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Edited by Georgios Androutsopoulos

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Notice

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Meet the editor

Georgios Androutsopoulos completed his Degree in Medicine in 1995, at National and Kapodestrian University of Athens. He received his Medical Specialization and completed his Doctorate of Medicine, at University of Patras. He started his academic career in 2012, as Lecturer and Consultant of Obstetrics and Gynecology at University of Patras. In 2014, he became Assistant Professor and Consultant at the same University and holds the position until today. Currently, he is the Head of the Division of Gynecological Oncology of the University of Patras. He has academic and clinical experience as well as heavy research and educational workload. Moreover, he has active participation in Undergraduate Educational Program as well as in Residency Training Program of the University of Patras.

Contents

Preface

Cesarean section is a very common surgical procedure in developed as well as in developing countries, causing many medical as well as socioeconomical problems.

The main aim of the current book, is the presentation of recent advances in surgical technique, most common perioperative complications and appropriate measures in order to reduce unnecessary cesarean sections.

The book has been divided in different sections: introduction, epidemiology - indications, surgical technique, complications, future considerations and necessary measures. Each section contains chapters on very interesting topics, that have been written by a multidisciplinary medical team consisted of prestigious Academics and experienced Clinicians.

In conclusion, the role of cesarean section should reconsidered and the procedure should be performed in carefully selected cases, in order to achieve clear benefits for both mother and fetus.

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Introduction

Chapter 1

Introductory Chapter: Is It Time to Reconsider the Importance of Cesarean Section?

Georgios Androutsopoulos

Additional information is available at the end of the chapter

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1. Introduction

Cesarean section is a surgical procedure and in many cases could be life-saving for fetus, mother, or both. During the last decades, there is a dramatical increase in cesarean section rates in developed and developing countries that causes many medical and socioeconomical problems [1].

2. History

The procedure was initially performed in ancient Egypt, Persia, India, and China, probably because of religious beliefs. During Medieval period and Renaissance, cesarean section was considered as a mandatory procedure in cases of maternal death and physicians should be able to perform it with success.

The first reported successful cesarean section because of prolonged and dystocic labor was performed in 1500. However, the use of cesarean section in cases of dystocia had many unresolved issues related with patients support, hemorrhage, and infections, while the procedure-related mortality rate was significantly increased.

Over the next centuries, there were various improvements in surgical technique and patient perioperative support (anesthesia, blood transfusion, and antibiotics) that essentially reduced the perioperative mortality rate. Nevertheless, the most important advances regarding cesarean section were taken place in the twentieth century.

More historical data regarding procedure and technique evolution over the centuries are presented in different chapters of this book.

3. Epidemiology

Over the last 50 years, cesarean section rates were dramatically increased in low, middle, and high income countries [1, 2]. It is worth noting that worldwide cesarean section rates have nearly doubled over the last 30 years, and there are several reasons for this phenomenon [1, 2]. This dramatical increase represents a major problem for the National Healthcare System of each country with many socioeconomical consequences.

More data regarding epidemiology as well as worldwide trends in cesarean section rates are presented in another section of this book.

4. Indications

The most common indications for primary cesarean section are: labor dystocia, abnormal or indeterminate fetal heart rate tracing, fetal malpresentation, multiple gestation, and suspected fetal macrosomia [3]. Based on their obstetric characteristics, all women having cesarean section can be classified into 10 groups using Robson classification system. This is very helpful for assessing, monitoring, and comparing cesarean section rates in the same Department as well as in different healthcare facilities [1].

More details regarding indications for cesarean section, as well as Robson classification system, are best presented elsewhere in this book.

5. Surgical approaches

In the past, Porro technique and vaginal cesarean has been described in order to reduce the risk for postoperative infections and minimize maternal morbidity and mortality. However, the development of antibiotics reduced the need for such aggressive surgical approaches.

Currently, the most common surgical techniques are: Pfannenstiel-Kerr, Joel-Cohen, and Misgav Ladach. Although, there are many differences among them, they represent a more conservative approach and related with improved postoperative course, quicker recovery, and return to daily activities.

Apart from that in case of uterine myomas and despite of the surgical technique used cesarean myomectomy remains an available option that should be used in carefully selected cases.

More details regarding various surgical techniques as well as cesarean myomectomy are presented in another chapter of this book.

6. Perioperative complications

Based on recent studies, cesarean section is associated with increased risk of severe maternal complications such as: perioperative hemorrhage (requiring blood transfusion or obstetric

hysterectomy), uterine rupture, bladder injury, thromboembolic events, intra-abdominal hematomas, wound infection, anesthetic complications, and prolonged hospitalization [4]. Especially in repeated cesarean sections, there is increased risk for abnormal placental invasion as well as for severe perioperative complications [5–7].

More details regarding intraoperative as well as early and late postoperative complications are presented in a different chapter of this book.

