Original Articles.

THE STRENGTH OF THE UTERINE SCAR AFTER CAESAREAN SECTION. AN EXPERIMENTAL AND CLINICAL STUDY.

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WITH the increasing popularity and the widening field of application of Caesarean section during recent years, certain problems in connection with it have forced themselves upon the attention of the profession. Not the least important of these is that of the strength of the resulting uterine scar. For it is upon this that will depend the advisability of allowing not only future pregnancies, but also, in certain instances, of even allowing the patient to go into labor.

With the number of Caesarean sections which have been performed for placenta previa, there has arisen a class of patients, for the most part having no pelvic deformity, who have a Caesarean scar in the uterus, and who may become pregnant again. Then there is another class in whom there is a slight degree of pelvic contraction, and upon whom, in one labor, with a large baby and weak, flagging pains, insufficient in strength to drive the head against the brim and mold it through, Caesarean section has been performed in preference to a difficult high intrapelvic operation. These patients often become pregnant again, and the question arises if, in a subsequent labor, the patient has stronger pains, and if the baby is of smaller size, whether she should be subjected to Caesarean section because of the presence of a uterine scar, or whether she may safely be allowed to try to drive the head through the brim and deliver herself.

It is not the purpose of the writers to enter into a discussion of the indications in general for Caesarean section, or of the justifiability of Caesarean section for placenta previa. That the two classes of patients referred to exist must be admitted, and it is necessary to know how to deal with them. It is especially in the interest of these patients, but also because of the general importance of a knowledge of the actual strength of a uterine scar, that this work has been undertaken.

It has seemed advisable to make this a clinical as well as an experimental study in order that the subject may be considered in the broadest possible light, and that the results of animal experimentation may be applied directly to clinical experience. The problem, therefore, resolves itself into four parts:

1. To determine the strength of experimental scars in animals.
2. To discover what has happened in human females who have been subjected to Caesarean section, and have later become pregnant again.
3. To investigate the reported cases of uterine rupture after Caesarean section, and determine whether the rupture actually took place in the scar or elsewhere.

4. If any undoubted instances of rupture of the scar are found, to search for factors predisposing to it.

PART I.

EXPERIMENTAL SCARS.

(Work performed in the Laboratory of Surgical Research of the Harvard Medical School.)

The plan of experimental work which first suggested itself was to remove the scar, after a period at least equal to that of gestation for the animal employed, and suspend weights, first to muscle containing the scar, and then to normal muscle, and determine which would bear the greater strain. It was quickly discovered, however, that such a method would be unreliable, because it was found that different parts of the uterus, and even the corresponding portion of the opposite cornu, varied greatly in strength, the greatest of care having been observed that the tested portions should be of equal size and that the weights should be applied in a regular sequence and at regular intervals. There remained but one method which could be employed, namely, to suspend weights to a piece of uterine wall containing the scar, until it broke, and, by careful observation to determine whether the rupture occurred at the site of the scar or in the muscle itself. Six guinea pigs and one cat were the animals used.

Technic.—The animal was etherized; the abdomen denuded of hair by the use of barium-starch paste, and scrubbed with soap and water, followed by alcohol. The abdomen was opened by an incision similar to that used in human beings, and the uterus by a longitudinal incision in the pregnant horn or horns. The fetus being removed, the uterine incisions were closed with a through-and-through continuous suture of No. 00 chromicized catgut, using an intestinal needle. It was impossible to avoid the endometrium and be sure of including all the muscle because of the thinness of the uterine wall, so the suture was passed through all the layers. Catgut was used in order that the presence of unabsorbed sutures should have no influence upon the result of the experiment. The abdomen was closed with through-and-through silkworm gut sutures.

Since the uterus would not be subjected to the greatest amount of strain under a period equal to that of gestation for the species employed, the animals were kept for this length of time or slightly longer and then killed, either by chloroform or by the intrapleural injection of 0.7 gr. of strychnia.

The scars were easily recognizable. They were, as a rule, slightly thinner than the remainder of the uterine wall, because of the natural tendency of cicatricial tissue to contract. A transverse section of the portion of the uterus containing the scar was removed and cut longitudinally at a point in the circumference of the organ farthest away from the cicatrix, making a flat ribbon of tissue, with the scar extending transversely across the middle. The ribbon thus formed was

suspended by one end from a clamp, and to the other was attached a second clamp, the scar lying midway between and parallel to the two clamps. From the middle of the lower one was suspended a small balance pan, such as is used on an ordinary apothecary's scale, for the weights. The force was thus applied to the entire width of the section of uterine wall, and at right angles to the scar. The weights were started at 50 gm., and 10 gm. were added every five seconds up to 100 gm., after which 5-gm. weights were added at the same interval until the tissue gave away.

Experiment 1. Guinea pig. Not weighed. Cesarean section, Aug. 20, 1907. One full-term fetus removed, and two left in utero, of which the animal delivered herself the following day. Chloroformed, Nov. 1, 1907. Two tests made of sections of uterine wall containing the scar. The scar remained perfectly solid in each test, while the muscles stretched and finally ruptured, once at 160 and once at 171 gm.

