wall enters.

During the discussion which followed the reading of my article it was said that apparently the nerve trunks would have to suffer anyway, when incisions were made through the abdominal wall. I am not prepared to accept this conclusion as valid; not in all cases, at any rate. The two cases cited by me go to show everything may depend upon the direction of the incisions. The anatomists appear to agree in descriptions which will warrant me in saying that all vertical sections which go through the rectus will divide nerve branches in direct proportion in number to the extent of these incisions,

presumably, however, the damage inflicted by these vertical incisions upon nerve tissue will in its results be slight because of their proximity to the median line and to the terminal areas of nerve distribution. Consequently, as far as the nerve trunks are concerned, we can cut with a free hand in what I will call the territory of the rectus muscles, shaping our incisions without reference to nerve anatomy.

Outside of the territory of the rectus, however, matters vary, my conclusions being that above the tenth rib horizontal line, horizontal incisions, will do but little damage, and below the tenth rib line, oblique incisions may be managed in such a way as not to damage nerve trunks at all, and yet to extend from near the spine in the lumbar region of the back to at least opposite the middle of Poupart's ligament in front.

Still another point is worthy of comment. It may occur to some to ask how I account for the fact that in my case, in which I have described incision as running parallel with Poupart's ligament upward and outward, I did so much damage to the motor nerve trunks. In answer to this it may be said that a line drawn parallel with Poupart's ligament removed from it from one-half inch to one-and-a-half inches will, if extended upward, strike the borders of the thorax at points varying with the amount of obliquity of the pelvis in the individual upon whom this measurement is made. And it also may be stated that in no case will this line be sufficiently oblique to save the nerve trunks of this area from the probability of damage, and I think that it follows that in case extended incisions

are required, while the line opposite Poupart's ligament may be parallel with it after passing the anterior superior spine, the direction must be changed somewhat more backwards to terminate just below the border of the twelfth rib near the spine, if we would minimize as much as possible the risk of dividing nerve trunks.

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