Chapter

Optimizing Techniques and Suture Materials for Caesarean Section

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Abstract

Cesarean section is an important part of comprehensive emergency obstetric and neonatal care and their numbers are increasing worldwide in the recent times. Proper healing of the scar after cesarean section is of paramount importance to avoid various obstetrical complications in future pregnancies. There is no standard technique on the method of closure following cesarean delivery. It is unclear as which technique and suture material should be used for closure of cesarean section in order to get the best results with minimal complications. The objective of this chapter is to review the literature, analyze the available resources and evaluate the evidence for closure of each layer post cesarean section. The following discussion will review closure of each step post cesarean section and provide evidence-based recommendations for closure technique.

Keywords: Cesarean section, closure technique, suture material

1. Introduction

Cesarean is a commonly performed obstetric surgery and in the recent times its number is constantly increasing. Standard technique for abdominal wall closure should be practiced considering the need to provide good support, prevent infections, sinus formation, and incision pain and scar dehiscence. There are multiple sutures and suturing techniques practiced worldwide for the closure of abdominal layers following cesarean section.

The history of sutures begins more than 2,000 years ago. Surgical and suture techniques evolved in the late 1800s with the development of sterilization procedures. It has been said that the scar is the "autograph of a surgeon". Every surgeon wants cosmetically acceptable scars along with optimal healing.

An ideal suture material should be cheap, sterile, non-electrolytic, non-allergenic, with adequate tensile strength, good handling characteristics, should not induce tissue reaction or cut through tissue.

A good suturing technique should ideally eliminate the dead space and minimize tension that causes wound separation. It involves correct wound placement with respect to relaxed tension lines. Consideration should focus on factors, such as systemic diseases and selection of ideal suture material that influence the outcome. The surgical technique used to close a given wound depends on the force and direction of tensions on the wound, the thickness of the tissues to be opposed and anatomic considerations.

1.1 Wound healing and inflammatory response

The physiology of wound healing has 3 phases: inflammation, proliferation, and remodeling. Various factors like cytokines, cellular mediators are involved in the healing process.

Phase I: Inflammation (Onset of injury to day 4–6): The first phase of wound healing is characterized by hypoxic, ischemic environment with macrophages, neutrophils and platelet. Collagen, platelet, thrombin, fibronectin and fibrin with complements form a blood clot which has 3 major functions

- Expresses cellular mediators
- Serves as reservoir to amplify cellular signaling
- Provides support and communication matrix for arriving inflammatory cells

Phase II: Proliferation (Days 4–14): It is marked by rapid construction of new tissue. Macrophages emit nitrous oxide thus dilating the vessels to accommodate influx of new cells. Granulation begins to form at this phase. Fibroblast which are recruited from the surrounding normal tissue starts synthesizing and depositing collagen.

Phase III: Maturation and remodeling (1 week- 1 year): The final stage of wound healing is characterized by evolution of matrix into ordered collagen complex. At one week, the wound has about 3 percent of its final strength, 30 percent of final strength at 3 weeks and ultimately achieves 80 percent of its final strength at 3 months and beyond. However wound will never regain the strength of an uninjured tissue.

2. Closure following Cesarean section

2.1 Uterine closure

A scarred uterus carries long term consequences. Thus, the technique and the suture material used are crucial for the uterine scar healing. But strong evidence regarding optimal techniques is scarce [1]. There are multiple techniques and suture materials used for closure of uterus during cesarean section.

Usually intraperitoneal repair of the uterus is undertaken. RCOG [2] and Cochrane review [3] on exteriorization of the uterus for repair of the uterine incision does not recommend routine exteriorization of the uterus as it is associated with more pain and does not improve operative outcomes such as hemorrhage and infection. However, a RCT conducted by Isabela Cristina et al., showed that number of sutures required is lower and the surgical time is shorter with extra-abdominal repair, although moderate and severe pain at 6 hours is less frequent with in situ uterine repair [4]. A meta-analysis in 2015 also showed that uterine repair by exteriorization may reduce blood loss and the associated decrease in hemoglobin, but did not find any difference between the two techniques with respect to intraoperative nausea, vomiting, or pain [5].