Experiment 2. Guinea pig. Weight, 800 gm. Cesarean section, Feb. 26, 1908. One nearly full-term fetus in left horn removed; right, not pregnant. Chloroformed, April 24, 1908. Left horn found again to be pregnant and nearly at term; right horn, empty. Weights applied to the section of uterine wall containing the scar, which could be distinctly seen and had been stretched very little, if any, by the uterine distention. The muscle gradually stretched and finally broke at 390 gm., midway between the scar and the lower clamp, but there was no suggestion of stretching or giving in the region of the scar.

Experiment 3. Cat. Not weighed. Cesarean section, May 15, 1908. Five full-term feti found, and all removed through a longitudinal median incision in the uterine body itself. Chloroformed, July 29, 1908. Weights applied to section of uterine wall containing scar. Rupture occurred at 170 gm., and, starting in muscle at the edge of the section, extended about half way across, and then ran upward into the scar and along the scar to the opposite edge.

An attempt was made to preserve this specimen with a view to determining by microscopical examination whether the extension of the rupture from the muscle took place directly in the scar or along the edge of it, but the sections were unsatisfactory. There was no doubt, however, that the specimen yielded first in the muscle, and that the scar was torn only secondarily.

Experiment 4. Guinea pig. Weight, 800 gm. Cesarean section, Oct. 10, 1908. One fetus 4 cm. in length removed from right, and one 2.5 cm. long from left, a separate incision being made in each horn. Killed with strychnia, Dec. 15, 1908. Scar in left cornu could not be found, but that in the right was plainly visible. There were no adhesions about the uterus whatever. The cicatrix in this case was considerably thinner than the rest of the uterine wall. In spite of this, the scar did not yield to a weight of 300 gm., at which the muscle broke midway between it and the lower clamp.

Experiment 5. Guinea pig. Weight, 800 gm. Cesarean section, Oct. 10, 1908. Two full-term feti removed from right horn by a 5-cm. incision. Left horn not pregnant. Killed with strychnia, Dec. 15, 1908. Scar about 1½ cm. in length along upper margin of right horn, of practically same thickness as rest of uterine wall. No adhesions anywhere. Weights applied. After a general stretching of the muscular tissue, in which the scar did not take part, rupture occurred at 490 gm., between the scar and the upper clamp.

Experiment 6. Guinea pig. Weight, 500 gm. Cesarean section, Oct. 11, 1908. Three full-term feti re-

moved from left horn through a 5-cm. incision; right horn, empty. Killed with strychnia, Dec. 15, 1908. Scar 1 cm. in length. No adhesions, but peritoneal surface not entirely smooth. Scar about one third the thickness of the uterine wall. Weights applied. Muscle split at 300 gm., starting above the scar, running part way across, then vertically downward through the cicatrix to a point midway between it and the lower clamp, from which it extended transversely across to the other edge of the muscle. The rupture passed through about the middle of the scar, at right angles to it, and did not extend along it, but was distinctly a tear of the muscle.

Experiment 7. Guinea pig. Weight, 1 kgm. Cesarean section, March 19, 1909. One full-term fetus removed from right horn and two from left. This pig again became pregnant, and, being at or near term, was chloroformed July 8, 1909.

Two feti were found in the right and one in the left horn. There was a broad, thick and dense adhesion between the mesentery and the uterine wall in the region of the scar in the right horn, the separation of which caused considerable thinning of the wall. In spite of this, however, a weight of 345 gm. was necessary to break it, the rupture occurring in the muscle below the scar. In this experiment the scar was seen to stretch more than in any other, but, owing to the artificial thinning of both the muscular and cicatricial tissue, too much stress must not be laid upon it. This scar was found in the middle of the distended portion of the horn, about over the head of the outer fetus.

The scar in the left horn was found close to the bifurcation, in a not greatly distended portion, and was free from adhesions. It was slightly thinner than the rest of the uterine wall. In one portion of the cicatrix there was an area of about 1 mm. in diameter, which was very much thinner than the remainder; in fact, nearly transparent. Similar areas had been noticed in the scars in several previous experiments, but as they had not affected the resistance of the whole scar, their significance was not grasped, and no mention has been previously made of them. Their importance will be discussed later.

The scar stretched slightly upon the application of weights, but not in the same degree as the muscle, and rupture took place in the latter, above the scar, at 420 gm.

To briefly summarize the results of these experiments: A number of pregnant animals were subjected to Cesarean section, performed as nearly as possible after the method used in human beings, seven of which recovered. The animals were killed after varying periods of time, in each case at least great enough to allow the development of a full-term gestation. Comparative tests were made of the muscle and scar by applying weights to a section of uterine wall containing both.

In every case the muscle gave away first; in one instance only the rupture extended secondarily into and along the scar, while in another it passed through the scar at right angles to it. Two animals were again pregnant and near term when the test was made, the result being the same as in those which were not, thus ruling out any change in the strength of the scar during pregnancy.

The criticism may be raised that it would have been more satisfactory if all our animals had been pregnant when the experiments were made.

This was not accomplished because of the rarity with which the animals became pregnant in the close captivity in which it was necessary to keep them. But as the results were the same in the two which did become pregnant as in the others, it seems fair to assume that our results would have been exactly the same had the entire seven become pregnant.

