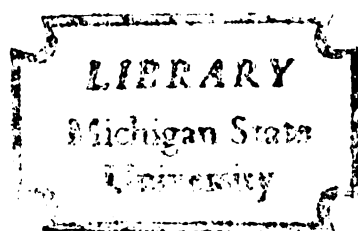


THESIS



UTERINE HEALING AFTER CESAREAN SECTION IN GOATS

by

Raj Pal Singh Tyagi

AN ABSTRACT

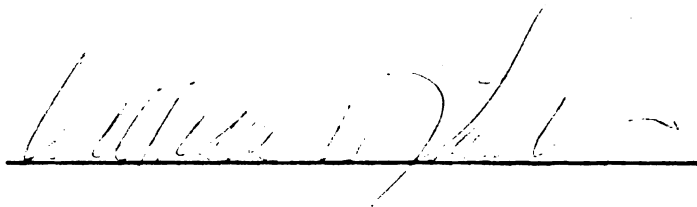
Submitted to the College of Veterinary Medicine
Michigan State University of Agriculture and
Applied Science in partial fulfillment of
the requirements for the degree of

MASTER OF SCIENCE

Department of Surgery and Medicine

1959

Approved

A handwritten signature in cursive script, appearing to read "William D. Jones", is written over a horizontal line.

This project was performed to study the healing process of uterine wounds following Cesarean section in goats. The following factors affecting healing were studied:

- A. Time necessary for healing.
- B. Suture materials.
- C. Suture technique.

Cesarean sections were performed on eight goats producing eighteen uterine incisions. In one goat, the two uterine incisions were sutured with number 50 nylon using a single row of simple interrupted stitches, and a single row of continuous lock-stitches respectively. The remaining uterine incisions were sutured with either 00 catgut or nylon using a double row of continuous lock-stitches, or two rows of simple interrupted stitches.

Biopsies were performed at intervals following the Cesarean sections and macroscopic and microscopic observations made.

The gross study of scars showed satisfactory healing in most cases. In two, sutured with catgut, adhesions to other organs were found at the site of the previous incision.

Microscopically, it was shown that healing had taken place by scar tissue formation. Fibroblastic proliferation was evident in all cases and could be demonstrated from 14 to 27 days post-operatively. In some cases, healing was so complete that the line of incision could not be followed through the sections. However, a preponderance of fibrous tissue denoted the probable site of the incision. No smooth muscle regeneration could be observed.

Considerable differences were found in the tissue reaction during healing with the use of different suture materials. With catgut, there was severe reaction around the sutures in four cases with adhesions to other organs in two. No such reactions were found with nylon.

In this study, both interrupted and continuous stitches showed good results. The continuous lock-stitch was faster, therefore, it was preferred. In one goat, a single row of simple interrupted stitches of number 50 nylon was used to close one of the wounds. These sutures gave way, leaving a gap of one centimeter which was revealed at the time of

RAJ PAL SINGH TYAGI

ABSTRACT

post-mortem examination. From this observation, it was concluded that a single layer of simple interrupted sutures did not produce a safe closure.

Infection and adhesions to other organs were considered to be important factors in the production of an imperfect scar.

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CHAPTER I

INTRODUCTION

In the last decade, due to the great improvements in anesthetic and surgical techniques, Cesarean section has become an established standard and important operation of veterinary obstetrical surgery. Not only must the patient and offspring survive the operation, but also the patient must be left in such a condition that it may give spontaneous birth after a subsequent pregnancy. In human obstetrics, unless the pregnancy for which the first operation was done is to be the last, each succeeding pregnancy means additional danger to the mother. This has been studied in great detail. The condition of the healed uterus after Cesarean was found to be an important factor in deciding the safety of a future pregnancy.

Wound healing in the uterine wall following Cesarean section is in some ways unique. The incision involves the wall of the organ which is largely composed of smooth muscles and a variable amount of connective tissue. There are mechanical

factors which are not encountered in association with wounds of other organs. Following the extraction of the foetus, but almost before re-approximation of the edges, contraction of the uterus begins. In a few days, the uterine body and the incision will be reduced to less than one half of its previous size.

The process of healing may be disturbed by several factors, such as improper suturing, interposition of the endometrium and hormonal activity of the uterus. Post-partum infection, with its inflammatory reaction and prolonged exudative phase, may result in delayed healing.

In spite of the existing wealth of literature dealing with the problems of wound healing, most of the studies have dealt only with skin wounds. The repair of wounds of hollow viscera, especially the uterus, has by comparison received very little attention. Most study has been devoted to the scars that follow Cesarean sections in human medicine. So far, very little study has been done on the scar that results from Cesarean section in animals and no work has been reported on the goat.

Due to the lack of information in the literature this project was performed to study the process of healing of uterine wounds following hysterotomies in the goat.

CHAPTER II

REVIEW OF THE LITERATURE

The literature concerning uterine closure and wound healing in man after Cesareans is rather voluminous. On the other hand, the veterinary literature seems to be lacking in this field. This review of literature is presented in three sections:

- A. Experimental studies.
- B. Closure technique.
- C. Suture materials.

A. Experimental Studies

The fundamental question in studies of uterine healing usually revolves around the behavior of the uterine scar in subsequent pregnancies; whether it shall prove adequately firm to tolerate the distention of the uterus as pregnancy advances and to withstand the stress of labor itself. For the past fifty years, several authors have been concerned with the anatomical study of the uterine scar. This seems to be due to the fact that the strength of the scar is intimately dependent upon the histology of wound healing in the uterus and

the location of the incision. There still appears to be considerable controversy as to the exact nature of the reparative processes taking place in healing of the uterine incision.

Hess, Pedowitz, Schwartz and Randall (19, 33, 37) supported the theory that "Once a Cesarean always a Cesarean" because most of the ruptures occurred through the site of previous incision. Williams (50) on the other hand believed this was erroneous. In a detailed study of uteri which had been subjected to one or more Cesarean sections, he noted that the old scar was invisible in most instances or could be identified at most by the presence of shallow vertical depressions over the external and internal surfaces of the anterior uterine wall. This observation has been confirmed again by Audebert and Holland and Losee (2, 21, 25).

Mason and Williams (29) made an experimental study of the strength of the uterine scar of pregnant guinea pigs. These authors did no histological work, but merely tested the strength of the scar by distending the uterine muscles, including the scar, by attaching weights. As the weights were increased, the strip ruptured and rupture always took place outside the line of incision. Seven experiments

were carried out from 7 to 10 weeks after the operation. By these experiments, they proved that the tissue gave way not at the scar, but through normal muscle fibers. From this study, they concluded that a carefully sutured and well united scar would stand any strain which could be endured by the uterine muscle.

Phaneuf (34) was unable to identify the cicatrix as such in forty-one repeated lower segment Cesarean sections. Whereas, Fuchs (14) found it impossible to visualize the scar in thirty-three of forty-six cases upon which he performed a second cervical hysterotomy. Corroboratory observations have been made by Delee and Green and Wetterwald (11, 48).

The literature on the reparative process is also divided into two schools of thought. Baunfunwald, Shanta and Braun cited by Audebert (2) reported complete muscle regeneration in the scar following a Cesarean section. More significant was Williams' (50) reiteration that microscopic examination of tissue removed from the site of incision revealed complete absence of fibrous tissue in the uterine wall. This demonstrated that the uterus, just as all other organs containing no

striated muscle, heals by complete regeneration of muscle fibers and not by fibroblastic response. Audebert, Losee and Williams (2, 25, 51) stated that in those cases where there was perfect coaptation of the incised tissues, where the various layers were not separated by blood clot or serum, and where there was no infection, the incision healed by complete muscular regeneration in 80 to 90 percent of the cases.

Losee (25) in describing his impression of early healing, stated that in the clean wound after incision, leucocytes, red blood cells, fibrin and later young connective tissue cells separated the surfaces. These afterwards were obliterated and eventually the muscle and fibrous strands separating the bundles assumed the relationship normally observed in other areas of the postpartum uterus. Other than thickened peritoneum, there was no scar tissue observed macroscopically or microscopically in the line of former incision when examined at a subsequent Cesarean operation, provided healing occurred under normal conditions.

On the other hand, Couvelaire (8) doubted that the reparative processes could occur without fibrous tissue formation. Fruhinsholz, Lauvray

and Nicoletti cited by Hindman (20) followed the same thought.

Siegel (44) in his experimental study used four pregnant and four non-pregnant dogs. A minimum of four incisions were made in the uterus of each animal so that comparisons were made between 16 sites of wound healing in the pregnant and non-pregnant uteri. He stated that the scars of the non-pregnant resembled those of the pregnant uteri except in the degree of scarring. The scars in the non-pregnant uteri had much less connective tissue and were thinner. Scars of the pregnant uteri were characterized by rich cellular stroma and large amounts of connective tissue. This abundance was thought to be due to pronounced vascularity resulting in the formation of large numbers of fibroblasts or proliferation of the interstitial connective tissue which increased during pregnancy. Finally, he came to the conclusion that the connective tissue formation, after incision into the pregnant uterus, was abundant and greater than in the non-pregnant uterus.