7. Necessary measures

Over the last decades, there is a dramatical increase in cesarean section rates as well as in procedure-related morbidity [2, 4, 5]. Moreover, there are many socioeconomical issues relevant with this phenomenon. However, there is no clear evidence of improved perinatal outcome in all cases having this mode of delivery [1, 5, 8].

In this light, significant efforts should be made in order to reduce cesarean section rates without any compromise on maternal and perinatal outcome. Moreover, vaginal birth after cesarean section remains an acceptable approach in carefully selected cases with the appropriate monitoring and support from a multidisciplinary medical team in well-organized medical centers.

More data regarding future considerations regarding increased cesarean section rates as well as necessary measures are best presented in another section of this book.

8. Conclusion

In conclusion, cesarean section remains a life-saving surgical procedure in our century. However, its importance in daily clinical practice should be reconsidered and the procedure should be performed in carefully selected cases in order to achieve clear benefits on maternal health and improved perinatal outcome [1].

Conflict of interest

I declare that I have no conflict of interest.

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Epidemiology - Indications

Chapter 2

Trends in Cesarean Section

Andres Sarmiento

Additional information is available at the end of the chapter

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Abstract

Cesarean section (CS) is part of the standard of care in modern obstetrics. Its availability, practicity, high acceptance among patients, and the permanent improvement in surgical techniques, anesthesia, blood replacement, and neonatal care have popularized the procedure as a safe and reasonable alternative to vaginal delivery for any individual born in the twenty-first century. Beyond an established recommended rate of 15% for all births, presently the main challenge in obstetrical care is to limit its use to patients that need the procedure in order to keep an adequate perinatal outcome. The rate of CS has been used in many healthcare settings as an indicator of an individual or institutional obstetrical performance. The issue of overuse of CS as a birth alternative beyond clear maternal or fetal indications has received extensive analysis not only from the reproductive medicine point of view but also from neonatal, ethical, financial, and public health stakeholders. Its place in modern obstetrics, and its impact on short-and long-term maternal and neonatal outcomes, health financial budgets, and in public health policies, have positioned CS a mayor issue to take care of in modern medicine.

Keywords: cesarean, perinatal outcome, maternal outcome, cesarean upon maternal request, medical autonomy

1. Introduction

Cesarean section (CS) is part of the standard of care in modern obstetrics. During the last 50 years, institutionalization of delivery pretended to make childbirth a safer event. The wide availability of cesarean section has been intended to favor maternal and neonatal outcomes in certain clinical situations in which vaginal delivery is not a safe alternative. Today, CS is an active part of obstetrical practice with aims to improve clinical performance and perinatal indicators. The indications for a cesarean section as an alternative to vaginal delivery have evolved over the centuries. From remote anecdotal references in the history of medicine, CS

has evolved to be part of the standard of obstetrical care today. Its practicity, disponibility, and apparent safeness have placed CS a first-line procedure in many clinical scenarios.

The rate of CS has been used in many healthcare settings as an indicator of an individual or institutional obstetrical performance. However, the worldwide reported CS rate seems to draw back from the World Health Organization recommendation. Significant variations are apparent between first-and third-world economies, health models, the standard of obstetrical care, reimbursement, obstetrical risk factors, and cultural influences. Other factors related to the type of practice in modern obstetrics have contributed to the popularization of cesarean section: liberalization of the use of a relatively safe procedure under a pragmatic point of view, limited training in instrumented vaginal delivery among the younger generations of obstetricians, optimization of time, minimizing possible legal medical complications, and evident improvements in surgical and anesthetic safety. Finally, new phenomena like acceptance of CS upon maternal request without any medical indications as a valid indication and the loss of medical autonomy in the modern practice of obstetrics will be addressed in this chapter as contributors to changes in CS rates [1, 18].

Over the last decades, obstetrics has evidenced a notorious increase in the rate of cesarean sections. The progressive institutionalization of birth has resulted in evident improvements not only in fetal and neonatal care but also in a growing number of cesarean sections [1]. Trends in rates have evolved in the United States from one digit numbers, 5% in 1970, and into 32.7% for 2014 [1, 6]. Unfortunately, this growing trend has not always corresponded to a warrant of quality improvement in perinatal outcome indicators. This worldwide concerning phenomenon of a growing cesarean rate has been reported and analyzed not only from the perspective of reproductive medicine but also as a neonatal, financial, public health, legal, and ethical issue.

The indications for a cesarean section as an alternative to vaginal delivery have evolved over the centuries. From remote anecdotal references in the history of obstetrics, CS is reported in many clinical scenarios as the most common way to be born.

2. Historical background

CS has been reported throughout the history of mankind. The term "*cesarean*" most probably comes from the Roman term "*caeso matris*," which meant cutting a fetus out of the maternal womb. The law *Lex Regia* (Numa Pompilius-715 BC) or *Lex Cesarea* ordered the fetal extraction out of the maternal uterus in case of maternal death for an individual burial. Jacques Guillemeau (1598) was the first author to use the term "section" to refer to the cesarean intervention as a birth choice.