The uniformity of result of these experiments can lead to but one conclusion: that a firmly united scar is even stronger than uterine muscle and should easily be able to withstand any strain which the latter is capable of bearing. It will be remembered that we noticed certain thin areas in some of the cicatrices. The significance of these will be spoken of later.

PART II.

HUMAN SCARS.

In this section no attempt will be made at a detailed study of the literature which has already been gone over thoroughly by v. Leuwen.¹ We shall simply make use of the statistics collected by him, and append brief accounts of three other cases of interest and importance in this connection. These were patients at the Boston Lying-In Hospital and are reported by permission of Dr. Charles M. Green, visiting physician to the hospital.

CASE I. This patient was the subject of a coxalgic pelvis, with a moderate degree of deformity. She entered the hospital in 1900, at the end of her first pregnancy, and in labor. Her pains were regular but of short duration, and after ten hours of labor the head remained high above the brim. Cesarean section was decided upon and performed by Dr. Reynolds, with the successful birth of an eight-pound male infant. Again, in 1901 and 1905, a practically identical series of events occurred; these times, however, the babies weighed only 7½ lb. each, both males. These operations were performed by Dr. Higgins and Dr. Green respectively.

Feb. 6, 1908, she arrived at term in her fourth pregnancy, and started in labor. This time the baby appeared to be smaller, and the pains were much stronger than in either of the preceding pregnancies, so that the head soon passed the brim, and she delivered herself without difficulty and with no complications whatever, in spite of the presence of the scars in the uterus. Convalescence was absolutely normal. This child weighed only 7 lb. 3 oz. and was a female.

CASE II. This was a colored woman whose pelvis was of the generally contracted rachitic type. She arrived at term in her first pregnancy Aug. 3, 1899, and started in labor. After nine hours of regular but short and weak pains the head had not engaged, so she was delivered by Cesarean section. The operation was performed by Dr. Haven, and resulted in the delivery of a living 6-lb. male child. Sept. 8, 1901, she was again operated upon by Dr. Swain after the same history of nine hours of ineffectual pains and failure of engagement. This baby, a female, weighed 6 lb. 6 oz. The third pregnancy was terminated by Cesarean section before the onset of labor because the child was obviously of a size at least equal to that of the two former, and it was considered both useless and dangerous to again subject her to the test of labor. This opera-

tion was performed by Dr. Green and resulted in the birth of a 6-lb. 8-oz. male.

She again appeared at the hospital the following year, and when examined during the last month of pregnancy it was apparent that the fetus was of smaller size than the preceding one, therefore instructions were given that she return at the onset of labor, and should be watched for a time. Labor began at 6 A.M., May 7, 1908. The patient entered the hospital at 9.30 P.M. the same day, having strong and regular pains at frequent intervals. According to instructions, she was watched for one hour, during which time the head engaged and descended considerably. Dr. Green, therefore, decided that the patient could deliver herself and she was allowed to proceed in labor, with the result of a spontaneous birth of a male child, this time weighing only 6 lb., after a labor lasting fourteen hours. There was absolutely no sign or symptom referable to weakness or any trouble with either of the scars, and convalescence was normal.

CASE III. The third patient, although not subjected to Cesarean section, went through a somewhat difficult labor without harm to a uterine scar, the result of a previous spontaneous rupture. This case has been reported elsewhere, in full, by Dr. Green,* but with his permission we will briefly outline it in this connection. The patient first entered the Lying-In Hospital March 6, 1907, at the end of her ninth pregnancy, in labor about eight hours, with a transverse presentation, prolapsed arm and undoubted evidences of rupture of the uterus. She was seen by Dr. Green, delivered without difficulty and the diagnosis confirmed. Immediate laparotomy revealed a rupture transversely across the anterior wall, in the lower segment. This was repaired with Pagenstecher, deep sutures through the muscle and superficial ones in the peritoneum. The patient made an uninterrupted recovery.

Within a year she became pregnant again, and on Aug. 23, 1908, was delivered successfully of a 6-lb. breech baby. No sign of rupture or weakness of the old scar was manifested.

In the literature, reports of pregnancy following Cesarean section are not uncommon. v. Leuwen was able to collect 194, occurring in 137 patients. Of these, 117 were again delivered by Cesarean section: 32 through the natural passages at term, in whom labor terminated spontaneously in 21 and as the result of some operative procedure in 11, in all without apparent damage to the uterine scar; and in 41 pregnancy terminated in miscarriage or premature labor. He found four cases of rupture of the uterus during his search, those of Guillaume,² Woyer,³ Targett⁴ and Everke.⁵

Among the 117 in whom Cesarean section was repeated, he found thinning of the scar reported in 20, while in the remainder the scars were all considered to be perfectly solid. Among the cases of pregnancy following Cesarean section, one of extreme interest is reported by Woyer.³ The operation was performed in Braun's clinic. Five years later, at the end of her second pregnancy, and after ten hours in labor, she was delivered by embryotomy. The interior of the uterus was explored immediately, and it was found that, while the old scar was solid in its lower two thirds and could scarcely be distinguished from the rest of the uterine wall, in the

* In a paper read by Dr. Green before the Obstetrical Society of Boston, Oct. 26, 1909, which will appear in this JOURNAL later.

region of the upper third the finger could be passed into a deep sulcus $1\frac{1}{2}$ cm. in length, where the scar was so thin as to leave not over 3 or 4 mm. between the finger and the peritoneal covering.