Couvellaire (8) described the process of early healing in the human uterus. He stated that the cicatrix in the uterine muscle always left a conjunctive scar. The two layers of the wound were

united by a band of fibrin. In two cases, at autopsy five days after operation, a band of fibrin was found to close the substratum of the conjunctive framework, which served as the basis of union between the various muscle bundles.

Further, he reported that in spite of the constant contraction and relaxation of the uterus, if infection was absent and the sutures had been so laid that the edges of the incision remained approximated, firm union almost invariably resulted. On the other hand, if there was necrosis due to infection, or if the sutures tore through leaving a gaping wound, there was an ingrowth of endometrium which involved almost the entire thickness of the wound. Such a scar, when seen in a subsequent pregnancy, was made up almost entirely of decidua and peritoneum, and its gross appearance in the unopened distended uterus was characteristic. Instead of the vertical shallow depression seen in the most perfectly healed scars, it was represented by a glistening translucent band of tissue which bulged outward beyond the general surface. After the uterus had been emptied, hardened and cut in cross-section, the scar was marked by very deep depressions on both the outer and inner surfaces.

Lauvray, cited by Audebert (2), stated that

in the early healing, the lips of the wound had serous effusion which brought them together. The fibrin of this exudate was deposited in such a manner that its filaments fixed themselves to the divided muscle bundles and connective tissue and a framework for the union was thus formed. This framework became the substratum of the new cell formation and the future scar tissue was outlined. Finally, there remained between the two lips of the old wound a sclerous tissue which lost the property of the uterine tissue.

Hess (19) reported in his experimental study the character of healing in three post Cesarean wounds of the human uterus. In all cases, microscopic sections revealed a preponderance of connective tissue in the scars, although in some instances this was interspersed with varying amounts of smooth muscle fibers. He came to the conclusion that in at least two species (rabbit and guinea pig), the initial reparative process of the uterine wound was one of fibroplasia. There was less evidence of participation of smooth muscle fibers. Examination of microscopic sections of Cesarean scars indicated that healing involved mainly fibrous tissue, particularly in lower segment incisions. In wounds involving the upper uterine segment, smooth muscle

fibers interspersed within connective tissue were more abundant. The character of the scar was altered by several factors. Infection with its inflammatory reaction and prolonged exudative phase resulted in defective healing. The common association of a history of a febrile postoperative course with wound disruption suggested a weaker scar. In some instances of secondary healing, infection was followed by a denser scar associated with firm adhesions which made subsequent section technically difficult.

Schwarz and Paddock (40) appeared to have settled the issue in their exhaustive histological study of the Cesarean scar in the human uterus. They clearly demonstrated the laying down of fibrin and fibroblasts along the line of incision in the early process of healing, and concluded that muscle regeneration played no important role in the healing of the scar, and that fibroblastic proliferation was practically normal. These observations were followed by a series of experiments on the uteri of pregnant guinea pigs at term. This work also showed that the process of healing was by scar tissue formation. In the early stages, the marked development of fibroblasts could be seen much like the limbs of a tree. As early as twelve days, in ordinary hematoxylin

and eosin sections, it was difficult to demonstrate the line of incision, because of the intimate intermingling of cut muscle edges with fibroblastic proliferation.

In another study on a series of uteri from pregnant rabbits, they demonstrated the proliferation of the fibroblasts along the line of incision entering the interstices between the adjacent muscle bundles. As the scar contracted, this became less perceptible and it was difficult to demonstrate the line of incision with ordinary stains after a period of two weeks. It was this marked shrinking of the newly developed connective tissue and its branching proliferation along the muscle fasciculae that made the Cesarean scar so frequently invisible at subsequent operations. This study was done by Schwartz and Paddock (41).

In 1957, Cheli (7) studied the healing processes of cattle, sheep and bitch uteri which were hysterotomized at different stages of pregnancy. He concluded that myometrium reacted to the operative attack by formation of cicatricial tissue. The cicatrix had no negative influence whatever on the reproductive activity of the subjects which had been operated or on their capacity to carry subsequent pregnancies.

B. Closure Technique

From the above information, it seems that the technique of closing the uterine wall is a decisive factor in the resultant healing process of the wound.

The history of uterine closure after Cesarean section may be said to extend over five periods: the first lasting from the earliest times to the beginning of the sixteenth century; the second extending from the year 1500 to 1876; the third beginning with the introduction by Porro of amputation of the body of the uterus and suture of the cervix in the laparotomy wound; the fourth, extending from 1882 to 1907, following the description by Sanger of an accurate technique for suturing the uterine incision, and the fifth beginning in 1907 when Frank devised the extraperitoneal technique.

Porro and William (35) stated that the first authentic Cesarean section was done in 1610 by Trautman of Wittenberg. Following this, it was occasionally performed until it became temporarily eclipsed by symphysiotomy in 1777. It was then taken up again after the latter operation had fallen into disrepute. During this period, the uterus was simply incised and the child extracted. The uterine walls were not sutured, the contraction

and retraction of the organ being relied upon to check hemorrhage.

According to the same reference, sutures were first employed by Lebas in 1769, but did not come into general use until after the appearance of Sanger's report (39) published in 1882. Sanger revolutionized Cesarean section by insisting upon the necessity for suturing the uterine incision. He advocated the use of Lembert's intestinal suture for closure of the uterus following hysterotomy and completely altered the prognosis of Cesarean section in humans.

Hindman (20) in his review of the literature from 1882 to 1938 discussed a total of 208 ruptures of the classical scar in subsequent pregnancies. The incidence of rupture following classical sections varied from two percent (Audebert (21)) to six percent (Kerr (23)) with a generally accepted average of four percent. Holland (21) in his extensive follow up of more than a thousand hysterotomies, demonstrated an incidence of 3.6 percent. A recent survey by McDowells, cited by Hindman (20), of 3,300 classical Cesarean sections disclosed that 50 (1.5 percent) had undergone spontaneous rupture in subsequent pregnancies with but a single death.

Spalding (45) observed that suturing the uterus to prevent death from hemorrhage was followed so frequently by peritonitis that Jorg in 1806, suggested a method of extraperitoneal Cesarean section which was successfully performed by Ritgen in 1821. Repeated Cesarean section was rarely successful in pre-antiseptic days, because there were extensive adhesions to the wall of the peritoneal cavity.

This stimulated Porro and Williams (35) in 1876, to devise the operation for removing the uterus and suturing the cervix into the laparotomy wound. While the Porro operation greatly reduced the mortality from Cesarean section, removal of the uterus was considered to be too radical to permit any marked increase in the list of indications for Cesarean section.

When Sanger (39) in 1882 described his well known conservative operation, the immediate results were found to be so good in regard to foetal and maternal mortality that the original small list of indications for Cesarean section was greatly increased. Sanger stated that rupture rarely occurred after his operation, and when it had occurred, it was because of poor technique on the part of the operator.

In 1922, Gamble (15) mentioned that hurried closure of the uterine incision without due care in accurately approximating the cut surfaces, the placing of the suture too widely apart, and the inclusion of the decidua in the line of sutures may all be factors in producing an imperfect scar. In his clinic, the incision was closed with two layers of catgut, the first consisting of deep buried interrupted sutures placed at intervals of about one centimeter, while the second consisted of superficial running sutures, which brought together the serosal edges. If, after the first layer of sutures had been placed, there was still considerable gaping of the muscularis, additional continuous buried sutures were used. The decidua was avoided, since any bits of it inverted into the wound might proliferate and develop into areas of unusual friability.

Davis (9) placed much emphasis on suturing and was of the opinion that the secret of preventing rupture lay in suturing the uterine incision correctly. Firstly, the stitches should not be too tightly tied. Secondly, the catgut should be twenty to forty day chromic catgut, otherwise absorption would be too rapid. Finally the sutures should be so applied that there are no

dead spaces. He stated it was a mistake to apply continuous sutures for suturing the uterine wall because they will loosen during the time of retraction of the uterus.

Williams (50) followed the technique of suturing the uterus in two layers, the first layer consisted of interrupted sutures going through the greater part of the uterine muscle, but not coming to the peritoneal surface. After the knots were tied and cut, they were buried by means of a second row of continuous sutures which brought together the superficial layer of muscle and peritoneum. Following this technique, he had only a single rupture in fifty pregnancies following previous sections, and that occurred in a woman who was profoundly infected at the first section.

In 1942, Potter (36) described the technique of suturing the uterine incision by using interrupted silk sutures. The sutures, which were spaced one-fourth of an inch apart, were tied sufficiently tight to hold the parts intact without blanching of tissues. Following this method, he noted the marked absence of the usual post-operative bleeding which, in the two layer technique, was a frequent occurrence. He concluded that this improved method of closure not

only corrected the difficulties, but also prevented strangulation of the muscle. He also observed that in the presence of infection of any degree, this mode of suture permitted free and adequate drainage into the uterine cavity.

Green and Bloem (18) in their experimental study used interrupted sutures in four wounds. Two of these incisions failed to show any scarring while the other two contained much scar tissue, but were anatomically strong. In these four cases, no bad scars resulted. They observed that the closure with interrupted sutures yielded better scars than closure with continuous sutures.