The main indication for practicing a CS has not always been maternal and fetal health. There are reports of religious indications in ancient Egypt (3000 BC) and in India (1500 BC). The Jewish Mishnah (140 BC) established that for twins, birth by CS for both products had privileges to claim primogeniture. The Council of Colonia (1280) determined mandatory to perform cesarean section when the mother died. In the Republic of Venice (1608), penalties were

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imposed on physicians who failed to make an attempt to save a soul in cases of maternal death. In the United States (1769–1833), it was mandatory for the Franciscan missionaries to have the knowledge and dexterity of how to practice a section [2, 5].

3. The evolution of the cesarean section

Francois Roussette (1530–1603) was the first physician to refer cesarean section as a procedure for living women (Paris-1581: Traitté nouveau de l'hysterotomotokie, ou enfantement caesarien). His report included 10 cases, even though he only participated in six of them since he was not a surgeon. Roussette referred for historical purposes the story of Jacob Nufer (1500), a swine castrator from Switzerland, apparently was the first documented man to perform a successful CS. Elizabeth Alice Pachin, his wife had a prolonged and dystocic labor during her first pregnancy. The intervention of 13 midwives was not successful and Nufer, after two requests to the town's mayor, was authorized to proceed to operate. He performed an abdominal and uterine incision with a blade, extracted the fetus and sutured the abdominal wall. The patient survived and subsequently had vaginal deliveries, including twins. The newborn lived until the age of 77 years [5].

However, cesarean sections as a surgical option in cases of dystocia historically were delayed in the practice of obstetrics due mainly to three elements:

(1) It was a late procedure in a patient already complicated,

(2) Infection, and

(3) Hemorrhage.

Trautmann of Wittenberg (Nurtemberg, Germany-1610) practiced the first medically documented CS in a living woman. The patient died 25 days later due to sepsis. By 1865, the maternal mortality rate secondary to CS practiced for maternal indications was estimated to be around 85% [2, 5].

In the historical evolution of CS practiced for maternal indications, some important milestones for the reduction of complications and increase in survival are: [3, 4].

- The description of a transverse incision technique by Ferdinand Adolf Lehrer (1881).
- Joseph Lister (UK-1860) description of the use of carbolic acid as an antiseptic.
- Eduardo Porro (Italy-1876) practiced the first CS with supravaginal hysterectomy.
- Use of silver and silk sutures for peritoneal closure by Max Sänger (1882).
- Abdominal incision by Hermann Johannes Pfannenstiel (1900).
- CS extra-peritoneal and transverse low by Krönig (1912).
- Munro Kerr (UK-1929) described the transversal incision on the uterine segment.

Later in medicine, the implementation and improvement of surgical techniques, anesthesia, blood transfusion, and antibiotics impacted positively in the performance and prognosis of CS as an alternative option to vaginal delivery.

In 1846, at the Massachusetts General Hospital, the dentist William T.G. Morton was the first to used diethyl ether to operate a facial tumor. Since then analgesia-anesthesia was used for many surgical procedures. However, this did not happen so fast in obstetrics. The belief, according to the Biblical mandate, that women in compensation for Eve's sin should suffer "birth in pain" was popularized. This argument lost value when Queen Victoria of England, head of the English church received chloroform during the birth of their children Leopoldo (1853) and Beatriz (1857) [5].

From 1880 through 1925, several techniques of extra-peritoneal CS and vaginal cesarean were described in order to decrease infection. The need of these techniques disappeared after 1928, with the discovery of penicillin, which became available in 1940.

The CS rate in the United States has changed dramatically during the last 50 years [6, 8].

1970: 5%,

1990: 23.5%, and.

2016: 31.9% (low-risk patients: 26.9%).

Worldwide CS rates have nearly doubled since 1990 (from 14.5 to 27.2%) [11].

In 1985, the WHO stated that the CS should not exceed 15% in any population group [8]. In the last decades, an invariable upward trend has been evident mainly in low-and middle-income countries. China (64.1%), Colombia (46.4%), Dominican Republic (56.4%), Egypt (51.8%), Iran (47.9%), and Brazil (55.6%, 80% for second deliveries) – when the first was by cesarean, are some examples [7, 11, 15].

Among countries of the organization for economic cooperation and development (OECD) the rate varies widely from 45 to 50% (Mexico and Turkey) to 15–17% (Netherland, Sweden, and Norway). In other European countries like France the CS rate has been relatively stable: 20.4% in 2003, 21.1% in 2010, and 20.4% in 2016 [9, 11, 14].

Although CS is widely available, the main recommendation and challenge are to limit its practice to patients that may have a clear benefit from the intervention. Quality assurance in labor and delivery should be part of the standard of care in any clinical scenario and assure a reasonable CS rate.

In 2001, Robson [10] proposed to adopt a standard classification system so that CS rates would no longer be thought of as being too high or too low, but rather whether they are appropriate or not, in the context of all information about clinical variables, including maternal satisfaction. The 10-group classification system (TGCS or Robson classification) is a method that provides essential information regarding common factors for a determined obstetric population where perinatal events and outcomes can be established, measured, compared, and audited.