In the course of this brief study of the effect of pregnancy upon the scar of a previous Cesarean section in human females, we have seen that two patients went through labor uneventfully in spite of three Cesarean scars in the uterine wall. We saw that one other scar, not the result of an incision, also stood the strain of delivery. And finally we saw in v. Leuwen's statistics 149 cicatrices which did not yield to the distention of a full-term pregnancy, and that 32 of these also stood the strain of labor successfully. The consideration of the reported instances of uterine rupture we will leave to the following section.

PART III.

REPORTED CASES OF UTERINE RUPTURE.

We have been able to find in the literature 21 cases of rupture of a uterus upon which Cesarean section with suture had previously been performed. Krukenberg,⁶ in 1886, collected 18 instances of rupture of the uterus after a Cesarean section without suture, and Ribemont-Dessaignes and Rudaux,⁷ in 1899, reported 1 case in which only the peritoneum had been closed because the patient was in poor condition. With these latter we shall have nothing to do and shall consider only the cases treated by the classical method of uterine closure, as inaugurated by Säger. The following is a brief account of the 21 first-mentioned cases. We shall review these only with reference to the factors having a direct bearing upon the strength or weakness of the scars, and for their clinical aspect will refer the readers to the original articles or to the excellent summary in Brodhead's ⁸ paper.

I. Guillaume.² Cesarean section in 1893, median incision. Uterus closed in layers; suture material not stated. Convalescence normal. Pregnancy again supervened in 1896. When near the eighth month acute abdominal symptoms appeared, and laparotomy revealed a rupture on the anterior surface of the uterus, said to occupy the site of the old scar. The fetus had escaped into the peritoneal cavity. The description of the rupture is very incomplete and unsatisfactory.

II. Woyer.³ Cesarean section performed in Chrobak's clinic in 1893, median incision. Closed with silk, a deep and a sero-serous layer, about thirty sutures in all. The placenta was found on the anterior wall. Convalescence normal.

The second pregnancy occurred about three years later and was complicated by twins and hydramnios, the abdominal distention appearing much greater than in the first. The patient collapsed after a few hours in labor, and at operation a rent was found in the anterior wall through which both ova had escaped. A careful description of the rupture appears and makes it evident that it occupied the site of the scar, and also that the cicatrix had been extremely thin, as the decidua and peritoneum were found almost in contact. Woyer believed that this was the result of a defect in union after the first operation. The placenta in the second pregnancy was situated on the posterior wall.

III. Targett.⁴ Cesarean section for impacted shoulder in 1898, median incision. The method and material of suture were not stated. Two and one-half years later, near the end of a second pregnancy, symptoms of uterine rupture supervened. At operation a large rupture was found on the anterior surface of the uterus, and the fetus and placenta free in the peritoneal cavity. Dr. Herbert Spencer, after examining the specimen, threw considerable doubt upon the site of the rupture actually having been in the scar. No mention is made of the placental site in either pregnancy.

IV. Horrocks,⁹ in the discussion of the preceding case, mentioned another supposed instance of rupture of an old Cesarean scar near term. As no details are given, either by Horrocks or by Galabin,¹⁰ who later reported the same case, it is absolutely valueless from our standpoint.

V. Everke.⁵ Cesarean section, median incision. Sutured according to Säger with silk. No dates are given. In a subsequent pregnancy, a rupture occurred which was said to have taken place in the scar near term, but before the onset of labor. Nothing is said concerning the placental site. The case is reported in a very meager and insufficient manner.

VI. Meyer.¹¹ Cesarean section, fundal incision. Sutured with catgut, in layers. Two and one-half years later a second Cesarean was performed at the beginning of labor, and a small rent was found in the old uterine scar, through which protruded a portion of the placenta. The scar was found to be soft and friable. A microscopic examination showed no tendency of the placenta to implantation upon or invasion of the cicatrix.

VII. Schütte.¹² Cesarean section, in 1901, for eclampsia, median incision. Material and method of suture not stated. Suppuration in the wound resulted in a fistula communicating with the uterine cavity, which healed after about three weeks. Eight months later the patient again became pregnant, and at the eighth month of her pregnancy had some abdominal symptoms after a fall out of bed, which quieted down, to reappear two weeks later with signs of collapse. Laparotomy revealed a rupture 3 to 4 cm. in length at the fundus, with the fetus free in the peritoneal cavity. The description of the rupture as well as of the original operation is very incomplete.

VIII. Kerr.¹³ Cesarean section, Oct. 29, 1901, in the third pregnancy; fundal incision, which passed through the placental site. Sutured with catgut, in layers. Normal convalescence. Again admitted to the hospital, Jan. 26, 1904, in the thirty-seventh week of her fourth pregnancy. During the night and the following morning, gradual onset of abdominal symptoms. The abdomen was then opened and a rupture found transversely over the highest part of the fundus, which was considered to occupy the site of the old scar. The fetus, with placenta and membranes intact, had escaped from the uterus.