Milne (31), in five cases presented to his clinic, closed the uterine incision with a single layer of continuous Lembert suture using number one medium chromic catgut with a swedged-on needle. An injection of two to three cubic centimeters of posterior pituitary extract was used intramuscularly to accelerate uterine involution. The incision through the peritoneum, abdominal musculature and aponeurotic layers was closed by a single layer of number two catgut using continuous or interrupted horizontal mattress sutures.

In 1953, Riley (38) mentioned the technique of suturing the uterus in ewes which he used in

clinics. He emphasized the use of an anchoring suture to hold the uterus into the incision as it was sutured. A single strand of number two chromic catgut was used to close the uterine incision. An anchoring tie was made approximately one inch from the lower extremity of the uterine incision, leaving the free end of catgut protruding about two inches from the surgeon's knot. Then a series of continuous right angle Cushing sutures were used dorsally up the length of the incision to a point about one inch beyond the proximal extremity of the incision. Without tying, the suturing was reversed, using the same stitch, and tied to the projecting piece of catgut left when the initial anchor suture was made. Thus, the first row of sutures closed the uterine incision, inverting the incision lips and bringing serosa to serosa, and the second layer effectively buried the first layer.

He observed that closure of the uterine incision should commence at the anterior or distal portion of the uterine incision since marked involution occurred quite rapidly in many cases. Therefore, it was easier for the operator to finish his suturing and tying where he could see and use his hands more freely.

Ellis (13) performed Cesarean section on 69

ewes under local anesthesia using thirty cubic centimeters of five percent procaine hydrochloride for infiltration. The lower left flank, lower right flank and the midline approaches were tried and the latter site was found to be the most satisfactory one. It was observed that involution of the uterus was rapid in ewes following removal of the fetuses and consequently the incision in the cornua sometimes became out of apposition with the abdominal incision. For this reason, the incision was kept as far back as the udder allowed. Continuous single Lembert sutures with number one and number two catgut were used for suturing the uterus, while the abdominal wound was sutured with interrupted sutures of nylon.

Arthur, Gould and Mackinnon and Bayliss (1, 16, 27) followed the same technique as described by Ellis and Milne.

Parkinson (32) described the operative technique in sheep and cattle. In sheep, he sutured the uterus using a continuous Lembert type of stitch with fine catgut. Abdominal muscles and the peritoneum were closed together, using six or seven mattress type sutures of medium catgut. The skin was closed the same way. In cases where the uterine contents were found to be septic, oil-wax

penicillin was inserted between each layer of sutures.

In cattle, once the calf had been delivered, the opposite edges of the uterine wall were picked up with forceps so that the foetal membranes could fall back into the uterus. With an assistant still holding the forceps and applying slight traction to keep the empty horn exterior to the abdomen, the uterus was closed with eight or nine interrupted Lembert type stitches of catgut. These were further reinforced with a continuous Lembert stitch, again using catgut. This was found to be especially necessary where a dead and decomposing foetus had been delivered. After the calf had been removed, contraction of the uterus was impressive. The incision was observed to contract to half its normal length before the second row of stitches had been inserted. After cleansing, the organ was replaced in the abdomen. The peritoneum and internal oblique muscle were then picked up together and sutured with coarse catgut using interrupted Halsted stitches. A special technique was used for closing the peritoneum and muscle in which the sutures were placed at least half an inch away from the cut edges. This was done to keep the lip projecting externally so it could be picked up and incorporated in the next

layer of stitches. This strengthened the wound and obliterated the dead space between the different layers of muscles. The next layer which was sutured consisted of external muscle, connective tissue and the lip projecting from the internal oblique muscle. Interrupted mattress type stitches of catgut were used. Oil-wax penicillin was applied along the line of stitches after the layers of sutures were completed. This method was recommended for its rapid healing and neatness of finish.

In 1956, Messervy et al. (30), in reporting the advantages of performing Cesarean sections through the left flank by vertical incision in the standing position, mentioned the following:

1. There was reduced shock because of less handling.
2. There was no omentum as it would be present in the right flank.
3. Wounds were found to be easier to suture and healed quicker perhaps due to the fact that the incision was through* muscles. The incision through the aponeurosis lower down in the flank parallel to the milk vein was found slower to heal.

He sutured the uterus with a continuous

Lembert stitch of number four catgut on a straight or curved atraumatic needle. At least one to one and one-half inches of the cut edges were inverted. He advised that suturing commence from the posterior extremity of the wound as the uterus might retract into the abdominal cavity and difficulty might otherwise be experienced in the insertion of sutures. Owing to rapid involution and tendency of sutures to loosen, there was less likelihood of strangulation of tissue and, therefore, sutures could be tied snugly. In closure of the incision, special care was taken to ensure that portions of foetal membranes were not interposed between wound edges as this was found to interfere with healing.

The abdominal wound was closed, using eversion stitches of number 50 nylon. Only six or seven stitches were inserted, each being held at the edges of the incision by rubber tubing through which the suture material was threaded at the time of insertion.

In 1957, Lensch (24) described the suturing technique which he used in 84 Cesarean sections. The uterus was closed by a running stitch with number five catgut. He started from the cranial end of the incision, going through the serosa and muscularis, but avoiding the mucosa so that foetal membranes would not be fixed to the uterine wall.

Protruding parts of the membranes were excised. In the event of a living foetus, a second line of stitches was not applied, but in case of delayed birth with an atonic and fragile uterus, a second line was required. The abdominal muscles were closed with catgut sutures with the stitches penetrating the internal and external muscles at the same time, thereby avoiding the formation of cavities. The skin was closed by "intraper-cutaneous" sutures using nylon thread.

In 39 operated animals, 9 were no longer used in breeding. Thirty were served or inseminated again with 24 becoming pregnant. One cow aborted in the sixth month of pregnancy. Twenty-one cows calved normally, and two required veterinary aid due to abnormal position and size of the foetus.

In 1958, De Bois (10) reported the operative technique of Cesarean section in 113 ewes and listed the results achieved with this method. A flank approach under inhalation anesthesia was used. The uterus was closed by means of number 90 knotted linen using Lembert stitches. In all cases, only one horn was incised and the foetuses from both the horns were removed from the same incision. The abdominal incision was also closed with knotted suture.

He could not study the fecundity of the operated animals as all of them had been intended for the graziery. Only three afterwards conceived and lambed in the normal way. Two of these animals dropped normal lambs twice.

C. Suture Materials

Regarding suture material, opinions are also divided. Babcock, Gamble and Potter (3, 15, 36) advocated the use of non-absorbable, non-irritating suture materials as they caused less tissue reaction and thus resulted in good healing. On the other hand, Schmitz (43) obtained excellent results with catgut and concluded that wound healing was less dependent on the material than on the method. Supporting this latter view was the work of Bowers, Burns and Mengle (5) with fine 5-0 chromic catgut suture in surgery of the gastroenteric tract, the biliary tract, and in dura, tendon, nerve and fascia.

In 1922, Gamble (15) mentioned that chromic catgut had given relatively satisfactory results. In a series of operations, he used silkworm-gut in a single instance, and the resulting scar was ideal. When the uterus was removed a year later, the sutures were still in situ, but dense adhesions

had developed along the entire length of the scar. He believed this was the result of knots irritating the surrounding tissues, and felt that when using this material the sutures should be buried and the superficial layer and peritoneum brought together with catgut over them.

Holland (21) believed that chromic catgut was absorbed more rapidly than was desirable, particularly in the presence of infection. Upon analysis of a large number of cases, he found that subsequent rupture occurred two and a half times more frequently after the use of catgut than silk. Consequently, he was of the opinion that non-absorbable sutures were preferable, and that silkworm-gut fulfilled the requirement most satisfactorily.

Prusman, cited by Gamble (15), objected to non-absorbable sutures on the ground that small channels were formed around them. When they were invaded by bacteria or even by endometrium, necrosis and weakening of the scar resulted.

In 1904, Eckstein (12) indicated the advantage of metallic sutures, and suggested the use of thin flat bands of lead which, in addition to being non-absorbable, would serve as a support for the scar in future pregnancies.

Babcock (3) reported his experience of ten years regarding the relation of wound reaction and lag in healing to the suture. He stated that around the catgut used in a wound closure there soon developed an intense polymorphonuclear infiltration within which, close to the catgut, was a zone of tissue necrosis. Thus, in a wound closed with catgut, the early inflammatory and necrotic reaction so delayed healing that the union was weakest about the seventh day and there might be a tendency to suppuration. He observed that by putting only a few sutures in the Cesarean wound the reaction was reduced and better healing resulted. In a septic field, he found nothing to equal non-irritating metallic sutures, which were not extruded even under suppuration.

Bates (4) reported the following advantageous features of fine silk:

1. Minimum wound reaction in healing.
2. Minimum infection in potentially clean wounds.
3. Firm support of the wound throughout its critical healing period.

He further studied the absorbability of catgut on healthy adult dogs which were subjected to gastroenterostomy under standard surgical conditions. The gastroenterostomies and the

abdominal wounds were each closed with the suture to be studied at intervals of 24 hours, four days, one week, two weeks, and four weeks. The wounds were examined grossly for the state of healing, persistence of gross fragments of catgut and peritoneal adhesions. Both the gastrocenterotomy and the abdominal wound in each case were examined microscopically.