Uterine closure can be done either in a single layer or by double layer and both interlocking and unlocked suturing techniques have been used. Methods concerning closure of the uterine incision need to be considered with regards to benefit and potential harm in order to offer the best available surgical care to women undergoing cesarean section.

Blumenfeld in a study with 127 women opines that single layer closure is associated with 7 fold increase in the risk of developing bladder adhesions compared to double layer closure but there was no difference in the outcome of other pelvic or abdominal adhesions thus favoring double layer closure [6].

Glavind in a similar study, using 2D TVS (Transvaginal sonography), assessed for the residual myometrial thickness, scar defect, depth, width and length in 68 women with single layer and 81 women with double layer closure. Study concluded that double layer closure improves the quality of the scar with significantly higher myometrial thickness and shorter scar defect. He also favors double layer closure for better long term outcomes [7].

A Cochrane review based on 19 studies on single versus double layer closure of the uterus, found that there was no statistically significant differences for the primary outcome, febrile morbidity, although the meta-analysis suggested single layer closure was associated with a reduction in mean blood loss [8]. RCOG recommends that, except within research content, the uterine incision should be sutured within two layers [2]. A meta-analysis of 9 RCTs including 3969 women, showed that single layer closure and double layer closure are associated with similar incidence of cesarean scar defects, uterine dehiscence, uterine rupture in subsequent pregnancies [9].

2.1.1 Locking vs. non locking sutures

Single layer closure and double layer closure carry the same risk of uterine rupture in subsequent pregnancy. However a LOCKED single layer closure is associated with an increase of uterine rupture compared to double layer closure. They demonstrated that the double-layer uterine closure with a first unlocked layer that excludes the decidua, compared with locked single-layer closure that includes the decidua, is associated with a greater residual myometrial thickness (RMT) and healing ratio, which suggests that this technique is associated with better healing of the uterine scar (**Figure 1**) [10].

However Jun Woo Han in his study on impact of uterine closure on residual myometrial thickness after cesarean section disagrees with the Roberge study. He believes the main causative factor of the RMT is the coaptation ratio of incised myometrium (BX/A_0B; **Figure 2A**). When a single layer with a locking suture is used to penetrate the full thickness of myometrium and the decidua, the 2 points of A_0 and A_0' barely join each other, even after the absorption of suture materials (**Figure 2B–D**), because the uterus that delivered the baby is a dynamically contracting, globular, and muscular organ. Moreover, the presence and length of the uncoaptated portion ($X\text{-}A_0$) are the predominant factors that influence the different degree of RMT. Therefore, the surgeon should aim to minimize the length of the line "$D_0\text{-}D_1$" and not exclude the decidua itself. This would minimize the potential adverse effect that is associated with the inversion of the decidua (such as adenomyosis) or influence RMT and prevent the postoperative endometrial defect of exposure of the myometrium to the endometrial cavity [11].

2.1.2 Decidua exclusion

Including full thickness of the uterine wall may bring decidua into the scar. Decidual inclusion results in defective uterine healing in 78% of cases. When deciduas was excluded from the suture, all cases resulted in perfect healing [12].

Isthmocele is a uterine scar defect as a result of poor healing of uterine incision. It results in menstrual spotting, dysmenorrhea, dyspareunia, chronic pelvic pain, with an increased risk of scar pregnancy, placentation abnormalities and development of uterine rupture in future pregnancies. Uterine closure technique is