IX. Eckstein.¹⁴ Cesarean section, in 1901, by Rubeska, of Prague. Fundal incision, closed by deep sutures of silk to the muscle, sero-muscular stitches of catgut, and, finally, continuous catgut to the peritoneum. Normal convalescence. In 1904 the patient became pregnant again, and, when nearly arrived at term, was seized with abdominal pain, accompanied by collapse. After three days she was operated upon. A rent 5 cm. long was found extending transversely across the fundus, and the intact ovum free in the peritoneal cavity. The placenta was attached on the region of the scar, which was greatly thinned, so that, upon microscopical examination, the decidua appeared almost under the peritoneum.

X. Schink.¹⁵ Cesarean section, Feb. 16, 1899, fundal incision. Closed in two planes, one deep, in-

cluding peritoneum and muscle; the other superficial, through peritoneum only. Suture material not stated. Normal convalescence. One year later she became pregnant again. Labor began at term and was terminated by perforation and extraction. July 8, 1902, she entered the clinic, pregnant for the third time. After some hours of strong labor pains the patient collapsed, and laparotomy was performed. The uterus was found ruptured exactly at the site of the old scar, and the intact ovum had escaped. The scar had apparently been greatly thinned, the edges of the rent consisting only of peritoneum and a very narrow strip of muscle.

XI. Werth.¹⁶ Cesarean section, in 1893, median incision. Closed with catgut in two layers, one deep, of interrupted stitches, and one superficial, continuous. The convalescence was normal. The next pregnancy terminated in a miscarriage at five months. In 1905 she again arrived at the end of pregnancy, and acute abdominal symptoms appearing, the abdomen was opened and a rupture found at the site of the old scar.

XII. Wyder.¹⁷ Cesarean section, in 1898, after three days in labor. Recovery complicated by suppuration in the wound, which resulted in extensive adhesions of the uterus to the abdominal wall. No details of the operation are given. Two years later premature labor at seven months. The next pregnancy occurred in 1904 and went to term. After twenty hours in labor symptoms of uterine rupture appeared. Operation revealed a tear 1 by 3 cm. located in the fundus. The ovum had not escaped.

XIII. Schneider.¹⁸ Cesarean section, in 1904, median incision. Sutured in layers; material not stated. Normal convalescence. In 1906 she again entered the clinic at term and seven hours in good labor. On opening the abdomen, with the intention of performing Cesarean section, a rupture was discovered in the upper third of the old cicatrix, through which a portion of the placenta protruded. The lower two thirds were perfect.

XIV. Koblangk.¹⁹ Cesarean section, in 1887, by Hofmeier, median incision. Sutured in layers and with silk. In 1901 again pregnant. Near the end of pregnancy, acute abdominal symptoms appeared, and, upon the abdomen being opened, a tear, extending throughout the entire length of the old scar, was found. The fetus was free in the peritoneal cavity.

XV. Prüssmann.²⁰ Cesarean section, 1894, by Olshausen. Vertical incision, sutured with catgut, after classical method of Sänger. Normal convalescence.

Cesarean section, 1902, by Henkel. Vertical incision sutured with catgut, fourteen interrupted deep stitches and a continuous to the peritoneum only.

In 1905, near the end of her third pregnancy, she was seized with abdominal pain and walked to the hospital, a distance which took her one hour to cover. She was immediately operated upon and a rupture was found in the anterior wall and fundus, corresponding to one of the old scars through which the fetus and placenta had escaped. The placental site had been on the posterior wall. Microscopical examination of the excised edges of the rent showed marked thinning of the uterine wall, the decidua and peritoneum being almost in contact.

XVI. Couvclaire.²¹ Cesarean section, July 8, 1903, median incision, not passing through the placental site. Sutured with catgut, ten interrupted through the entire thickness of the uterine wall, with an additional continuous sero-serous layer. There was a slight elevation of temperature during the early part of the convalescence. The second pregnancy resulted in miscarriage at two months. The third pregnancy began in March, 1905, and was complicated with hydramnios.

Early in the ninth month symptoms of rupture appeared, and immediate operation disclosed a vertical rent in the anterior wall with the fetus free in the abdomen.

A careful description of the rupture is appended, and the location was demonstrated to have been along the edge of the fibrous scar, but at the upper end deviating into the muscle, while the scar continued upward intact. The uterine wall was much thinned in the region of the cicatrix (2 to 5 mm. in thickness), which was also occupied by the placental site. There was no grafting of the placenta on to the musculature, and the scar was covered with decidua. The child's weight in the first pregnancy was 3,080 gm., and in the last, 3,510 gm.

XVII. Mabbott.²² Cesarean section, in 1902, fundal incision. Sutured with catgut, three layers. Two years later the same patient appeared again, giving a history of labor pains at twelve to fifteen-minute intervals for twenty hours. The cervix was not dilated, however. On opening the abdomen to perform Cesarean section again, a transverse rupture of the fundus, 7 cm. in length, apparently in the old scar, was found, through which protruded a pouch of membranes the size of a fist. The placenta lay upon the posterior wall.