He found that plain catgut excited a prompt, violent exudative foreign body reaction which delayed the appearance of fibroblasts and so delayed wound healing. Large plain catgut was absorbed practically as fast as smaller sizes, and any size failed to hold throughout the time wound support was needed. Chromic catgut was associated with a retarded and lessened exudative foreign body reaction and with the early appearance of fibroblasts and early healing. Small chromic functioned longer than very large chromic catgut. Wound support and healing were most satisfactory when the smallest chromic suture was employed.

CHAPTER III

MATERIALS AND METHODS

In this study, adult female pregnant goats were used. Their weights varied from 85 to 115 pounds. Near term, they were kept in separate stalls on ration consisting of hay and ground dairy feed*.

Each animal was bred by artificial insemination and, when the usual physical signs of approaching parturition developed, a Cesarean section was performed. The animal was fasted overnight and an antiferment turcapsol** was given orally via stomach tube, one hour before the operation. This was done in an attempt to slow down the fermentation process in the rumen. Ten minutes before the operation, a tranquilizer, triflupromazine hydrochloride (vetame***), was injected intravenously at the rate of one milli-

*Okemos Elevator Co., Okemos, Michigan.

**Pitman-Moore Co., Division of Allied Laboratories, Inc., Indianapolis, Indiana.

***E. R. Squibb and Sons, New Brunswick, New Jersey.

gram per pound of body weight as a preanesthetic. A trough shaped wooden table top was designed and was placed on a normal size small animal operating table. The animal was restrained on this in left lateral recumbency by tying both the front and hind limbs with separate ropes.

In the first case (goat 5), an ultra short acting barbiturate, thiamylal sodium (surital*), provided general anesthesia, but in the rest of the animals a paravertebral lumbar nerve block technique was used. Ten cubic centimeters of a two percent solution of procaine hydrochloride was deposited on the last thoracic and first and second lumbar nerves on the left side. In all, thirty cubic centimeters of the solution were used. The left paralumbar fossa was clipped and scrubbed with liquid germicidal detergent*. After masking the operative site with sterile drapes, a low vertical six inch flank incision was made through the skin, muscles and peritoneum midway between the last rib and tuber-coxa. The uterus was located and brought to the outside through the incision. Then a five inch incision was made into each horn, close to the body of the uterus

*Parke, Davis and Co., Detroit, Michigan.

in all the animals, except goat 10 in which the uterus was incised at four places.

The foetuses were immediately delivered, dried with towels and removed to a cardboard box fitted with light bulbs to keep them warm.

After extraction of the kids, the protruding foetal membranes were returned to the uterine horns. In goat 5, the uterine incisions were closed with size 00, medium chromic catgut by the use of a double row of continuous lock-stitches. In goat 10, 13 and 18, the uterine incision in one horn was sutured with size 00, chromic catgut by the use of a double row of continuous lock-stitches, while a double row of interrupted sutures were used to close the incision in the other horn. In goats 1, 2 and 21, the uterine incisions were closed with number 50 nylon by the use of a double row of continuous lock-stitches in one horn and a double row of interrupted stitches in the other. In goat 3 only, a single row of continuous lock-stitches was used in one horn and a single row of interrupted stitches was used in the opposite horn. In all cases, the peritoneum and muscles of the abdominal wall were closed with single simple interrupted non-absorbable sutures (vetafil*) and the skin

*Bengen and Co., Hannover, Western Germany.

brought in apposition with simple interrupted sutures of the same material. The goats were removed from the operating table and placed in a box stall.

The healing process of the uterine wounds was checked after the following period of time; 3, 14, 18, 19, 21, 26 and 27 days. At the end of the desired number of days, the uterus was exposed under aseptic conditions and a biopsy was performed. Surital was used to provide general anesthesia in all cases. One inch of uterine tissue was obtained at the site of the scar and fixed in ten percent formalin. After fixation, portions of the tissue, including the healing edges of the wound, were dehydrated and infiltrated following the technique described by Johnson et al. (22). Then the tissue was embedded in paraffin, and cut at seven microns. Harris' hematoxylin was used as routine stain. Weigert's and Van Geison's stains were used for the study of elastic and collagenous tissues and muscle fibers.

CHAPTER IV

RESULTS

A. General Considerations

Surital was used for general anesthesia in the first animal of this series. It showed no detrimental effect on the goat. Of the two kids, one died one hour after birth of respiratory failure and the other died two days later. Both had shown some degree of depression. To overcome this drawback in subsequent cases, a tranquilizer (vetame) and paravertebral anesthesia were used. This gave satisfactory anesthesia lasting for about one and one-half hours and had no ill effect upon the kids. This method of anesthesia also proved useful in that the kids could be attended by the mother immediately after the operation.

To determine the best approach to the uterus near the bifurcation of the horns, the mid-line and the lower left flank approaches were tried on two non-pregnant goats. The lower left flank approach was found to be more satisfactory. In the mid-line approach, the udder was a considerable hinderance.

A five inch incision was made in the left

lower flank region, extending mainly in a dorso-ventral direction. The lower part of the incision terminated one inch above the mammary vein. An anatomical study of this area was made and the incision was found to pass through the following layers:

1. Skin - Very thin and freely movable.
2. Muscle cutaneous trunci - Present throughout the entire incision and increased in thickness as the ventral limit of the incision was reached.
3. Oblique muscles - Ventrally, the incision passed through the combined aponeurotic part of the external and internal oblique muscles.
4. Internal sheath of the rectus abdominis muscle which at the site consisted of the aponeurosis of the transverse abdominal muscle.
5. Peritoneum.

In this study, it was noted that any slight variation in the site of incision altered the disposition of the muscular and aponeurotic tissues. For instance, the incision made at the time of biopsy was two inches behind and dorsal to the previous incision. Consequently, at the upper

extremity of the incision, muscle fibers of the external and internal obliques were evident, but no muscle fibers of the rectus abdominis and transversalis were present.

Incision in the horn was made close to the body of the uterus. In removing the foetuses, emphasis was placed upon extension of either fore or hind limbs to ensure that flexed elbows or flexed stifles were not drawn through the uterine incision simultaneously causing rupture. A careful search of the uterus for twins or triplets was carried out in all cases.

It was observed that involution of the uterus was not so rapid as reported by other authors following removal of the foetuses, and no difficulty was encountered in suturing the incisions of the uterine horns.

Difficulty was encountered in separating the foetal membranes from the uterine mucosa. To allow them to separate naturally, they were left inside the uterus after removing the kids. The foetal membranes were usually expelled post-operatively within twelve hours. However, in some goats the retention of foetal membranes extended up to 24 hours followed by a foetid discharge from the vagina in one animal.

From the eight operated goats, nineteen kids were delivered, twelve were living, two were mumified and five died because of premature birth. It was observed that of the twelve living kids a few which were delivered prematurely had difficulty in breathing.

During the routine postoperative care of the goats, the temperature was recorded for three days in all animals. Recovery was uneventful in all except goat 3 which had a temperature of 105°F. and died three days after operation. Goat 5 had a temperature of 103°F. for three days and then it returned to normal. In goat 3, 100 cubic centimeters of cal-dextro* were given intraperitoneally. No medicine was given postoperatively in the remaining animals.

The character of healing was studied in eighteen post-Cesarean wounds during this experiment. Macroscopically at biopsy it was found that healing was complete in all animals except goat 3 which died three days after operation due to uterine infection and hemorrhage from a carotid loop. The carotid loop had been permanently

*Fort Dodge Laboratories, Inc., Fort Dodge, Iowa.

established some time previously for experimental work by another graduate student. Although most animals had a clear scar with no adhesions to adjacent organs, goats 5 and 10 showed adhesions. In goat 10, biopsy was made at two different intervals; that is 14 and 19 days postoperatively. At the first biopsy, the wound was free of adhesions, but at the second, extensive adhesions were observed between the wall of the uterus and omentum.

Microscopically, the line of incision could be followed readily in the tissues obtained from goats 10 (Figures 1 and 2), 13 and 21 at 14, 18 and 21 days after operation respectively. But, in other cases this could not be observed because of complete healing. However, a preponderance of fibrous tissue denoted the probable site of the incision.

Considerable differences were found in the tissue reaction during healing with the use of different suturing materials (Figures 3 and 4). Around the catgut sutures, a marked tissue reaction characterized by the presence of numerous leucocytes and blood could usually be seen. With nylon sutures, there was very little or no tissue reaction (Figures 5 and 6). No

Figure 1. Uterus of goat 10, 14 days postoperatively. Two rows of continuous lock-stitches of 00 chromic catgut were used. The incision is visible running vertically through the center of the tissue. Large dark masses are catgut surrounded by phagocytes. 17x.

Figure 2. Higher magnification of incision shown above. Fibroblastic proliferation is evident between the edges of the incision. 75x.

