This is a draft of an article written a few years ago with the collaboration of Professor Baskett. Because of its length, it was never published. I post it here because of its general interest to obstetricians. Dr. Baskett has not reviewed this draft, and I assume all responsibility for any errors or omissions.

Historical Notes on the Use of Uterine Sutures at Cesarean Section

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Introduction

Cesarean section has become an everyday operation with standardized technical details. Despite individual and local variations —single- vs. double-layer closure of the uterine incision, for example— all surgeons suture the uterine incision. This was not always the case. Until Max Sänger (1853-1903), from Leipzig, popularized what is now called the "classical" cesarean section in 1882, the consensus of expert opinion favored leaving the uterine wound open. This review will summarize the historical literature on this topic.

Early Cesarean Section

Cesarean section was rarely performed on living women before the widespread utilization of antisepsis and anesthesia in obstetrics during the mid-1880s. The poor outcomes for both mother and child re-enforced the notion that this was a procedure of last resort. Although reliable reports of successful cases first appeared during the 1500s, these were considered unusual enough during the next few centuries to warrant publication. The Frenchman François Rousset **(**c 1530-1603) coined the word "cæsarien" and was the first author to advocate the earlier and more frequent use of abdominal delivery. In his 1581

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book, he presented an extensive and well-reasoned discussion of the indications and risks of the procedure, based on cases with which he was familiar.[i] Whatever doubts would later be raised about the veracity of Rousset's case reports, or of his own role in these operations, it is apparent to the medical reader that *someone* was performing this surgery more than 400 years ago. Such technical details could never have been the product of Rousset's imagination. The mere performance of Cesarean section continued to arouse controversy in the medical world for three centuries after Rousset. It is fair to say, however that nothing important was added to the theory or technique of cesarean section during this time, except perhaps the use of uterine sutures.

Early views on the Use of Sutures at Cesarean Section: the French Experience until 1770

On this subject, Rousset wrote: "…the *[uterine]* wound retracts immediately after birth...because, the child and placenta delivered, there is nothing left within the uterus to prevent all its parts from approaching one another. This is sufficient to bring the edges so close to each other that no sutures are necessary, and the wound seems to heal by primary intention. Healing is also facilitated by the natural heat and humidity that the uterus used to convey to the child within, as well as the warmth of adjacent organs; this is better than any intervention…"[ii] It was Rousset's opinion that the blood loss at Cesarean was not much greater than that seen following vaginal delivery. He also shared the widely-held view that the blood lost at birth was simply retained menstrual flow that provided nourishment for the child, but was of no benefit to its mother. Borrowing heavily from Rousset's work, later writers said much the same thing: Jacques Duval (c1556-?)

Professor of Medicine at Rouen, wrote in 1612: “Insofar as it contracts, re-joins, and scars…without the help of sutures, medications, or other treatments, there is no other organ that heals as well as the uterus.”[iii] In his 1708 textbook of surgery, the Parisian surgeon/anatomist Pierre Dionis (d.1718) wrote: “One must not suture the uterus because, as it contracts, the edges of the wound come together on their own.”[iv] Guillaume Mauquest de la Motte (1665-1737), a surgeon/obstetrician in Normandy, remarked in 1732: “It is unbelievable how quickly Nature heals the uterine wound…and the latter can safely be left to its care…the use of suture should be limited to the abdominal structures…”[v]

The influential Parisian obstetrician, André Levret (1703-1780), also spoke against suturing the uterus: "I hesitate to talk about uterine sutures, because all surgeons believe that they would be harmful. They become useless because of the intense contractions that this organ has shortly after the extraction of the child."[vi]