The 10 Robson classification groups have been thoroughly used by many research groups with the intention to standardize and eventually regulate the CS rate in a specific obstetric scenario.

The 10-group classification system−Robson groups [10]:

1. Nulliparous, single cephalic, ≥37 weeks, spontaneous labor.
2. Nulliparous, single cephalic, ≥37 weeks, induced or cesarean before labor.
3. Multiparous (excluding previous cesareans), single cephalic, ≥37 weeks, spontaneous labor.
4. Multiparous (excluding previous cesareans), single cephalic, ≥37 weeks, induced or cesarean before labor.
5. Previous cesarean, single cephalic ≥37 weeks.
6. All nulliparous breeches.
7. All multiparous breeches (including previous cesareans).
8. All multiple pregnancies (including previous cesareans).
9. All abnormal lies (including previous cesareans).
10. All single cephalic, ≤36 weeks (including previous cesareans).

This system implies that the information collected must be clinically relevant, carefully defined and collected, and timely and permanently available. This information should be used to permanently audit and standardize indications for inductions and to practice cesarean sections. It should be used as a parameter for monthly critical analysis and reference in time and with other obstetrical units. Also, each parameter can be further subdivided for more detailed analysis [10, 12].

In most studies, the main contributors to explain the increase in CS rates are groups 1, 2, and 5 [12].

This classification, however, only takes part of the variables of an obstetric population into account. Important information like maternal age or body mass index (BMI), are not part of the classification.

Although the 1985 WHO recommendation on the CS continues to be a referred indicator in obstetric literature, recent evidence based on demographic differences across the 194 WHO member countries suggest that the optimal global CS rate may be around 20% [13]. In countries like France, that have been successful in keeping CS rates stable, the main difference has been lowering sections before initiation of labor and in women with one previous cesarean section (57.5% in 2010 and 50.2% in 2016) [14].

Other nonmedical factors have also been reported: supply-side demand induction, decision issues related to professional convenience, and optimization of time and predilection for CS in private versus public hospitals [16, 17].

With the inclusion of obstetric protocols of systematic use of prenatal diagnosis and fetal surveillance techniques during pregnancy and delivery, the number of CS secondary to fetal indications has increased. Even though there is no evidence that the universal use of intrapartum

fetal surveillance has had a positive impact on perinatal morbidity and mortality in low-risk obstetric population in the last 30 years, its use is part of the daily routine in any obstetrical ward [16, 29, 30].

Unfortunately, high CS rates are not always correlated to better maternal-fetal outcomes. Several systematic reviews have shown that, although CS can be a truly life-saving procedure in some cases, it's also associated with anomalous short-term immune response in the newborn, and a greater risk of developing immune-mediated diseases such as asthma, allergies, or DM type 1. From a financial perspective, globally, the cost of practicing CS without a clear medical indication has been estimated at $2.32 billion [15, 16].

4. Cesarean delivery under maternal request

An important contributor to the rising trend of CS worldwide, and particularly in Latin America, is the surge of cesarean section upon maternal request (CSMR). The most accepted definition of this indication is a CS performed in an obstetric patient with a singleton, term pregnancy, by maternal request, and with no medical indication [19]. The performance of this surgery without any medical indication has given rise to in-depth medical, legal, ethical, and financial debates, especially when the use of limited health resources is a concerning issue for an elective and frequent procedure [20]. Despite a presumable under-registered data, CSMR is estimated to correspond to 4–15% of all deliveries in the United States. As much as 82% of obstetricians in the United States recognize having performed at least one CSMR [21, 22]. In addition, a high degree of variation in the use of CSMR, ranging between 6% in the United Kingdom and up to 80% of deliveries in Brazil has been reported [23, 24].

Diverse factors including patients and health providers have been reported as contributors to the increase in CSMR. Referred patient factors are fear of pain, a sense of safeness, and confidence, a hypothetic control over a somewhat unpredictable event, and a false perception of a reduced risk of urinary incontinence in the obstetric patient and/or hypoxic encephalopathy in the newborn [25]. Factors depending on medical personal include a pragmatic view of birth, efficiency in working time, and finally a hypothetical avoidance of medical and legal complains. Advances in surgical and anesthetic protocols may also be important issues in safety matters [26].

Presently there is controversy deeming the safety of CSMR for both, the mother, and the neonate. A summary of the evidence was presented by the United States National Institutes of Health, referring that CSMR might be associated to a diminished risk of bleeding or need for transfusion, and a lower risk of trauma and organ damage. However, there is still uncertainty about the short-term impact of CSMR on perinatal outcomes, as well as in future pregnancies [26]. Direct evidence about the risks of CSMR, particularly when compared to cesarean sections, is limited.