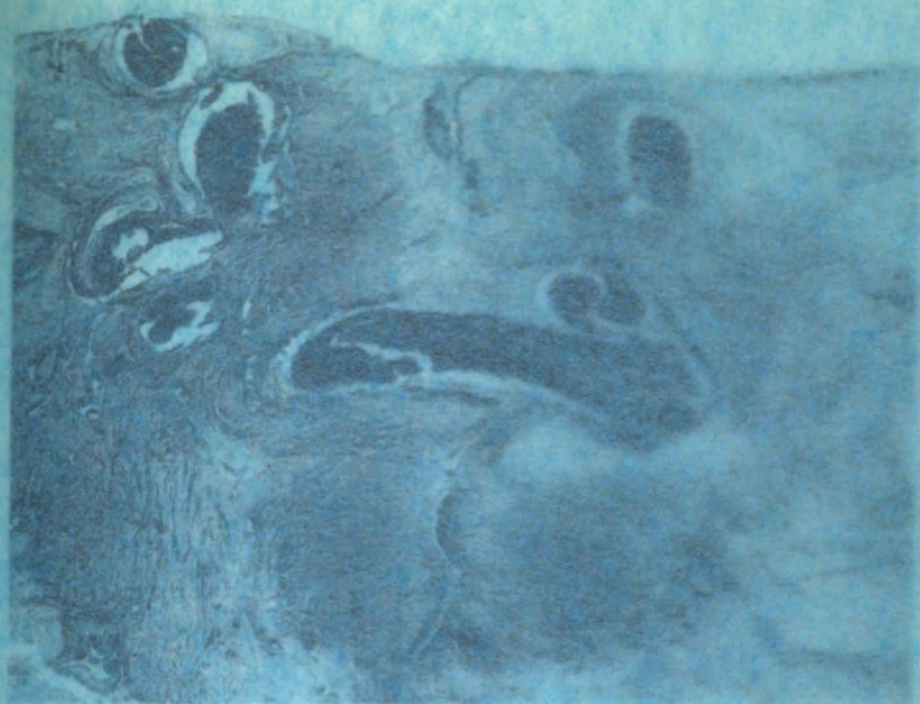


Figure 1

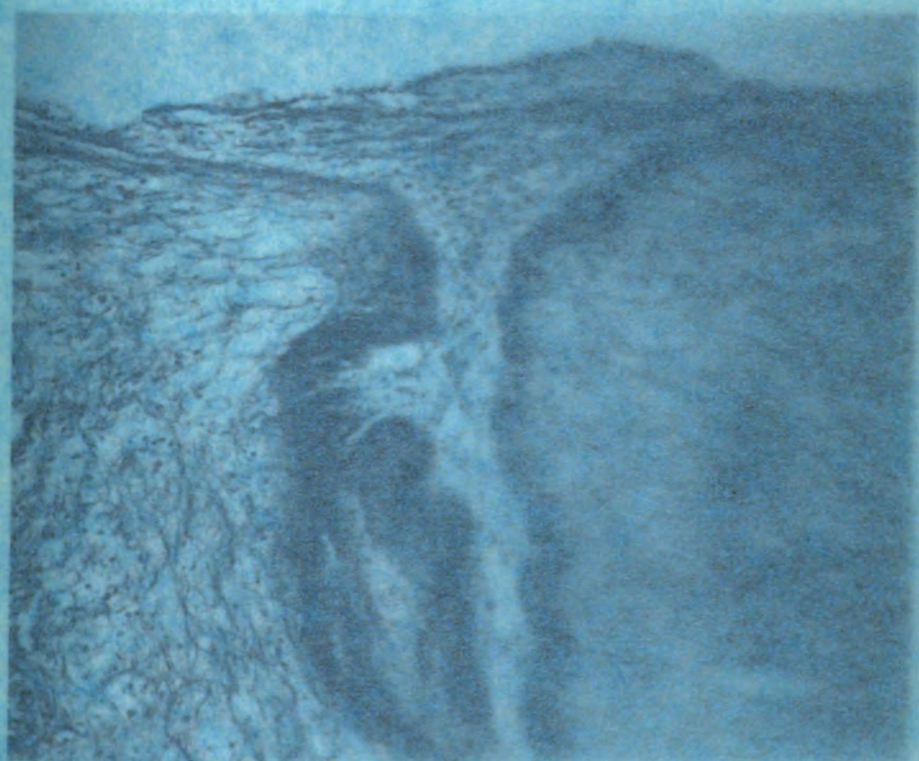


Figure 2



Figure 1

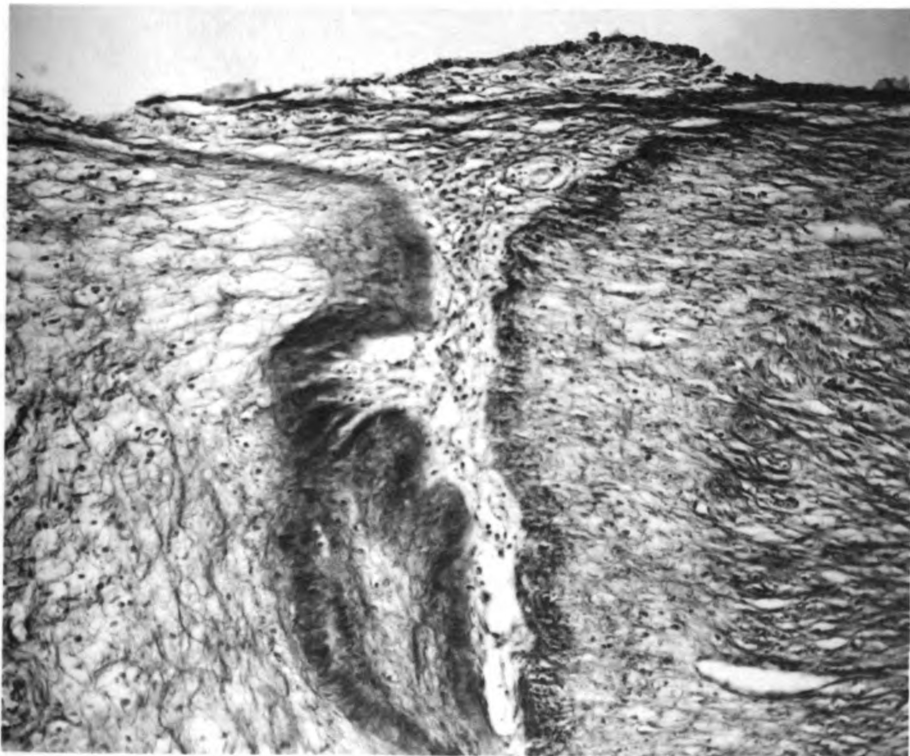


Figure 2

Figure 3. Uterus of goat 1, 14 days postoperatively. Two rows of simple interrupted stitches of number 50 nylon were used. The incision runs vertically through the center of the tissue and is almost indiscernable. There is little peritoneal reaction. The straight line through the tissue is an artifact. 75x.

Figure 4. Uterus of goat 21, 21 days postoperatively. Two rows of continuous lock-stitches of 00 chromic catgut were used. An intense peritoneal proliferation surrounds the catgut near the surface of the uterus. The line of incision cannot be definitely distinguished. 75x.