The First Successful Case Report: 1770

To our knowledge, the first description of uterine sutures at a cesarean section was published in 1770 by Normandy Gallot, a doctor from St Maurice-de-Girard in Poitou, as an open letter to his colleague Bougourd in Saint Malo, Brittany.[vii] From second-hand accounts, he described a procedure performed the previous year by Jean Le Bas (1717-1797), an experienced surgeon from Mouilleron. On August 27, 1769, LeBas was called to assist a younger surgeon who was unable to complete the extraction of a fetus, dead

after a 3-day obstructed labor from a shoulder presentation with a prolapsed arm. After declaring vaginal delivery to be impossible, he recommended and performed an immediate cesarean: “After extracting the fetus and placenta through a 4-5 inch uterine incision, he closed the uterine incision with 2-3 sutures, and the abdomen with four stitches...She received no special aftercare or dietary restrictions and remained afebrile through her labor and convalescence. At one point the incision looked inflamed…vaginal douches of quinquina in wine were administered, and warm poultices applied to the wound; shortly after there was suppuration and healing proceeded rapidly after the expulsion of the uterine sutures. She was fully recovered by October 8, and was back at work eight days later.” Gallot offered no details about the location of the uterine incision, the type of suture employed, or the manner of closing the abdomen. However, surgeons commonly used waxed braided linen at that time; it is also not clear if the expelled sutures were passed through the vagina or the abdominal wall. He commented: "the application of sutures to the uterus at first seemed to me somewhat extraordinary, and I questioned it. In the end, the surgeons and the others assisting at the operation convinced me. This should have reduced the success of this operation; however, all turned out well."

It is also worth noting the opinion of Jean Louis Baudelocque (1746-1810) of Paris in the late 18th century, since his work had a major influence on American Obstetrics: “The uterine wound requires little care: within a few minutes it contracts and shrinks to less than half its original size, except in cases of uterine inertia. This wound would heal easily were it not that it usually serves as a drain for the abundant fluids that pour out of the uterus in the first few days postpartum.”[viii] Irrigation of the uterine wound with an

infusion of medicinal plants was advocated by both Rousset and Jean Ruleau[ix], the surgeon/accoucheur at Saintes, but, Baudelocque continues, "it seems to us clear that all these things are useless. Healing is the job of Nature, and only hemorrhage needs any particular attention from us."

The Next Successful Case: 1840

The next report of a successful case of cesarean section involving uterine suturing did not appear in the literature until 1840. Dr. Godefroy explained his rationale for suturing the uterus as follows: "Notwithstanding the significant shrinking of the uterine incision following contraction of the uterus, it remained gaping 3-4 cm, enough to allow a loop of bowel or omentum to get caught up in; I was also concerned that this opening would allow lochia to drain into the peritoneal cavity…I decided to prevent these complications by suturing the uterus. Using an ordinary straight needle threaded with a double loop of waxed linen (since I did not have flat curved ones with me), with a thimble on my finger, I introduced my needles from outside-in on the right side, and inside-out on the left through the full thickness of the uterus, a few millimeters from the edges. The three sutures, one in the middle, the others at the extremities, were then loosely tightened, tied with a double knot, and cut. The wound was perfectly approximated, and the uterus left to itself." [x]

A spirited discussion before the Academy of Medicine of Belgium involving several prominent local obstetricians highlighted the essential points of controversy in 1850. Dr. Sauveur felt that the uterine wound healed by secondary intention and hence suture was

unnecessary. Dr. Didot believed that a major cause of death following cesarean section was gaping of the uterine wound which allowed amniotic fluid and lochia to enter the peritoneal cavity and interfered with its healing; for this reason he recommended closing the wound with sutures.[xi]

The British Experience with Uterine Sutures

It was not until 1863 that the subject of uterine sutures first appeared in the British literature. At a meeting of the Obstetrical Society of London, JG Swaine presented a case of cesarean section resulting in maternal death. Autopsy revealed inflammation of the peritoneal surfaces but no evidence of significant bleeding; the external portion of the uterine incision gaped widely, but the internal edges were in close apposition.[xii] Apparently unaware of the Continental literature, the London surgeon and pioneer ovariotomist Spencer Wells (1818-1897) conjectured that suturing the uterine incision might prevent the egress of blood and uterine secretions into the peritoneal cavity, perhaps reducing the mortality of the operation. Since sutures were known to cause inflammation, he proposed long threads brought out through the vagina and left untied so they could later be removed. This suggestion received no support from his colleagues.