XVIII. Paddock.²³ Cesarean section, in 1905, median incision. Closed with catgut in three layers. Two years later she became pregnant again, and when near term there was an onset of acute abdominal symptoms. Laparotomy disclosed a rupture which was believed to be in the old cicatrix. The intact ovum had escaped from the uterus. The child of the first Cesarean section weighed 8½ lb.; the last weighed 9½ lb., and from the size of the abdomen and the amount of fluid found in the peritoneal cavity the operator made a diagnosis of hydramnios.

XIX. Löbenstine.²⁴ Cesarean section, in 1904, median incision in the anterior wall. Sutured with catgut in three layers. Normal convalescence. A second Cesarean was performed, in 1906, by a longitudinal incision in the fundus, passing well over to the posterior wall. Sutured with catgut in three layers. In 1908, at the end of her third pregnancy, she went into labor, and, after about five hours, collapsed. The abdomen was opened, the child and placenta found free in the peritoneal cavity, and the uterus ruptured along the median line from the internal os to the fundus. There was considerable doubt as to which scar gave away, and, in fact, there was nothing in the description of the case to show that the rupture occurred in either.

XX. Meyer.²⁵ Cesarean section, in 1898, fundal incision. Sutured with catgut, interrupted, eight deep and four superficial. The convalescence was slightly febrile from the second to twelfth days, but the temperature was never over 38.8 C. by rectum. The patient again became pregnant in December, 1906. Aug. 25, 1907, following a violent effort, she began to have some abdominal pain, and one week later entered the hospital, where she was operated upon. A rent the size of a dollar was found in the region of the fundus. The placenta was situated far from the rupture. The first child weighed 3,400 gm., and the second only 3,000. From the description given the exact site of the rupture is not clear.

XXI. Brodhead.⁸ Cesarean section, Dec. 31, 1904, median incision. Sutured with catgut in layers. Normal convalescence. Nov. 26, 1906, the patient re-entered, supposedly at the end of the eighth month of pregnancy, with symptoms of uterine rupture. Laparotomy revealed a tear at the site of the old scar, through which both fetus and placenta had escaped. The weight of the fetus, 7 lb. 5 oz., would suggest that

the patient was farther along in pregnancy than she supposed.

Out of these 21 cases, 1, that of Horrocks, is reported in such brief and insufficient manner that we must entirely omit it from consideration. Of the remaining 20, in 5 the rupture is accurately described and the account is supplemented by a description of the microscopical appearances of the uterine wall about it. In 4 of these the rupture was demonstrated to have taken place in the scar, and in the fifth along the edge of it. The other cases are reported less carefully. In many there is nothing in the description to show that the rupture actually occurred in the scar, and in none is there absolute proof. In Targett's⁴ case the examination of the specimen itself was not convincing to Spencer.

On the other hand, in view of the facts that ruptures of the uterus are much less common in the body than in the lower segment, and that the ruptures described always were in approximately the region of the old cicatrix, and extended in the same direction as it, we must admit that most of the cases were probably genuine, although not reported in a convincing manner.

PART IV.

FACTORS PREDISPOSING TO RUPTURE OF THE CÆSAREAN SCAR.

We have seen demonstrated the genuineness of five, and admitted the occurrence of other cases of rupture of a Cesarean scar. On the other hand, we have shown experimentally that a well-united scar in animals is stronger and more resistant than the uterine muscle. How, then, are we to explain this apparent discrepancy between the experimental and clinical evidence? Is it because of an inherent difference between the tissues of animals and of human females, or is there some other cause to which we may ascribe the occurrence of ruptures?

We saw in the second part of our study that cases have occurred in the human race where a uterine scar has apparently stood, not only the strain of pregnancy, but of labor as well. We also saw that, out of a large number of pregnancies following Cesarean section, rupture occurred in but few. Therefore we can dismiss the possibility of an inherent difference in the tissues of animals and of human beings, and we are led to but one conclusion, namely, that for some reason there is in certain instances an unusual weakness of the uterine scar, as a result of which its breaking strength is greatly diminished.

The following theories have been suggested by various writers to account for this undue weakness:

1. Overdistention of the uterus.
2. Weakening of the scar by the insertion of the placenta upon it.
3. Imperfect consolidation of the scar as a result of: (a) Location of the incision; (b) suture of the placental site; (c) infection in the uterine wound; (d) improper suture material; (e) imperfect methods of suture.

The first theory can be readily dismissed. It was suggested primarily by the occurrence of hydramnios in three cases (Paddock's,²³ Couvelaire's²¹ and Woyer's,³ complicated with the presence of twins in the latter). If overdistention of the uterus alone could cause rupture, the scar under normal circumstances being stronger and firmer than the muscle, the rupture would occur in the latter. Therefore, as the primary cause in the reported cases, overdistention can be excluded. It must, however, be considered as an important factor in producing rupture of a cicatrix already weakened.