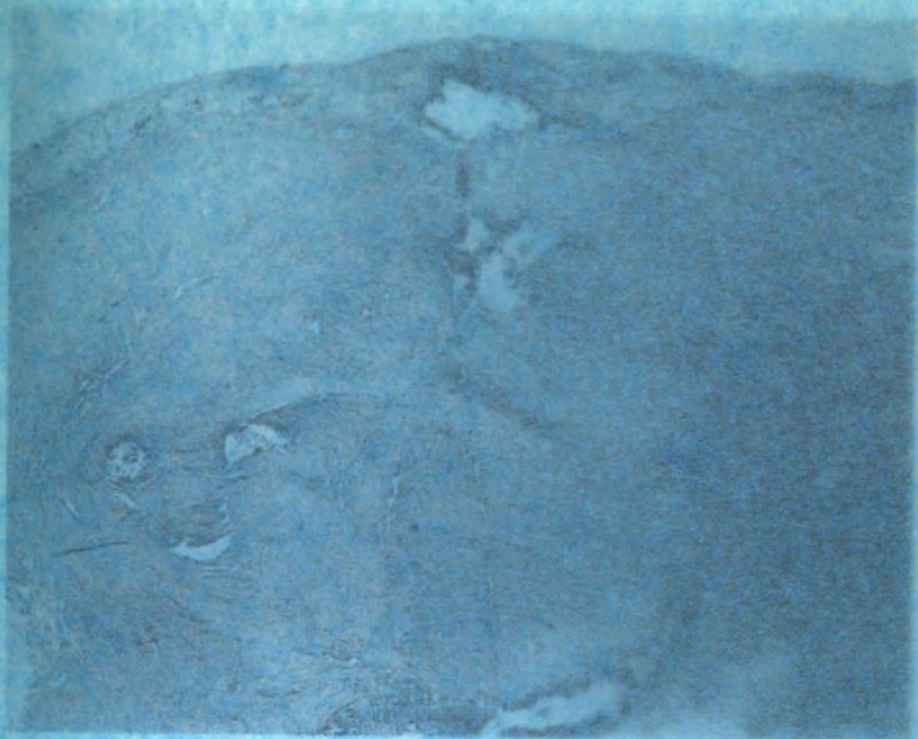


Figure 3

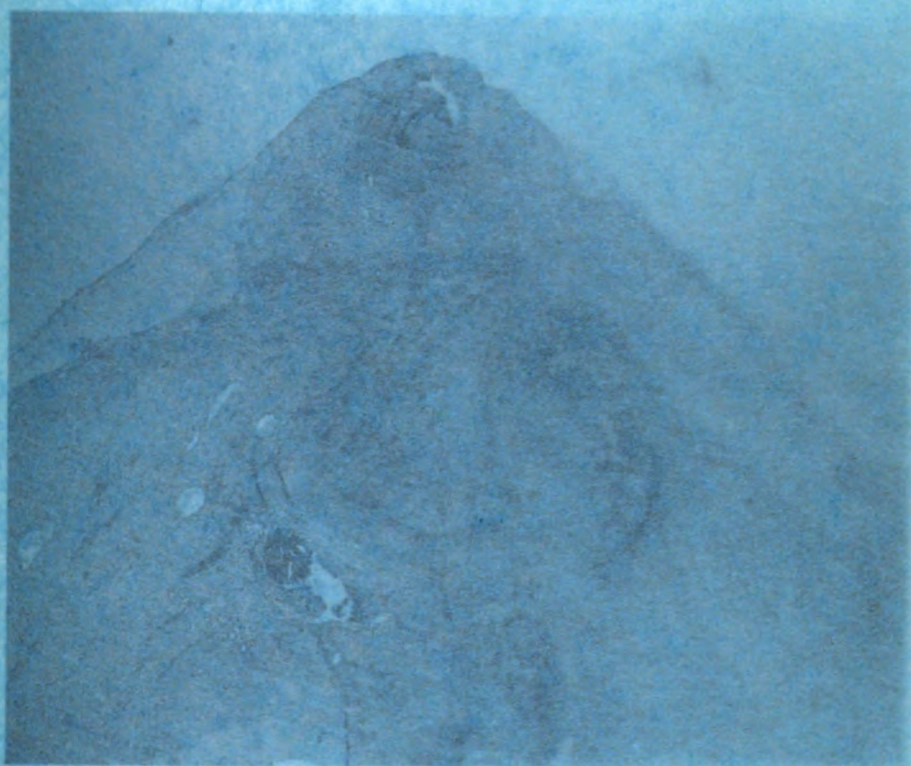


Figure 4



Figure 3

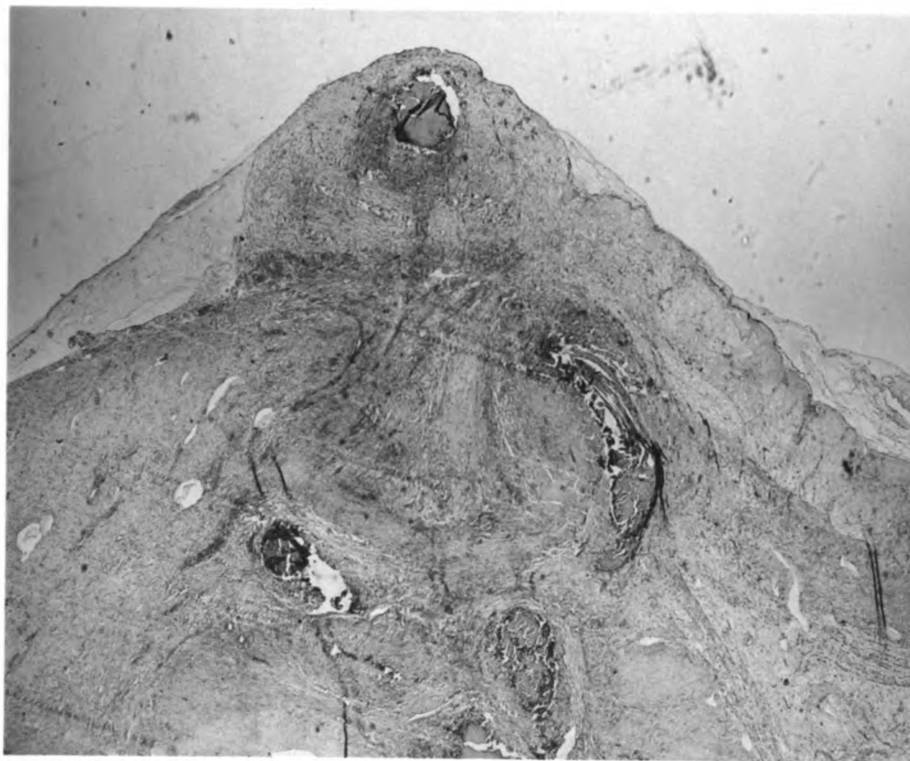


Figure 4

Figure 5. Number 50 nylon in uterus 19 days post-operatively. Note the honeycomb appearance of the nylon and lack of surrounding tissue reaction. 75x.

Figure 6. Chromic 00 catgut in uterus 27 days postoperatively. Phagocytes are infiltrating the catgut along its surface. 75x.



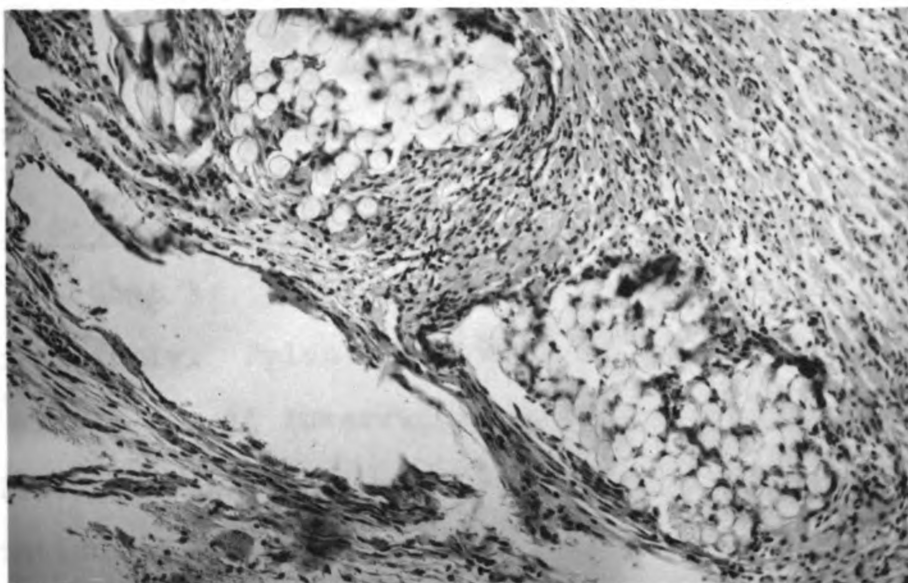


Figure 5



Figure 6

evidence of smooth muscle regeneration could be observed during this study.

B. Studies of Individual Cases

Goat 3: Uterine scar three days post-operatively. Nylon was used to close the wounds. A single row of interrupted stitches was used to close the incision in one horn, and a single row of continuous lock-stitches was used in the opposite horn.

This animal died three days after operation and at post-mortem the following gross lesions were noticed:

1. Marked post-mortem changes.
2. Pale mucous membranes.
3. Fibrinous exudate and blood tinged fluid in the abdominal cavity.
4. A hole about one centimeter in diameter in the uterine wound which was stitched with simple interrupted stitches. The continuous lock-stitches used in the other horn were intact.
5. Uterus moderately distended with fluid. Bacterial examination of the uterus revealed the presence of coliforms, an enterococcus and a beta streptococcus.

Conclusions and comments by the pathologist: "It is my opinion this animal died from a peritonitis due partially to the spilling of uterine contents in the abdominal cavity and external hemorrhage from the area where the catheter was inserted into the carotid artery".

Microscopic study revealed no healing of the uterine wound and there was infection present as evidenced by numerous bacteria and leucocytes. Suture material was not evident anywhere in the section. There was a wide gap between the two edges of the incision which was filled with fibrinous exudate. There was hemorrhage along the line of incision. In this case, the line of cleavage was clearly defined.

Goat 1: Uterine scar 14 days post-operatively. Nylon was used for suturing the wounds. There were two wounds in the uterus, one in each horn. In one wound a double row of interrupted nylon stitches were used, whereas, in the other wound a double row of continuous lock-stitches were used. A gross study of the tissue showed healing with no adhesions to other organs.

Microscopic examination revealed healing had progressed well and the approximation of wound edges along the incision line was almost perfect.

There was no sign of infection. Very little reaction was seen around the edges of the wound. At places tissue surrounding the suture material was rich with leucocytes and cells of the reticulo-endothelial system. A few giant cells could be seen around the suture material. Where the inflammatory reaction surrounding the suture material was marked, the infiltration of fibroblasts and white blood cells was quite evident. Here the line of incision could not be distinguished.

Goat 2: Uterine scar 19 days post-operatively. Nylon was used to close the wounds. There were two wounds in the uterus, one in each horn. In one wound, a double row of interrupted stitches were used, whereas, in the other wound a double row of continuous lock-stitches were used.