On behalf of these facts and since the evidence to recommend or ban the practice of CSMR is mostly based on retrospective analyses, our group realized a 4-year period research study based in our hospital obstetric low-risk population [18]. Our objectives were to compare, in

a prospective observational setting, the following results: (a) multiple maternal outcomes among low-risk women who intended to have CSMR versus vaginal delivery, and (b) multiple neonatal outcomes derived from the same obstetric population. We hypothesized to find the different frequency of maternal and neonatal outcomes between CSMR and vaginal deliveries in our low-risk obstetric population.

We developed a prospective observational study that included obstetric patients aged 18–45 with low-risk term pregnancies that delivered at our hospital. Previous board ethical committee approval, patients requesting CSMR were individualized to receive further information, after what all of them signed an information consent form before being admitted to the study. The presence of any of 5 pre-specified adverse maternal outcomes and of any of 17 pre-specified adverse neonatal outcomes was compared between CSMR and vaginal births. Induced vaginal births were analyzed separately. All recruited patients were offered the same standard of medical care. The effect of confounders was adjusted using multivariate logistic regression. The demographic characteristics of our participants showed healthy, actively working women, mostly in their early 1930s, married, and with private health insurance coverage, who presented for delivery with a term, low-risk pregnancy.

The study incorporated 214 patients with CSMR, 341 with spontaneous vaginal delivery (SVD), and 376 with induced vaginal delivery (IVD). Relative to the spontaneous delivery arm, the multivariate-adjusted odds ratios for adverse maternal outcomes were 0.21 (95% CI: 0.05–0.97) in the CSMR group and 0.93 (95% CI: 0.42–2.06) in the IVD arm. The multivariate ORs for adverse neonatal outcomes were 0.59 (95% CI: 0.36–0.93) for CSMR and 0.84 (95% CI: 0.59–1.21) for IVD. The frequency of hospital admission for the newborn was lowest in the cesarean delivery group (10.3% compared to 15.8% for spontaneous deliveries and 16.2% for induced vaginal deliveries).

Our preliminary results suggested that among low-risk pregnancy patients that received a standardized obstetric care protocol, CSMR was associated with a lower rate of adverse perinatal outcomes when compared to spontaneous vaginal delivery. Due to our limited number and type of population additional studies are needed to assess the long-term safety of CSMR.

Despite that all three groups were very similar at inclusion we found a lower absolute rate of adverse maternal and neonatal outcomes among obstetric patients who chose CSMR over a vaginal delivery. Furthermore, when the effects of variables with the highest potential were adjusted to be considered confounders, this result continued to be significant, in some cases yielding even lower estimates of the odds ratio. Despite the perception that cesarean sections implied longer hospitalizations, the absolute difference in the total days of hospital admission between the CSMR and spontaneous vaginal birth groups was on average 0.5 days, a difference that has minimal clinical implications.

In the same way, the rate of primary neonatal poor outcome was also lower for the CSMR group, a difference that also persisted after correction with multivariate models. We consider this a noteworthy result since multiple related adverse neonatal outcomes were identified and registered. Moreover, newborns from CSMR women were admitted significantly less and had slightly higher APGAR scores than those born vaginally. Stunningly, our results

disagree with those of the WHO Global Survey on Maternal and Perinatal Health [27]. In their report, cesarean sections were associated with an increased risk of severe adverse maternal outcomes. An explanation for the result discrepancy may be the fact that in the WHO study as in many others, elective and emergency, term and preterm, low and high risk, cesarean sections have been included for analysis as a single group.

We recognized a low rate of obstetric hemorrhage requiring blood transfusion in all groups (0.3% in spontaneous vaginal, 1.3% in induced vaginal, and 0.5% in CSMR). In a retrospective review of more than 400,000 births, Holm et al. found a lower risk of severe post-partum hemorrhage with CSMR in both nulliparous patients and in those with a previous cesarean section [28]. There is evidence that the frequency of hemorrhage and obstetric shock is generally lower with elective sections, and that the overall risk of blood transfusion is low, except when associated with antepartum established anemia and placenta previa. In a Canadian population-based revision of vaginal delivery versus cesarean section practiced for breech presentation, maternal morbidity was similar between groups, but neonatal morbidity was lower among babies born by cesarean [20]. In the same way, in a retrospective analysis of almost 30,000 deliveries in the United States, the incidence of persistent pulmonary hypertension was 3.7/1000 live births among neonates born by elective section, but only 0.8/1000 live births among neonates delivered vaginally [22]. Part of the inconsistency among results from different studies may be explained in association with the role of gestational age as a confounding factor. This is shown by the fact that when elective cesarean sections are performed after 39 weeks, clinical variables of neonatal respiratory morbidity are not increased compared to vaginal delivery [23].

Our results seem to point out that under specific optimal low-risk obstetric population conditions, CSMR may be a clinical procedure with an equivalent impact on both mother and neonate compared to vaginal birth.

The main assets of our study embrace its prospective nature, the cautious and widespread documentation of outcomes and covariates, and the use of homogeneous high-quality care protocols that allow to better evaluate the advantages and disadvantages of each mode of delivery.