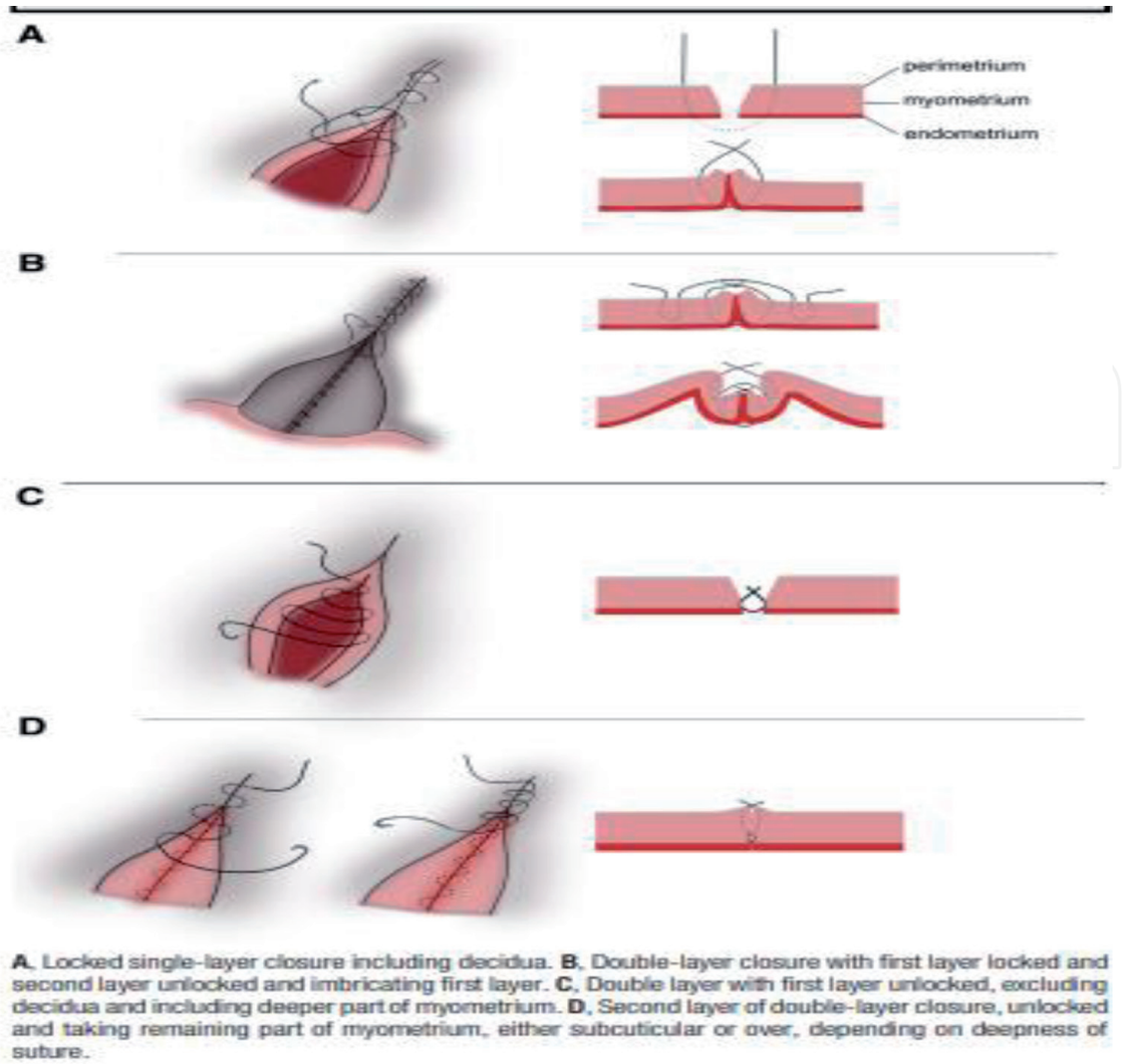

Figure 1.
Locked versus unlocked suturing techniques.

considered to be the most important factor associated with isthmocele formation. A study to demonstrate the factors associated with isthmocele concluded that uterine closure using the FFNN (Far far near near technique) continuous unlocked double layer technique is beneficial in terms of providing protection from isthmocele formation and ensuring sufficient RMT [13].

2.1.3 Types of suture material

The uterine incision is closed using an absorbable suture of number 0 or number 1. The commonly used suture materials are chromic catgut and polyglactin. Chromic catgut, being a natural suture material, has comparatively marked tissue reactivity, inconsistent tensile strength retention and reabsorption.

2.1.3.1 Catgut

Plain catgut is a natural suture material derived from the submucosa of sheep intestine or the serosa of cattle intestine. Chromic catgut is a modification of plain catgut that is tanned with chromic salts to improve strength and delay dissolution. Catgut is absorbed by phagocytosis, and is associated with a marked tissue inflammation that can be detrimental to healing. Conversely, tissue inflammation may lead to a more rapid breakdown of catgut. Plain gut has a median survival time of