By 1870, surgeons in England and elsewhere had gained experience with laparotomy for ovarian pathology and intra-abdominal sutures. Robert Barnes (1817-1907), a London obstetrician, wrote: “The tendency to gaping of the uterine wound …and…the liability to effusion and secondary hæmorrhage and peritonitis, are now recognized as reasons for

closing the uterine wound, and for bringing the uterus into proximity with the abdominal wall."[xiii]

Back on the Continent

Also in 1870, Étienne Stéphane Tarnier (1828-1897), a Paris obstetrician best remembered for his axis-traction forceps, sought the opinion of his peers about a new technique —based on the work of the Berlin gynecologist Eduard Martin(1809-1875) and Lestocquoy, in France— that would address all the problems of the cesarean: hemorrhage, protrusion of the bowel through the abdominal incision, and contamination of the peritoneal cavity with blood and lochia.[xiv] He rehearsed this operation on the cadaver of a woman who had died of uterine cancer during her last month of pregnancy. After incising the abdominal wall, 7 interrupted sutures were placed on each side, connecting the uterine wall to the abdominal incision. The uterus was incised between these two rows of suture; without rushing this took about 20 minutes. Jean-Anne-Henri DePaul (1811-1883), a prominent Parisian obstetrician, expressed concern that puncturing the uterus 28 times with a needle might cause additional bleeding, as well as pain when the uterus retracted. He also thought that Tarnier exaggerated the risk of hemorrhage at cesarean: in 30 cases with which he was familiar, there had not been a single death from bleeding; almost every death following cesarean section was due to peritonitis or metro-peritonitis. He mentioned the extraperitoneal approach as one worthy of further investigation.

Baudon (Paris, 1873) illustrated a method of closing the uterine and abdominal wounds simultaneously with metal sutures that could later be removed. This allowed uterine drainage through the abdominal wall.[xv]

In 1874, Joseph Alexis Stolz (1803-1896), of Strasbourg, made the following points: "...the uterine incision has no tendency to close itself, no matter how strongly the uterus contracts. At most it becomes *prismatic*, that is the edges of the mucosa approximate, but the muscular layer remains gaping. The uterine wound is covered by omentum, bowel, or the abdominal wall itself, to which it becomes adherent, and that the gap is filled with a sanguineous exudation. On more than one occasion this wound has become fistulous, allowing menstrual blood to flow into the abdomen. The question remains whether better results can be achieved by suturing the incision: in particular, to prevent the drainage of lochia into the abdominal cavity, prevent adhesions and fistulas, and leave the uterus free and mobile as it needs to be to assume its normal function. There is ample evidence that women who have been delivered by cesarean section can become pregnant again. Although we have seen a few go to term after a 2nd or even a 3rd incision, we have also frequently observed abortions caused by uterine adhesions, rupture of the uterine scar followed by extrusion of the fetus into the abdominal cavity…"[xvi]

The American Experience with Uterine Sutures

In 1867, F.L. Dibble of New Haven CT, attended a woman who had been in labor for 48 hours. Membranes had been ruptured for 12 hours; the head was above the pelvic brim,

the cervix 1 inch dilated, and the distance from the sacral promontory to the symphysis measured 1.5 inches. A second consultant felt that embryotomy would be too risky for the woman and he proposed abdominal delivery as the only way to save her life. In a display of defensive medicine common even in olden times, a committee of 11 local doctors was assembled over the next 12 hours, and they supported this plan of action after each examining the patient. A living child was delivered through a vertical midline incision and "…five uterine vessels were ligated, the ends of the ligatures cut short, the uterine walls were secured by interrupted sutures of fine hemden thread, the parietes of the abdomen were closed with silver wire, adhesive plaster…Throughout the entire operation, not as much blood was lost as ordinarily accompanies a natural delivery." After draining copious pus during the second and third weeks, the wound was almost completely healed by the fourth week; mother and child recovered. [xvii]