Gross examination of the scar showed healing with no adhesions to adjacent structures. The nylon sutures were lying very superficially in the serosa. There was very little scarring on the external surface of the uterus. There was good approximation throughout the wound and histological findings were no different than in goat 1. Very little reaction was seen in the tissue. The reaction around the nylon sutures was practically nil. In the entire area of the incision, a marked

proliferation of fibrous tissue could be seen. The line of incision could not be distinguished in the sections.

Goat 13: Uterine scar 18 days post-operatively. Catgut was used to close the wounds. There were two wounds in the uterus, one in each horn. A double row of simple interrupted stitches were used in one horn, whereas, in the other wound a double row of continuous lock-stitches were inserted.

Gross examination of the scar showed complete healing with no adhesions to other structures. There was a considerable amount of scarring at the site of the incision.

Microscopic study revealed complete adherence of the wound edges. Scar tissue was still in formation as evidenced by the presence of young fibroblasts in the area of incision. There was quite extensive reaction around the suture material and reabsorption was still in progress. Layers around the suture material from within outward were as follows:

1. Central layer: Catgut giving the appearance of a homogenous pink mass.
2. Middle layer: White blood cells and cellular debris.

3. External layer: Young fibroblasts with blood capillaries and white blood cells dispersed between them.

There was extensive reaction in the area of the wound. The line of incision was not visible throughout the section.

Goat 10: Uterine scars 14 and 19 days post-operatively. Catgut was used to close the wounds. Four incisions were made in the uterus two in each horn. In two wounds, a double row of interrupted stitches were used, whereas, in the remaining two wounds a double row of continuous lock-stitches were used.

Gross examination after 14 days showed complete healing with all the wounds being free from adhesions. After 19 days, extensive omental adhesions were observed at the site of the wounds.

Microscopic study revealed healing had progressed well in all the tissues and no infection was present. The line of incision could be readily followed through the tissues taken at 14 days after operation, but the tissue taken 19 days after operation showed no incision line. Fibroblasts could be seen along the entire wound and at some places blood was present between the two edges of the wound. There was a marked reaction around the

catgut sutures which were present in all the tissues.

Goat 21: Uterine scar 21 days postoperatively. There were two wounds in the uterus, one in each horn. Nylon was used for suturing the wounds. In one wound, a double row of simple interrupted stitches were used, whereas, in the other horn a double row of continuous lock-stitches were used.

Gross examination of the scar showed complete healing with very little granulation tissue on the external surface of the uterus.

Microscopic study revealed very little healing at a few places along the line of incision, but where the edges had been well approximated there was good union between the two sides. At places red cells were present between the two edges of the wound. Suture material was present, but there was no inflammatory reaction in the surrounding tissue. Some white blood cells and young fibroblastic cells could be seen infiltrating the suture material and it presented the appearance of adipose tissue or of a honey comb. The line of incision could be readily followed in the tissue.

Goat 5: Uterine scar 26 days postoperatively. There were two wounds in the uterus, one in each horn. Catgut was used to close the wounds. A

double row of continuous lock-stitches were inserted in both the horns.

Gross examination of the scar showed slight adhesions around the catgut sutures.

Microscopic sections showed extensive tissue reaction. The tissue was heavily infected and there was marked increase of neutrophils. At places, clotted blood was also present. Damage extended into the mucosa, involving the epithelium at a few places. The adventitia was rich with engorged blood vessels showing excessive inflammatory changes.

Goat 18: Uterine scar 27 days post-operatively. There were two wounds in the uterus, one in each horn. Catgut was used for suturing the wounds. In one horn a double row of simple interrupted stitches were used, whereas, in the opposite horn a double row of continuous lock-stitches were inserted.

Gross examination of the scar showed healing with no adhesions to other organs.

Microscopic study revealed phagocytic action in the tissue and some hemorrhage in the area of the wound. Engorgement of the vessels was seen at a few places. The incision line could not be distinguished.

TABLE I
SUMMARY OF DATA

Goat Number	Suture Material	Type of stitches and number of rows A. Right horn B. Left horn	Number of days post- operative biopsy made
3	Nylon	A. Single row of simple inter- rupted stitches. B. Continuous lock-stitches.	3 days
1	Nylon	A. Two rows of simple inter- rupted stitches. B. Two rows of continuous lock-stitches.	14 days
10	Catgut	A. Two rows of simple inter- rupted stitches. B. Two rows of continuous lock-stitches.	14 days
13	Catgut	A. Two rows of simple inter- rupted stitches. B. Two rows of continuous lock-stitches.	18 days

TABLE I
(Continued)
SUMMARY OF DATA

Goat Number	Gross Appearance	Microscopic Appearance
3	A hole one centimeter in diameter in the uterine incision. No adhesions. No adhesions. Stitches were intact.	No healing. Infection present. Line of cleavage clearly defined. No healing.
1	No adhesions.	Complete healing. No infection. Very little reaction in the tissue. Line of incision could not be distinguished.
10	No adhesions.	Healing in progress. No infection. Marked reaction around sutures. Line of incision could be followed in the tissue.
13	No adhesions.	Healing complete. Extensive reaction around sutures. Line of incision could be distinguished in tissue.

TABLE I
(Continued)
SUMMARY OF DATA

Goat Number	Suture Material	Type of stitches and number of rows A. Right horn B. Left horn	Number of days post- operative biopsy made
10	Catgut	A. Double row of interrupted stitches. B. Double row of continuous lock-stitches.	19 days
2	Nylon	A. Two rows of interrupted stitches. B. Two rows of continuous lock-stitches.	19 days
21	Nylon	A. Two rows of simple inter- rupted stitches. B. Two rows of continuous lock-stitches.	21 days
5	Catgut	A. and B. Double row of continuous lock-stitches.	26 days
18	Catgut	A. Two rows of simple inter- rupted stitches. B. Two rows of continuous lock-stitches.	27 days

TABLE I
(Continued)
SUMMARY OF DATA

Goat Number	Gross Appearance	Microscopic Appearance
10	Extensive adhesions around the sutures in both the wounds.	Healing complete. Line of incision not clearly defined. No infection. Marked reaction around the sutures.
2	No adhesions.	Healing was good. Very little reaction in the tissue. No reaction around the sutures. Line of incision could not be distinguished.
21	No adhesions.	Little healing at few places along the line of incision. The incision line could be readily followed. No tissue reaction.
5	Slight Adhesions.	Infection present. Extensive tissue reaction. Complete healing. Incision line could not be distinguished.
18	No adhesions.	Healing complete. Phagocytic action in tissue and incision line could not be distinguished.

CHAPTER V

DISCUSSION

A. Operative Technique

Ever since Sanger (39) first described the technique of Cesarean section, the history of the operation has been a recital of a series of efforts to find the most suitable point of entrance into the uterus. Almost all operative techniques in the veterinary field have been standardized and one or possibly two methods are almost universally recognized as the most successful. This cannot be said of Cesarean section. Large numbers of successful cases, varying in suture techniques are recorded.

One of the American authors cited by Lensch (24) states, "I have carried more than 500 Cesarean sections in standing and lying cattle, as laparotomy right and left, in the lying animal in the median plane, paramedian left and right according to the position of the foetus. Each of these methods has its drawbacks and advantages. In obstetrical surgery, different to all other surgery, it is most important to master every technique

according to the position of the foetus. The obstetrical patient forces the veterinarian to adapt his method to the special condition".

What is required is a site from which the uterus can be readily brought into the incision and maintained there without undue strain on the operator or his assistant. Unquestionably, success depends largely upon experience and good assistants. As to the detailed operation, it seems to matter little in the result whether the abdominal incision is made in the flank region or at mid-line; whether the uterine incision is close to the bifurcation of the horns or away from it. Anyone able to do a Cesarean section is generally capable of deciding for himself the best way to deliver a given case.

In this study, the lower left flank incision was found much more suitable than any other site. The peritoneum could be entered along the lower border of the rumen. On pulling the omentum forward, the uterus was immediately exposed and could be drawn into the incision. This approach prevented the escape of abdominal viscera and no difficulty was encountered in handling the uterus. The advantage of the left flank site is that there is less danger of intestinal prolapse. However, if the rumen is nearly full, it may be difficult

to keep out of the way.

It is interesting to note that in human obstetrics there is a current tendency to favor spinal anesthesia for blocking pain perception. By this method, there is minimal transplacental diffusion of drug to depress fetal metabolism. Newborn infants seldom require resuscitation after spinal anesthesia, whereas, it is often necessary after general anesthesia. The University of Denver Hospital reported that fetal mortality associated with Cesarean section was 19 percent during the first five-year period preceeding 1946 (46). All of these operations were performed under general anesthesia administered by inhalation. During the next five year period, 96 percent of the Cesarean sections were performed under regional anesthesia. Fetal mortality dropped from 19 to 8 percent. The improvement was attributed largely to the use of regional instead of general anesthesia. Comparable data are not available in veterinary medicine, but the similarity of other principles of anesthesiology in man and animals justifies the assumption that the above data for human beings may have application to domestic animals.