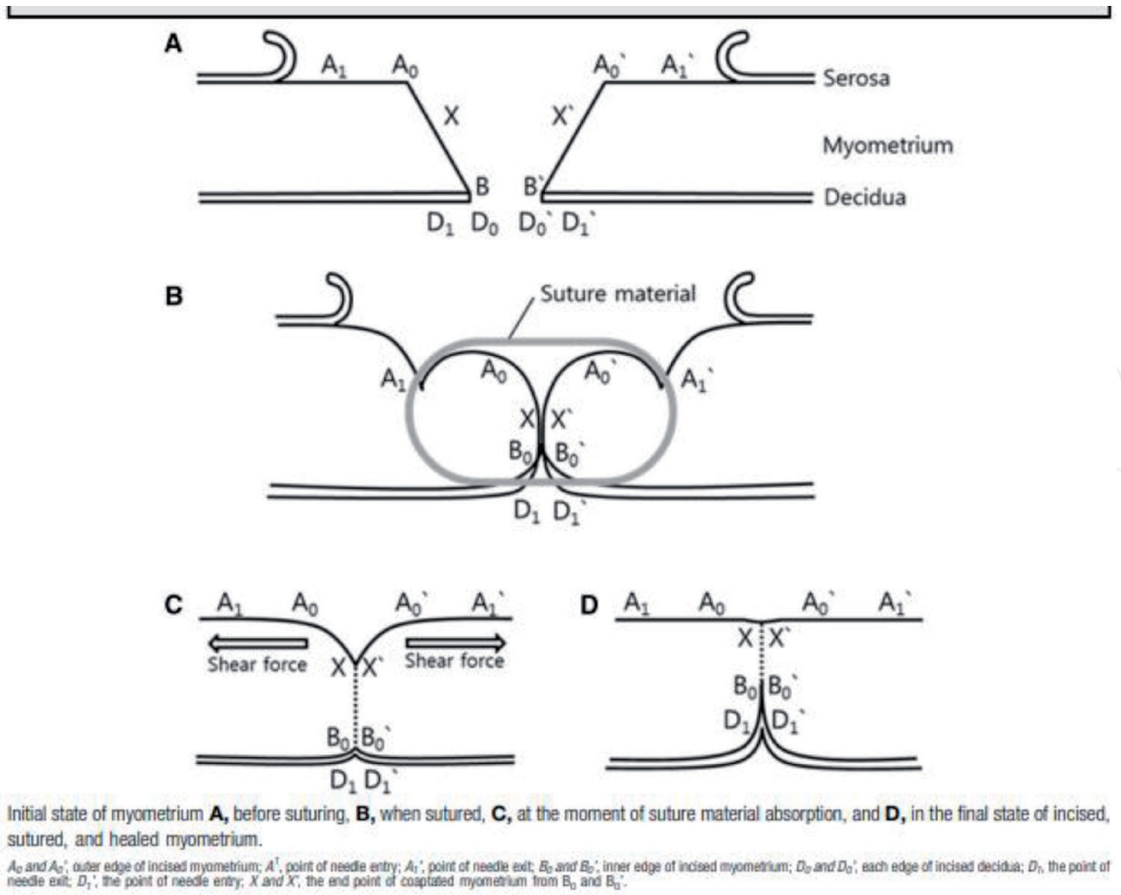

Figure 2.
Cut plane of uterine incision site when closing with single layer locking suture that penetrates the full thickness of myometrium and includes the decidua.

4 days in the oral cavity, whereas chromic gut retains its strength for 2 to 3 weeks. In moist environments such as the oral cavity, the strength of gut is reduced by 20–30%.Gut is a stiff material that must be moistened in alcohol, and forms knots that can be irritating to the oral tissues. Infection rates may increase with the use of gut. The advent of synthetic materials preferable to gut, with less tissue reactivity and more predictable resorption, has almost made catgut obsolete [14].

2.1.3.2 Polyglactin 910

Polyglactin 910 is a absorbable, braided, multifilament, coated synthetic suture. It is a heteropolymer consisting of 90% of glycolideand 10% of lactide and is degraded by hydrolysis. It is available with an antibiotic impregnation with triclosan. The residual tensile strength of a polyglactin 910 suture is consistently greater than that of polyglycolic acid suture and is absorbed more rapidly. Absorption starts at 40 days, and completes by day 70 with no remains by day 90. It retains 75% of its tensile strength at 2 weeks and 50% at 3 weeks. It elicits less tissue reactions and promote faster wound healing with good strength [15].