In contrast, our main methodological drawback lies in the undersized postpartum follow-up, which does not permit us to evaluate long-term postpartum complications. CSMR may be associated with numerous potential risks, which can be classified as immediate, late, and long-term. We did not find an added incidence of short-term risks (infection, hemorrhage, intra-operative genital/urinary lesions, other intra-abdominal complications, and anesthetic risks or death). However, we cannot rule out late (thromboembolic disease, prolonged recovery, hospital readmission, adhesions, and incisional hernias) or long-term (abnormal placental implantation, uterine scar dehiscence/rupture, hysterectomy, infertility, early fetal loss, ectopic pregnancy, and intrauterine growth retardation) complications in these patients. Undouble, extended prospective studies are needed in order to validate our results.

In conclusion, in this prospective investigation that only included the term, low-risk pregnancies of women with a very specific demography and chosen with strict inclusion criteria, CSMR was associated with a lower rate of adverse perinatal outcomes for both mother and newborn, compared to vaginal birth. While these results may look promising, this evidence

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must not be used to suggest or advice CSMR as a first line alternative for childbirth. Our results have been used to launch a formal protocol in our hospital for cases of CSMR and to accurately inform our patients about birth options; their respective short-and long-term complications are a critical element in the consent form. In our hospital, all patients that request a CS are individualized for counsel and further information. It has discouraged hospital under recording of CS indications, has contributed to the exactness of surgical indications on medical records and has turned a previous individualize practice into a controlled institutional protocol of medical attention that is permanently audited and followed up. Also, this model has endorsed us to keep low indicators of maternal, neonatal, and anesthetic complications without a negative impact on financial issues.

5. Loss of medical autonomy as a factor affecting CS

Medical autonomy is understood as the self-determination of professional behaviors, according to individual values based on professional ethics, supported by the best available scientific evidence, giving priority to the interests of the patient, and without external interference or coercion. The modern concept of autonomy is based on the ideas of Kant (1788), according to which morality is based on consciousness and reason as the fundamental elements and "what man should do" [31].

On the other hand, the profession as a work activity derives its name from "professing" or declaring society a commitment to behavior.

Medicine as a profession is based on four fundamental elements:

(1) missionary and vocational activity,

(2) knowledge and expertise,

(3) an ethical code of behavior, and

(4) self-regulation.

In the twenty-first century, professional autonomy is articulated by three factors such as:

(1) self-assessment and self-regulation of medical practice,

(2) responsible use of technology, and

(3) financial factors.

These three factors cannot conflict with the element of quality of care.

Under this frame of reference, the behavior of the cesarean rate can be a magnificent example of the loss of medical autonomy in certain practice scenarios. The exercise of modern obstetrics within the current social paradigms becomes a very complex task. Modern times have imposed as a fundamental principle the fact that "time is money" for which we always live in a hurry, there is no time for communication or patient medical relationship, moral relativism, and pragmatism of behavior predominates. Thus, although birth is a profound and powerful

human experience and for women generates feelings of empowerment, success and personal achievement, the excessive increase in the cesarean rate is a consequence of the medicalization of birth and a change in attitude of the patient and the doctor within the new social model that undoubtedly impacts professional practice.

Undoubtedly, any of the above may have a medical field of discussion in the indication and relevance; however, the last two are the ones that generate great controversy today due to the laxity in its acceptance, its underreporting in the clinical history, and ethical considerations in your practice. The rate of CS in Colombia reached 46% in 2014, moving further away from the universal recommendation of 15% of the WHO. Having a preference for its practice in specific geographical areas where it can reach percentages greater than 70% and with a clear predilection for private institutions.

Medical autonomy is being affected by a series of factors that threaten the full exercise of obstetrics. Optimization of time, remuneration, disinformation of the patient with inappropriate use of their autonomy, fear of legal medical suits, the misuse of medical technology, therapeutic pragmatism, and finally poor medical training with limitations in the expertise of the care of the vaginal delivery. In addition to these factors that undermine medical autonomy, others that can contribute to understanding this phenomenon are the aforementioned loss of the physician-patient relationship, the model of medicalized care, demographic changes (the role of women in today's society), the standard of obstetric care with the programming of birth, and the negative perspective about the vaginal delivery that new generations of patients and obstetricians have.

A separate mention deserves the media who have contributed through inaccurate information or decontextualized cultural and social myths about supposed benefits of surgical delivery that feed a social behavior that tends to be replicated.

Highlighting the value of informed consent, explained and discussed with the patient in a quiet environment during prenatal care and never on the scenario of a delivery room, is that it rationalizes the decision, informs objectively, and allows the patient to choose the right decision, which is not always the easiest.

Proposals for intervention to regain medical autonomy in obstetric practice:

1. Institutionalization of obstetric care: follow-up indicators and protocols,
2. Health team practice supported by midwives,
3. Training of residents and health personnel,
4. Rational use of methods of fetal surveillance,
5. Routine use of informed consent,
6. Patient education,
7. Permanent availability of analgesia and anesthesia,
8. Individualized care of cases of CS by maternal request,
9. Vaginal delivery as a public health policy, and
10. Working with the media.