While assisting at a cesarean section in 1871, Charles Rodenstein (Westchester, NY) was asked to close. Acting instinctively in the presence of profuse bleeding from the uterine and abdominal incisions, he used silk sutures for hemostasis. When the operator returned to the bedside he was unhappy with the uterine sutures; to counteract this perceived injury, he re-opened the wound on the third day and removed them. This prompted Rodenstein to review this topic for the first time in the American literature. He collected accounts of over 400 cesareans performed during the 19th century. The maternal mortality was 43%: "…surprisingly few died from hemorrhage, contrary to what might be expected...In examining post-mortem records, I am struck by the frequency of the expression *the edges of the wound gaped, the uterine incision did not close*…". Citing

recent successful cases from England and the USA, where metal sutures had been employed, he concluded that uterine sutures could be introduced without interfering with the success of the operation: “I believe that CS mortality will be considerably reduced if sutures are used at all CS.” [xviii]

Beginning in 1872, Robert P. Harris (1822-1899) of Philadelphia made it his life’s work to chronicle the cases of cesarean section performed in the USA. He published detailed accounts of 60 operations performed between 1822 and 1871; 32 mothers and 27 children survived. He identified 7 cases, 6 of them from 1867-71, in which uterine sutures had been used; only 2 mothers survived. He commented: “There may be some cases where the uterine wound should be united, under pressure by sutures, to avoid hemorrhage, and gaping… but these are exceptional ones, as is that reported by Prof Sager…where sutures were used to prevent hemorrhage and the gaping caused by the presence of a small fibroid tumor directly in the line of the incision.” Abram Sager (1810-1877), the first professor of Obstetrics at the University of Michigan in Ann Arbor, operated on a rachitic dwarf, 8-9 hours after the onset of labor, with the cervix still closed and membranes intact; 4 silver sutures were used to close the uterine wound. The mother died of secondary shock, the baby survived. Adding Rodenstein’s cases to his own, Harris wrote: “I am not aware of any form of removable uninterrupted suture having ever been used in this country. Judging from the results of eleven cases in which I find that sutures have been used, I am disposed to believe that they do not materially add to the gravity of the operation, as five of the women recovered. It is a matter for future determination whether the tendency of the suture to produce inflammation is not much more than

counterbalanced by its arresting hemorrhage and the escape of noxious discharges into the peritoneal cavity, as well as the prevention of the visceral strangulation of the wound." [xix]

In 1876, S. S. Lungren (Toledo, Ohio) described a cesarean section performed on a woman with pelvic contracture, prior to rupture of membranes.[xx] Five #28 silver sutures were used to close the uterine wound, ¼ inch from the edge, nearly full-thickness. Each suture was twisted twice, cut near the twist, and bent 90 degrees toward the wound. 5 weeks after the operation she was doing all her usual chores. It is clear from his monograph that he was unaware of the existing literature on the use of sutures.

Edward W. Jenks (1833-1903), of Detroit MI, also reported a successful case of cesarean section in 1877 where sutures were employed for hemostasis, and to prevent the egress of lochia into the abdominal cavity. He closed the uterine wound with four silver wire sutures inserted deep within the myometrium without including the serosa, hoping that during involution they would be extruded from within the uterine cavity; these wires were twisted and the ends folded back into the uterine wound. Jenks reviewed the status of abdominal delivery in the USA; in the matter of sutures, he opined: "The advice in many obstetrical works, about being in no haste to close up the wound, but to wait until the uterus contracts, is not good surgical advice. Sutures…insure contraction, and…prevent what might otherwise be a long delay, lessening the danger from shock; further, the uterine sutures prevent the escape…of blood or lochia into the peritoneal cavity…thus diminishing the danger of peritonitis or septicemia. I…prefer catgut or

silver as the material for uterine sutures, but in the absence of either would rather use silk or linen than to make use of none."[xxi]