But, chromic gut has an excellent historical record in obstetrics and the knotted tensile strength of 0 chromic gut is adequate to withstand the disruptive forces on the repaired hysterotomy [16].

2.1.3.3 Polyglycolic acid (PGA) (Dexon, Dexon II)

PGA is a synthetic, braided polymer. When compared with chromic catgut, PGA is less reactive and is experimentally better able to resist infection from

contaminating bacteria. PGA has excellent knot security and maintains at least 50% of its tensile strength for 25 days. The main drawback of PGA is that it has a high friction coefficient and "binds and snags" when wet. It is for the same reason that some experience is required to pass this material properly through tissues and to "seat" the throws during knotting. There is a modified PGA (dexon plus) which is coated with poloxamer 188, an agent that significantly reduces the friction and drag through the tissues. Although handling has become easier with this modification, more throws (four to six) are required to prevent knot slippage than for plain PGA (three to four). The main uses of PGA are for closures of superficial fascia (subcutaneous tissue) in wounds and ligature of small blood vessels for effective hemostasis [17].

A study to assess different suturing techniques and different materials (catgut plain, Dexon and Vicryl) on healing of uterine incision in Cesarean section (CS) concluded that the best uterine scar was seen after using one layer interrupted Vicryl and Dexon suture and the worst healing results were obtained after two-row interrupted and continuous sutures using catgut [18]. As compared to catgut, use of synthetic sutures were associated with thicker myometrium in subsequent delivery. Increased inflammation in natural absorbable suture may lead to increase in fibrosis and impaired healing rendering difficulty in subsequent pregnancies and delivery [19].

The CORONIS trial on the cesarean section surgical techniques compared the chromic catgut and polyglactin-910 for uterine closure. There were no statistically significant differences noted in the primary outcome, which was the composite of death, maternal infectious morbidity, further operative procedures, or blood transfusion (>1 unit) up to the 6 weeks follow up visit [20]. A 3 year follow up study was done to the CORONIS trial and there was no evidence of a difference in the main comparisons for adverse pregnancy outcomes in subsequent pregnancy, such as uterine rupture [21].

Thus, it can be concluded that both chromic catgut and polyglactin-910 of number 0 or 1 can be safely used for the uterine repair during cesarean section, though polyglactin has been used more often in the recent times.

2.1.4 Uterine compression sutures

The B-Lynch surgical technique is used for the management of massive postpartum hemorrhage (PPH) secondary to uterine atony with failed conservative management. Long term study demonstrated, the B-Lynch surgical technique is safe, effective and free of short- and long-term complication [22].

2.1.4.1 B Lynch sutures

A large Mayo needle with absorbable suture is used to enter the uterine cavity from below the uterine incision and exit just above the incision. The suture is looped over the fundus, then enters and exits the uterine cavity posteriorly, forms a second loop over the fundus and finally enters just above and exits just below the uterine incision The suture should be pulled very tight at this point and tied anteriorly (**Figure 3**).

2.1.4.2 Hayman sutures

It is performed to control bleeding in atonic postpartum hemorrhage post vaginal delivery and rarely after uterine incision closure in cesarean delivery. Two loops are formed over the fundus and tied after applying compression (**Figure 4**).