Implantation of the placental site upon the cicatrix has been vigorously advocated as the chief factor predisposing to rupture by Eckstein¹⁴ and Kerr,¹³ their theory being that the scar tissue is invaded by the embryonic elements of the placenta, by a process similar to that which takes place on the wall of the tube in extra-uterine pregnancy. Kerr adduces no histological evidence in favor of his views, and the microscopical examination of Eckstein's case was not conclusive.

On the other hand, Couvelaire²¹ was able to demonstrate in the case reported by him that there was no such invasion of the cicatrix, and that the inner surface of it was covered with decidua. The placental site was stated in 9 instances, in 5 of which it was upon the cicatrix and in 4 elsewhere. Thus the influence of the placental site may be practically ruled out as a factor causing weakness of the scar. We are then forced to accept a primary defect in consolidation of the scar as the only explanation possible for the occurrence of rupture in certain cases, and to search for the underlying cause of this.

The location of the incision was in 13 cases median; in 6, fundal. It has been asserted that a fundal scar is more predisposed to rupture than a median one. There is, of course, no means of determining the exact relative popularity of the two incisions. *A priori* there seems to be an undue proportion of fundal cicatrices among those ruptured. On the other hand, with more than twice as many median as fundal included in the list, it can hardly be claimed with fairness that location of the incision has had much to do with the strength of the scar.

Suture of the placental site has received its share of blame. It has been stated that the part of the uterine wall over which the placenta lies is softer (Kerr¹³) and thinner (Pinard and Varnier²⁰) than the remainder, and therefore that suture of an incision in this region cannot result in so firm a scar. Only three writers state whether the incision passed through the placental site. Of these, in two it did, and in one did not, not sufficient data upon which to base definite conclusions. However, considering the great frequency with which the placenta is met with under the uterine incision, it seems that rupture of the scar is certainly not a widespread complication of an incision in this location.

Infection in the uterine wound must be considered very seriously as a cause of dangerous

weakness of the cicatrix. In Schütte's case there can be little doubt that defective union of the scar followed the uterine fistula. In Wyder's¹⁷ case the presence of suppuration in the abdominal wound, together with the evidences of adhesion of the uterus to the anterior abdominal wall afterward, is strongly suggestive of an infection involving also the uterine incision. Meyer's²⁵ second case, which he considered as the result of infection, is not conclusive, since the only evidence of it was a moderate elevation of temperature. It may be fairly stated that infection in the uterine wound must be reckoned with as a factor in weakening the scar in certain instances.

The question of suture material is another important point to be considered. Ten of the ruptured cicatrices were united with catgut and four with silk (seven not stated). Catgut has been condemned for use in suturing the uterus after Cesarean section by many because of at least one reported instance where the sutures became untied by the contractions and retractions of the uterus after delivery.²⁷ The preponderance of catgut sutured wounds among the cases of rupture certainly is suggestive that a similar occurrence may have taken place in some of these. On the other hand, this theory does not explain all of the cases, so that, accepting infection and improper suture material as factors in certain instances, we must look still farther for the explanation of all the ruptures which have occurred.

We have quoted, as previously stated, only those cases in which the uterus was sutured according to the principles laid down by Sänger, and, if we are to attribute the occurrence of rupture to the method of suture, we must, therefore, search for some error in technic. With the exception of three of the American cases, which were sutured in three layers (and with catgut), the classical method of deep muscular stitches, avoiding decidua, with a second sero-serous layer to complete it, was performed in all. Now there are two errors in the technic of placing these sutures which can lead to weakness in the scar.

1. Not including the entire thickness of the muscle.

2. Not placing the deep stitches near enough together.

In the suture of the uterus it must be remembered that we are dealing with muscle, although unstriated, and that the inherent property of muscular tissue when cut across is to retract; therefore, if a wound of muscle is not held closely together throughout its length and depth, the retraction tends to draw the edges of the wound apart. All of the ruptured scars of which a description of any value is given were greatly thinned. v. Leuwen found also 20 non-ruptured cicatrices described as thin. On the other hand, he found 97 of firm consistency and normal thickness. Of course the scar will be somewhat thinner than the rest of the uterine wall from the natural tendency of scar tissue to contract.

In the haste to get the uterus sewn up, and at

the same time desire to avoid the decidua, the mistake is easily made of not including the whole thickness of the uterine muscle in the suture. This explains one error in technic, leading to the production of a weak scar. To explain the other we must turn back to our work with the animals. It will be remembered that in several instances we met with extremely thin areas in an otherwise solid scar. Now the incisions in our experimental work were not closed with great care, and the stitches were sometimes placed relatively far apart. The thin places described were simply the result of too great a distance between two successive sutures, which allowed the intervening muscle to retract so that a solid union could not take place.

It is very evident that such a thinned place in a human scar, when subjected to pressure, might give away, and the rent thus made subsequently extend along the solid part of the scar. It is probable that the thin area in the uterine wall in the case reported by Woyer³ (see Part II) was formed in this manner, and probably also the thinning of certain scars along part of their length, as mentioned by v. Leuwen,¹ resulted from the same error of technic.

CONCLUSIONS.