Medicine is a moral activity, exercised by individuals who adhere to a code of behavior. Medical autonomy should be the result of the balance of the factors that affect the practice. Trust is the fundamental principle of medical professionalism and the basis of the social contract between the obstetrician and the society [32].

6. Conclusion

The indications for the cesarean section have changed throughout history. They have been shaped by religious, cultural, economic, professional, and technological reasons that have impacted medicine. CS originated as a precept for saving the soul, if not the life of the fetus. From the nineteenth century, it changed to save the obstetric patient. Finally, since the end of twentieth century, Western obstetric medicine has focused on the maternal and fetal benefits of the procedure. In the last 30 years, the fetal indications of the procedure have triggered its frequency with a definite impact on the model of modern obstetric practice.

Attempts to reduce CS rates in underdeveloped countries have not been efficient. Its place in today's obstetric practice, its impact on short-and long-term maternal and neonatal outcomes, health financial budgets, and in public health policies, has positioned CS a major issue in modern obstetrics.

Our goal as health providers is to assure that CS is practiced on patients and neonates that will benefit from it. Women should be adequately informed and brought into the conversation about the benefits and disadvantages, both short and long term, of birth by cesarean delivery [13].

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Chapter 3

Value of Caesarian Section in HIV-Positive Women

Simona Claudia Cambrea and Anca Daniela Pinzaru

Additional information is available at the end of the chapter

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Abstract

The international main goal is to reduce mother-to-child HIV transmission. The appropriate birth delivery for seropositive woman has been analyzed since the beginning of the twenty-first century. Although at the beginning of HIV pandemic delivery by caesarian section (C-section) was considered mandatory in many studies and meta-analyses, recent information reveal limited benefits. Mother-to-child transmission is higher when mothers are diagnosed late during pregnancy, in advanced stages with a high HIV viral load, and labor with membranes ruptured for more than 4 h, especially when the antiretroviral treatment is not respected. During vaginal delivery, the risk of HIV transmitting to infant is due to microtransfusions during uterine contractions or by newborn exposure to cervicovaginal secretions or blood. Although the indication of C-section in HIV-positive women is controversial, there are some situations in which C-section remains mandatory. In mothers diagnosed late during pregnancy, in situation in which HIV viral load is not affordable in real time in the last trimester of pregnancy, and in mothers with poor adherence to antiretroviral treatment, C-section remains one of the most important measures of prevention for HIV mother-to-child transmission.

Keywords: HIV, delivery, C-section, newborn, HIV viral load

1. Introduction

Human immunodeficiency virus (HIV) continues to be an important European public health problem, especially in low-to-medium income countries, such as Romania. UAIDS declared in 2016 between 6100 and 7500 women aged 15 and over as being diagnosed with HIV in our country [1]. The medical system crisis and poverty are the two most important reasons of remaining underdiagnosed. Therefore, the unofficial number is much higher. Worldwide the number is significantly higher.

Pregnancy in HIV-positive females is a challenge due to its risk and fatal complications.

Mother-to-child transmission is particularly analyzed in preventing HIV spreading. The type of birth management in HIV-positive women makes the difference between healthy infants or future new HIV infection sources. Assessing the risks and benefits of every type of birth should be analyzed at the beginning of every pregnancy [2].

The proper method of delivery in HIV-positive female has been analyzed since the beginning of the twenty-first century [3]. Villari et al. in 1993 elaborated an important meta-analysis about six cohort studies regarding the elective caesarian benefits in HIV females. It underlined only a slight effectiveness of C-section in reducing vertical HIV transmission [3, 4]. Until 1999 the international literature was uncertain. A randomized clinical study providing certain information regarding the necessity of selective C-section in preventing HIV transmission was published [5].

In undiagnosed women the vertical transmission is evaluated at 30%. The risk could be higher, depending on the disease evolution/stage and treatment effectiveness [6].

Vaginal birth could lead to newborn infection, increased mortality, and morbidity, especially in undiagnosed or untreated females [6, 7]. To minimize the transmission risk, elective caesarian section (before labor settles or membrane ruptures) is considered the most important method [3].

A scheduled C-section, for the 38th week of pregnancy, to prevent mother-to-child transmission is recommended in women with unknown of high viral load near the delivery time [8]. HIV-positive pregnant women should start their antiretroviral treatment as soon as possible for their own health and to protect their baby [8].

2. Etiology

HIV could be induced in humans by two entities: HIV-1 (with three representative groups: M, major; O, outlier; and N, new) and HIV-2, both from the Retroviridae family. The enzymatic proteins and the most part of the structure are encoded by three genes (gag, pol, and env). HIV-1 is the most frequent. Regarding the expression and infectious release of the virus, there are other six genes involved (regulatory = tat and rev and accessory: vif, vpr, vpu, and nef). On the host cellular membranes, the envelope glycoprotein has contact with CD4, CD1, and CD2 major receptors. HIV-1, a RNA virus, during its replication, enzyme called reverse transcriptase transformed it into a DNA virus. Viral DNA is integrated as proviral DNA. Then, during transcription, proviral DNA is transformed in mRNA, which during translation synthesize immature viral proteins. Assembly viral proteins create mature viral particles and then during budding the new viral particles will be release and they will infect the new cells. HIV-2 is less encountered as HIV-1. It has a slower clinical course, but the outcome is similar to type 1 [9–11].