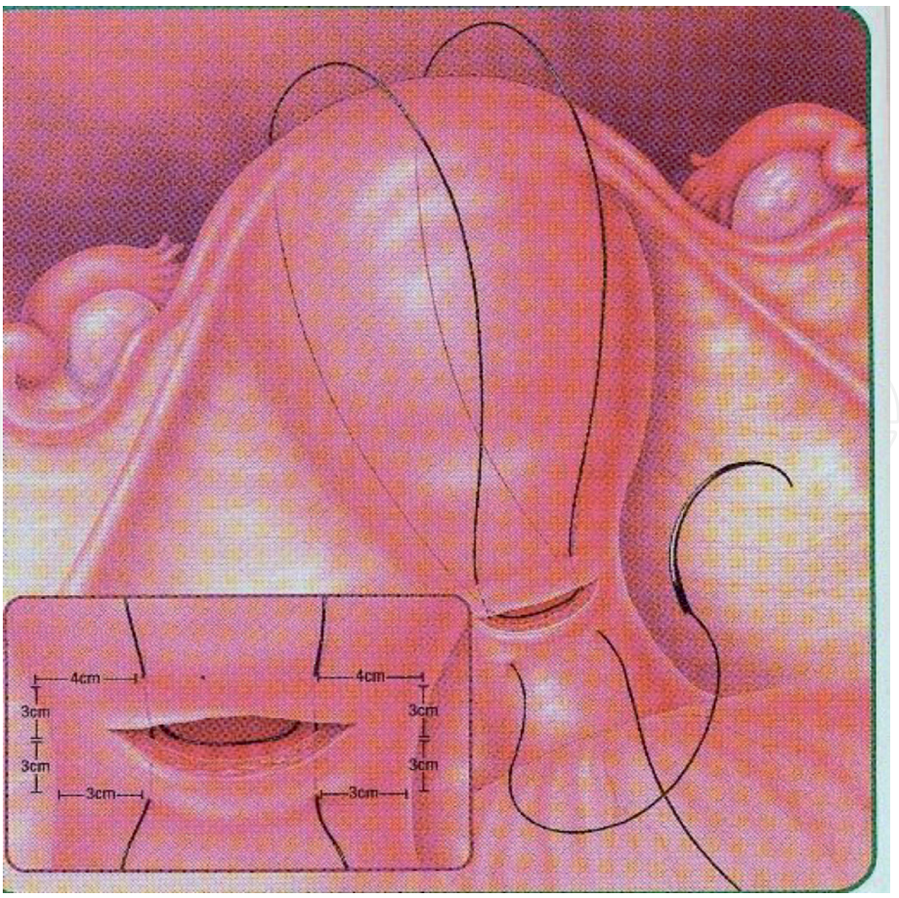

Figure 3.
B lynch suture.

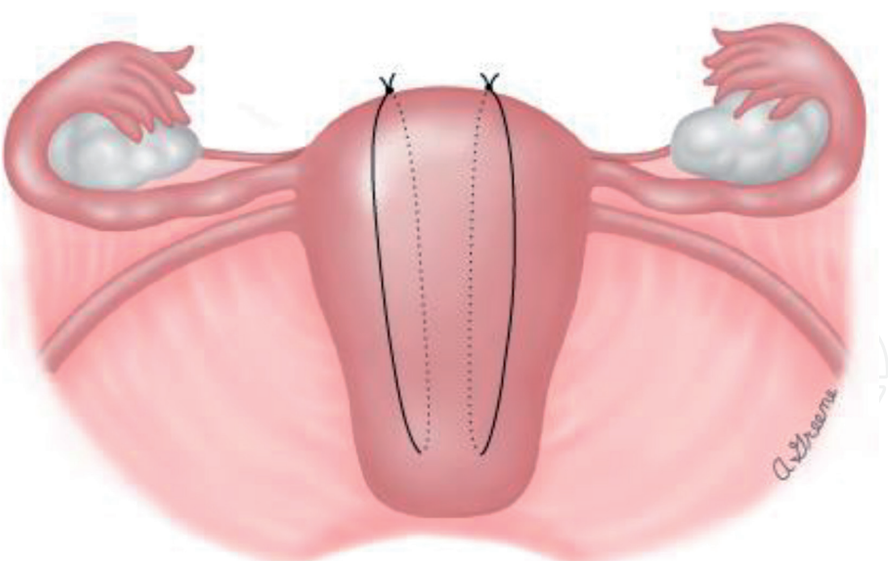

Figure 4.
Hayman suture.

2.1.4.3 Cho square sutures

A needle transfixes the uterus from anterior to posterior(point 1) and then from posterior to anterior (point 2), the same is done again at points 3 and 4 to approximate the uterine walls in a square manner. Usually 4 to 5 sutures are required **Figure 5a** and **b**.