In this study, general anesthesia was used in goat 5. It had no untoward effect on the

mother, but certainly had a depressing effect on the kids. To avoid this difficulty a combination of tranquilizer (vetame) as preanesthetic and procaine hydrochloride as a local anesthetic was used. Following this technique no difficulty was encountered in obtaining good anesthesia and no ill effects were noticed upon the kids.

Although paravertebral lumbar anesthesia is preferred for surgery on the region of the paralumbar fossa, difficulty may sometimes be encountered in anesthetizing excessively fat animals because of the obliterated anatomical landmarks. In this study, no such difficulty was encountered in blocking the nerves.

B. Uterine Healing After Cesarean Section

The histological characteristics of the healing wound to a large extent reflect the strength of the scar. The type of tissue of which the latter is composed will govern its ability to withstand the effects of the ensuing pregnancy and the additional strain of labor. On this subject many differences of opinion were expressed in the literature. A large group of obstetricians believed that the uterine incision healed by the formation of scar tissue while another group firmly believed

that healing was entirely by the process of muscle regeneration. Since the assertion by Williams (50) that union resulted from regeneration of smooth muscles, most authors have directed their attention to the anatomical studies of these scars. The ability of smooth muscle fibers to undergo growth changes and reproduce themselves has been demonstrated by many authors (19, 21, 25).

In spite of the above statements, in this study no smooth muscle regeneration could be observed. On the other hand, in all eight uteri of this series microscopic study revealed the presence of fibroblasts along the line of incision with the scar being composed mainly of connective tissue. These results agreed with Schwarz' and Paddock's findings (40, 41) which showed that healing was the result of proliferation of fibrous tissue and clearly demonstrated the lying down of fibroblasts along the incision line. Their observation has not been contradicted. Cheli (7) has also observed the formation of cicatricial tissue in uteri of cattle and sheep following Cesarean section.

McCallum (26) in his text-book of pathology, stated that from experimental and other studies of the healing of defects in smooth muscle, very

little activity was found in this region. Sometimes mitotic figures were described, but more recent studies favored the idea that there was very little regeneration of muscle tissue in higher vertebrates and that healing by scar tissue brought together the muscle edges at the site of the defect. Moreover, muscle regeneration played no conspicuous part in the final picture as proved by the work of Walsh and Loeb (47). They showed that mitotic figures were rarely found in the uterus of the guinea pig more than seven days after delivery and rarely more than eleven days when the uterus was injured.

Thus it appears that muscle regeneration, if it has to play a conspicuous part in the disappearance of these scars must do it early. It was quite evident from the sections of this series which were taken fourteen to twenty-seven days postoperatively that this was not the case.

Study of eighteen uterine scars showed results similar to those reported by Covelaire and Losee (8, 25), in that the deposition of a considerable band of fibrin between the cut edges formed the basis from which healing took place.

Fibroblastic proliferation which was definitely evident in all goats, and which could

be considered to be normal healing, indicated that the early process was similar to that described by Schwarz and Paddock (41) in the guinea pig and rabbit.

Phaneuf and Williams (34, 50) have reported that the old scars were invisible in most instances and could not be identified at the time of re-operation.

The absence of a demonstrable scar over a considerable extent of well healed uterine wall might be due to the fact that the line of scar tissue was originally small. Secondly, the scar tissue, which ramified along the line of incision between the adjacent muscle bundles, contracted pulling the muscle bundles close together. Therefore, as the scar contracted it simulated more and more the normal pattern of the uterine wall and was not demonstrable on histological examination.

In goats 1, 2, 5 and 18 on histological examination the line of incision could not be distinguished through the sections because of complete healing. In some of these it was difficult in the healed uterus to locate grossly the site of the incision line. In these, the uterus was indistinguishable from the unoperated uterus.

C. Suturing Technique

Zinke (52) in a discussion on Cesarean section scars at the sixty-eighth annual session of the American Medical Association, observed, "One of the conclusions I have reached is that it matters little what type of sutures we use in sewing up the wound, but that it is most important that we have an aseptic wound; that we bring the sides of the incision into perfect apposition. This procedure is absolutely essential to a firm uterine scar".

In this study, three methods were used in closing the uterine incisions. In goat 3, a single layer of interrupted stitches of number 50 nylon was used to close the wound in one horn. In this case, the sutures gave way leaving a gap of about one centimeter and the animal died three days after operation. Post-mortem examination revealed the spilling of uterine contents into the abdominal cavity and peritonitis, which could have been the cause of death. From this observation, it was concluded that a single layer of number 50 nylon does not produce a safe closure. In the remaining animals a double row of continuous lock-stitches or a double row of interrupted stitches were used to close the uterine incisions. It was interesting to note that both types of stitches gave good

results and healing was satisfactory in all the cases. These results agreed with the observation of a previous investigator (Zinke (52)).

Kerr (23) stated that the defective scar was not due to faulty technique, but to (a) The difficulty of securing complete asepsis, owing to the danger of infection from the vagina; (b) The hinderance to the healing process resulting from the degenerated state of uterine muscle post-operatively; (c) The irregular distribution of the sheets of muscle forming the uterine wall; (d) The state of unrest of the uterus subsequent to operation, caused not only by the retraction but by occasional contractions during which stitches were stretched.

The first part of Kerr's statement does not agree with the findings of this experiment. In goat 5, in spite of infection, healing was complete and the scar was normal. It was observed in this study that perfect suture technique played a more important part in good healing, although other factors described by Kerr may be of additional importance.

Two essential points for producing a better scar were observed. One was inclusion of the entire wall of the uterus in the suture in order

to secure proper coaptation of the entire length of the incision. The other was the prevention of infection. There is some difference of opinion as to whether the uterine wound should be closed with interrupted or continuous stitches. Green and Bloom (18) observed that closure with interrupted stitches yielded better scars than closure with continuous stitches. Others (1, 13, 27) have preferred continuous stitches. In this study, both types showed good results. The continuous lock-stitch was faster, therefore, it was preferred.

D. Suture Materials

Suture materials are an important factor in a closure. By placing a suture one implants a foreign body. The tissue disposes of foreign bodies by either digestion or burial. It digests absorbable materials by phagocytic action and buries the non-absorbable material in fibrous tissue. The essential point of a good suture is that it should be strong enough to bring and hold the structures in apposition so that healing may proceed unimpaired until complete. At the same time, it should not constitute an irritating foreign body. The tension applied to sutures should be only sufficient to bring the tissue

into apposition. There is swelling following trauma in the process of suturing so sutures are automatically tightened during healing. If tied too tightly, they interfere with blood supply, causing a local area of ischemia which retards healing.

The fact that a wide variety of suture material has been used by many authors in closing the uterine incision is sufficient proof that none is entirely satisfactory from every point of view. Plain and chromic catgut, silk worm-gut, kangaroo tendon, silk, nylon and metallic wire have been employed at one time or another.

Holland (21) upon the analysis of a large number of cases, found that subsequent ruptures occurred two and a half times more frequently after the use of catgut than after the use of silk. On the other hand Prusman, cited by Gamble (15), objected to non-absorbable sutures on the ground that in the presence of infection they caused necrosis and weakening of the scar. Bowers et al. (5) and Schmitz et al. (43) also favored the use of catgut.

In this series of operations, number 50 nylon and 00 chromic catgut were used to close the incisions. The former showed more satisfactory results than the latter. With catgut

there was marked reaction around the sutures in most cases and in two, goats 5 and 10, omental adhesions developed along the incision line, probably as a result of stiff knots irritating the surrounding tissues. With nylon very little or no reaction was found around the suture material and the uterine scar at the time of biopsy was free of adhesions. This was perhaps due to the fact that the non-absorbable material possesses great tensile strength, consequently, fine materials could be used thereby reducing the size of the foreign body. Furthermore, the advantage of non-absorbable materials such as nylon over catgut is that they do not possess the power of capillary attraction and have a smooth surface which is less irritant to the tissue causing less tissue reaction.

According to Gamble (15), adhesions following Cesarean section were common but in this study adhesions were found only in two cases, so it was not justifiable to draw any inference from these data. It is difficult to determine just how much harm such adhesions do. Doubtless they may give rise to considerable abdominal discomfort, which may occasionally be so great as to necessitate a second operation and cause difficulties at the time of operation. For example, in goat 10 of

this series after the adhesions had been freed, the hemorrhage from the surface of the uterus was difficult to control.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Cesarean sections were performed on eight goats producing eighteen uterine incisions. In one goat, the two uterine incisions were sutured with number 50 nylon using a single row of simple interrupted stitches and a single row of continuous lock-stitches respectively. The single row of simple interrupted sutures did not produce a safe closure. The remaining uterine incisions were sutured with either catgut or nylon using a double row of continuous lock-stitches or two rows of simple interrupted stitches.

Biopsies were performed at intervals following the Cesarean sections and macroscopic and microscopic observations made.

Microscopic examination revealed that the edges of the wound throughout the entire line of incision were held together by early proliferation of fibroblasts along with blood capillaries.

A definite scar tissue developed which could be demonstrated 14 to 27 days postoperatively.

Muscle regeneration could not be observed in

the healing process.

With catgut sutures there was severe tissue reaction in four cases with omental adhesions in two. No such reactions were found with nylon.

Infection and adhesions played important roles in the production of an imperfect scar.

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