As a result of our experimental work, and study of the literature, the writers feel justified in drawing the following conclusions regarding the uterine scar after Cesarean section:

1. A carefully sutured and well-united scar will withstand any strain which can be endured by the uterine muscle.

2. Rupture of a Cesarean scar is always secondary to unusual weakness of the scar, dependent upon imperfect consolidation.

3. The most frequent cause of imperfect consolidation is placing the deep stitches too far apart, or not including the entire thickness of the uterine muscle.

4. Location of the incision and suture of the placental site probably do not affect the strength of the scar.

5. Infection, in certain instances, plays a very important part in causing weakness of the cicatrix.

6. Catgut as a suture material is open to the objection that there is at least a possibility of the stitches becoming untied, and that certainly more cases of rupture have occurred after its use than after the use of silk.

7. As a corollary to the foregoing conclusions, it seems evident that, given a uterus which has been sutured with care to include the entire thickness of the muscular portion of the wall in each stitch, and to place the deep stitches close together throughout the entire length of the incision, using silk or linen, and where there has been no evidence of sepsis during the convalescence, such a uterus may be subjected with safety to distention by a full-term pregnancy, or even, in the absence of mechanical indications for Cesarean section, to the strain of labor itself.

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THE SYMPTOMATOLOGY, DIAGNOSIS AND TREATMENT OF PRIMARY APYCOGENOUS ANGIOCHOLITIS.*

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WHEN, a few days ago, your chairman kindly asked me to address you, the suddenness of the invitation rather embarrassed me as to the selection of a subject, but I finally came to the conclusion that the question of primary angiocholitis would probably be of interest because, from being an entirely medical affection, it has now crossed the frontiers of surgery. Then, again, I have to date operated one hundred and eighty-two times for various affections of the liver, gall bladder and ducts, so that I feel I can speak with some authority on the subject. From personal observation I have been strongly inclined to believe that drainage of the gall bladder and ducts is indicated in quite a large number of hepatic affections, and three years ago I published a paper on "The Surgical Treatment of Hepatic Cirrhosis, with Special Reference to Biliary Drainage," in the *American Journal of the Medical Sciences*, July, 1906.

To-night I desire to call your attention to the symptomatology and diagnosis of primary angiocholitis, and will briefly refer to the surgical indications, based upon a personal experience of seven cases. I would also have it understood, as the title of the address indicates, that reference will only be made to those instances of the disease in which suppuration has not taken place.

From the pathologic standpoint one must take into consideration the lesions of the gall bladder and bile ducts, according to whether one is dealing with the attenuated type of angiocholitis or one of medium intensity. In the former, an acute biliary infection produces changes common to ordinary catarrhal inflammation, with

desquamation of the mucosa, which forms an exudate, choking up the biliary ducts and covering the turgescent mucosa with cellular débris. At the same time the submucous connective tissue layer becomes thickened and embryonal cells collect in its midst. Bacteriological examination shows a more or less marked microbic infiltration in the superficial strata of the ducts, but soon the bacteria penetrate the walls of the glandular cul-de-sac, and the lumen of the excretory canals is also obstructed. The connective tissue, then, becomes infiltrated with round cells, the number being in direct relation to that of the bacteria.

Such are the purely superficial lesions in mild attenuated angiocholitis, but when the infection extends in depth, propagating itself outwardly through the walls of the ducts, two very different lesions make their appearance. In the first place, the large ducts show the development of true areolæ containing leucocytes and which are the origin of abscess formation. Then from the canaliculi, the infection penetrates the parenchyma because the connective tissue periphery of the hepatic lobule is too weak to resist the invasion, and thus the hepatic cell itself becomes involved. Thus an angiocholitis presents three stages, namely, the mucous, catarrhal and sclerosis of the ducts.

The liver is hypertrophied and a secondary splenomegalia, or even adenomegalia, is noted. The condition of the gall bladder varies. In some cases its walls are sclerous and retracted, while atrophy of the organ is so marked that it may be reduced to the size of a thimble. On the other hand, it may be enormously dilated, and in my experience this is more frequent. Its walls are then found exceedingly thin, and microscopically the mucous lining and glandular elements have disappeared at certain spots. Masses of leucocytes may be found under the mucosa, peritoneum or between the muscular fibers. From this thinning of the walls perforation of the gall bladder may occur.

The contents of the gall bladder are usually of a serous nature, but in some instances they may contain some bile or be distinctly hematic. A perivesicular reaction frequently complicates the situation, producing adhesions with the abdominal wall, transverse colon, small intestine, stomach or omentum.

In the commencement the symptoms of primary angiocholitis vary. Gastro-intestinal disturbances are very frequent, such as anorexia, nausea, distaste for food, vomiting, diarrhea or constipation. Sometimes the abdomen is distended and the patient complains of a feeling of weight. The right hypochondrium is the seat of dull pain and the spontaneous sensitiveness becomes increased by movement, while upon pressure considerable pain may be elicited, extending to the right shoulder or throughout the abdomen. In other cases, and I have frequently noted it, the pain in the hepatic region becomes paroxysmical and may be particularly marked in one of the lobes of the liver. Under these circumstances a diagnosis of biliary colic is often made. Icterus

* Address delivered before the Brookline Medical Club, Oct. 13, 1909.