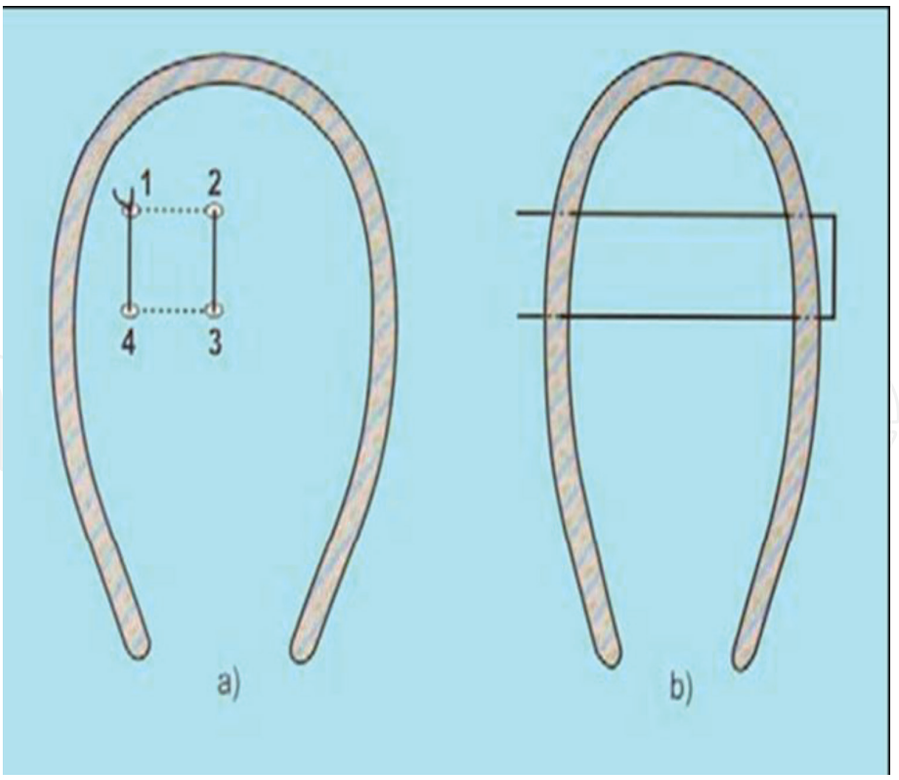

Figure 5.
Cho square suture.

Several studies are conducted to assess the ideal suture and size for uterine compression sutures but they have concluded no variations in outcome with type of suture used but it was observed that uterine preservation rate was significantly higher in cases with size 2 suture than in those with size 1 suture [23].

Placement of compression sutures that transverse the uterine cavity postpartum for PPH may be associated with a significant risk of uterine synechiae. Risk of synechiae following uterine compression sutures in the management of major postpartum hemorrhage [24].

2.2 Peritoneal and rectus muscle closure

The closure of peritoneum and the approximation the rectus muscle at cesarean section has always been debatable. The promoters of practicing peritoneal closure argue that this leads to less adhesion formation and comparative ease during a repeat cesarean section, but it also has an added disadvantage of prolonging the operative time and increased need for maternal analgesia. As far as peritoneal closure is concerned, visceral peritoneum is generally not closed as bladder adhesion is increased [25]. A review of 21 trials comparing closure versus non closure of the peritoneum showed that there was a reduction in operative time and the evidence on adhesion formation was limited and inconsistent [26]. RCOG too recommends that neither the visceral nor the parietal peritoneum should be sutured at cesarean section because this reduces operating time and the need for postoperative analgesia and improves maternal satisfaction [2]. Rectus muscle reapproximation increases immediate postoperative pain without difference in operative time, surgical complications, or maternal satisfaction but, closure of the rectus muscles at cesarean delivery was found to reduce adhesions.

If peritoneal closure and rectus muscle approximation is done in cases with diastasis recti abdominis, use absorbable sutures such as chromic catgut and

polyglactin-910. A new modified undermined suture technique for rectus muscle, which gives increased post-operative satisfaction, has been tried, using Z suture method with absorbable 1/0 suture material [27].

2.3 Rectus sheath closure

Different techniques and suture materials are used in cesarean section for closure of the rectus sheath. Few general principles are to be followed while closing the abdominal wall to achieve good healing and reduce complications. All sutures used to close the musculofascial wall must be tied with enough tension to approximate the edges of the incision. If greater tension is applied, the tissue will become ischemic and necrosis will develop. The sutures should be placed at least 1 to 1.5 cm from the wound edge. In patients at increased risk of wound disruption, sutures should be placed 2 cm from the edge [28].