The Porro Operation

Sutures or not, the mortality of cesarean section remained high —50-80% in most series reported before 1875. In retrospect, surgery was usually performed too late, often after days of labor and failed attempts at vaginal extraction —a perfect setup for infection and uterine atony. The Italian Eduardo Porro's (1842-1902) contribution was to remove the supracervical portion of the uterus after extracting the child, and fixing the stump to the lower aspect of the abdominal incision for drainage; the latter part of the operation would later be found to be unnecessary to its success. This yielded much better results for the mother, and was soon adopted throughout Europe and the USA. The idea had been proposed in 1834 by James Blundell (1790-1878), of London, who showed its promise by experimenting successfully on pregnant rabbits: "…the dangers of the Cæsarian operation might, perhaps, be considerably diminished by the total removal of the uterus." [xxii] Until the advent of antibiotics in the 1940s, cesarean section was contraindicated in septic cases unless the surgeon was prepared to remove the uterus. J. Whitridge Williams(1866-1931), the Johns Hopkins author of the eponymic American textbook, himself performed a variant of Porro's operation in 31% of his cesareans before 1921.[xxiii] Despite its success at saving lives, the Porro operation forever removed the possibility of future childbearing, and surgeons continued to experiment.

The "Conservative" Cesarean Section

According to Williams, Sänger revolutionized the Cæsarean section in 1882 by directing attention to the necessity for the employment of uterine sutures. As the uterus was not sacrificed in this operation, it was designated the *conservative*, in contradistinction to the Porro Cæsarean section."[xxiv] In an 1885 review, Sänger stressed four principles: 1. Strict asepsis 2. Numerous sutures, inserted close together; one third of them in a deep layer incorporating the myometrium and serosa, two-thirds in a superficial serosal layer. 3. Avoidance of the decidua 4. Permanent or slowly-absorbed suture material, such as silver wire or silk, until more satisfactory animal-based absorbable sutures are discovered.[xxv] A feature of his operation was undermining the serosa for 5 mm on each side of the vertical uterine incision, and excising a 2 mm strip of myometrium on each side —thereby allowing serosa-to-serosa approximation without tension.

The latter step was bloody and time-consuming, and soon found to be unnecessary —a point made by some of Sänger's contemporaries who disputed the originality of his work. Chief among them was Henry J. Garrigues (1831-1913), a prominent New York obstetrician whose own claim to fame rested on the introduction of antisepsis in hospital midwifery practice.[xxvi] In 1886 Garrigues wrote: "German and French gynecological journals have of late contained reports of Cesarean sections performed *after Sänger's method*…it may not be impertinent to ask, *What is Sänger's method?*...Sänger has not even proposed anything new that in the hands of others has proved valuable…in 1882 he published a book…which is meritorious in so far as the author protested against the

indiscriminate use of Porro's operation…but as to originality, its two hundred pages contain only one new idea and that one has been found in practice to be an unnecessary complication of the operation, and has therefore been given up."[xxvii] Sänger defended his honor with vigor, replying in a letter that filled 24 pages. He re-iterated his main point: "If…one step should be selected to be placed at the head of the modern improvements, it is unquestionably the uterine suture." He concluded: "Now that I have answered Garrigues quite thoroughly, I can calmly await the verdict of all impartial persons. I have the satisfaction of knowing that it will not be unfavorable to me, for right and truth are on my side."[xxviii]

In the evolution of the technique of cesarean section the contribution of Ferdinand Adolf Kehrer (1837-1914) is frequently overlooked.[xxix] Working in Heidelberg, Kehrer pioneered the transverse lower segment uterine incision that we use today. Furthermore he emphasized the double layer (*doppelnaht*) closure, using separate sutures for the muscle and overlying peritoneum. The work of Sänger and his classical cesarean section suture was theoretical when he published it in early 1882, and his technique was not carried out until May of that year. Kehrer first performed his technique on September 15, 1881 and again in November 1881 and published these two cases with details of his *doppelnaht* closure the following year. However, it was Sänger's publication and technique that held sway until the 1920s when Munro Kerr (1868-1960) of Glasgow, among others, popularised the transverse lower segment incision originally described by Kehrer 40 years earlier.[xxx]

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