The commonly used technique is to put continuous sutures without any locking. Continuous suture when used in one layer avoids high tension on suture and does not compress the wound edges. This prevents devascularization of the sheath and formation of a good quality collagen, i.e., type I [29]. Running sutures have the advantage of speed, since knots need only be tied at two or three points. Interrupted and figure-of-eight sutures can be used for reinforcing in thin rectus sheath and has an advantage, of not coming apart if insecurely tied.

Rectus sheath closure is routinely performed with non-absorbable or delayed absorbable sutures. It is generally accepted that non-absorbable sutures cause less tissue reaction and are more resistant to infection than the absorbable sutures. However, these sutures are associated with higher incidence of buttonhole hernias and sinus formation leading to increased wound pain. Care should be taken while tying the knots to avoid slippage. The commonly used suture materials for rectus sheath closure are polyglactin-910 number 1 and polypropylene number 1. Cochrane review found no studies examining different suture techniques or material for rectus sheath closure.

2.4 Subcutaneous tissue and skin closure

Suturing of the subcutaneous tissue has always been debated. Level one evidence says that suture closure of the subcutaneous fat at the time of CS reduces the risk of wound disruption in women with a subcutaneous tissue larger than two centimeters. Doing so will not only reduce collection in this space but also decrease wound tension. Though studies do show that it does not affect long-term cosmetic outcome [30].

A basic need of skin closure is good approximation. Apart from cosmetically good scars it is also necessary that the skin closure technique should be technically easy, acceptable, speedy and economical. Good tissue union and cosmetically acceptable scars are vital for ideal surgical practice.

Technique of skin closure in a cesarean section can be continuous subcuticular stitch, interrupted mattress stitch, staples or adhesive compounds.

With a plethora of skin closure materials currently available, choosing a solution that combines excellent and rapid cosmetic results with practicality and cost-effectiveness can be difficult, if not tricky. Suture materials currently available are natural, synthetic, absorbable, or non-absorbable, single filament or braided.

Mattress sutures have an advantage of occluding dead space and keeping the skin edges everted without tension. This is useful especially in older women where skin tends to get inverted.

The disadvantage with this type of suture is that there can be difficulty in approximation and prominent suture marks as sutures tend to be removed later.

To overcome the disadvantage of traditional interrupted mattress suture, Hohenleutner et al., described the intradermal buried vertical mattress suture [31]. This suture technique is safe, easy and fast to perform, everts skin edges and achieves good cosmetic results without leaving suture marks.

Subcuticular suture was first described by Halsted [32]. It is a cosmetic stitch, more difficult, but a good choice especially in younger women whose skin is soft and supple, hence making approximation easy. It is preferable to use absorbable suture for this stitch as the ends are also buried and suture removal is not required.

Though subcuticular stitch has better patient compliance than mattress stitch, the post-operative scar assessment at 6 weeks have yielded similar results in both.

Staples are attractive because of the speed of application.

An RCT study of staples with subcuticular stitch by Figueroa D showed that surgical staples were significantly associated with a higher incidence wound disruptions among those randomized to staples. This observation persisted when the outcome is restricted to disruptions >1 cm in length or > 0.5 cm in depth and typically led to additional scheduled clinic follow-up visits [33].

Another RCT by Madsen AM, comparing absorbable subcuticular staples with suture showed that wound complications, and cosmesis were similar [34]. So if one wants to use staples for closure then the absorbable one would be preferred, as metal staples though faster, has more wound morbidity.

There are many advantages of tissue adhesives over suturing and other methods of wound closure, such as a lower infection rate, less operating room time, good cosmetic results, lower costs, ease of use, immediate wound sealing, faster return to work, elimination of needle-stick injuries and eliminating the need for post-operative suture removal [35]. An RCT by Daykan Y, says that skin closure with glue or synthetic subcuticular suture have similar outcomes with respect to surgical site infection and wound disruptions [36]. The commonly used adhesive is octyl-2-cyanoacrylat.

3. Conclusion

Various techniques and suture materials for closure of uterus and the abdominal wall following cesarean section have been described. Many studies and meta-analysis have been done to compare different methods with varying results. It is best left to the decision of the operating surgeon and the institutional protocols to decide about the technique of closure and the suture material to be used.

Conflict of interest

Authors declare no conflict of interest.

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