The key of infection with HIV is cellular dysfunction, humoral immune dysfunction, and aberrant lymphocyte turnover [9, 10].

The male-female ratio in acquiring HIV infection is 2:3, due to women particular anatomy. After unprotected sexual intercourse, envelope glycoprotein gp120 with the infected particles remains on mucosae surface for a period. Langerhans cells from the cervix have an important

affinity for some types of HIV serotypes. The lack of medical education or poverty could interfere with periodical gynecological examination. Females may present multiple entry points for HIV infection, such as ulceration or inflammation of the vaginal mucosae facilitating the entry and multiplication of the virus. Cofactors of transmission are considered the other sexually transmitted diseases (chlamydia, syphilis) [12–15].

Cultural or religious beliefs could make the women an easier target to sexually transmitted infections. In some communities women are discriminated, are not included in healthcare programs, and do not undergo to periodical gynecological examination. In some situation, women are regarded as "sinners" and blamed for being ill. Social status sometimes prevents women in asking and receiving proper treatment [12–15].

Due to poverty or sexual inequality, women are involved in illicit commercial sex work. Promiscuity is the main reason in HIV explosion, especially in poor, uneducated environments [15].

3. Epidemiology and risk factors

HIV pandemic has been intensely epidemiologically analyzed. The main purpose was to determine the viable method on reducing mother-to-child transmission. Since the beginning of the twenty-first century until the beginning of the twenty-second century, discussing the more effective method of birth offered contradictory data. In 1999 a European clinical trial underlined the benefits of elective caesarian section in transmitting vertical HIV [5, 11].

HIV could be acquired during blood transfusion or contact with contaminated fluids, dental extractions, vertical transmission, or unprotected sexual intercourse. It is one of the most severe sexually transmitted diseases.

Vertical transmission could occur before or in different stages of pregnancy or postpartum. Pregnancy, labor with membranes ruptured for more than 4 h, infected blood contact or cervicovaginal secretions, and breastfeeding are key points in preventing HIV. Premasticated food could be another method of contamination. In undiagnosed women, the vertical transmission is evaluated at 30% [6, 10].

Infants born from seropositive females should be tested immediately after birth, at 14–21 days, 1–2 months, and 4–6 months. International guidelines recommend viral assay—HIV RNA and HIV DNA. Detection of antibodies is not recommended in children less than 12–18 months due to the presence of residual mother's antibodies. Mothers diagnosed after birth or incompliant to treatment or with high viral load have a higher risk of HIV transmission. Their infants must be tested at 2–4 weeks from caesarian delivery or antiretroviral prophylaxis. At infants the positive diagnosis is established based on two consecutive positive virologic assays (>1 month and >4 months of life). In children >12–18 months, the HIV antibody tests will be used [16].

HIV genomes had been discovered in different fractions of human milk; therefore breastfeeding should be forbidden. Breastfeeding is not allowed even in women undergoing retroviral treatment because the infected genome could still be present. Replacement formulas are the recommended alternative. If the mother already breastfeeds the infant, without knowing

her health status, it is recommended to begin of prophylaxis. Infants born from HIV-positive mother are tested in the first 4–6 weeks of life. Complementary food is offered at 6 months, according to international guidelines [10, 11].

During vaginal delivery, the risk of transmitting HIV to infant is due to microtransfusions during uterine contractions or to exposure to cervicovaginal secretions or blood [3].

Risk factors in HIV vertical transmission were:

- Maternal viral load (a higher viral load reflects a lower CD4 T lymphocyte, therefore a more advanced clinical stage).
- Period of exposure (undiagnosed before or during the pregnancy, vaginal birth with labor and membranes ruptured, breastfeeding).
- Treatment compliance (incompliant mother to antiretroviral treatment has a higher viral load).
- Mother's nutritional and clinical status.
- Type of delivery, preterm delivery; membrane ruptures more than 4 h.
- Breastfeeding, premasticated food.
- Behavioral attitude [15].

The actual data sustain that vertical transmission could be encountered at any maternal viral load, but the risk is lower <1000 copies/ml. The risk is higher when CD4+ count is under 700/mm^3 [9, 15].

Establishing the exact moment of contamination is essential in minimizing the risk of vertical transmission. The longer the mother is left untreated, the higher the risk of transmission to her child. In utero contamination had been observed after histological analysis of fetal or placenta tissue. The presence of p24 antigen in fetal tissue represents in utero transmission of the HIV infection [15].

In mother-to-child transmission, the minimum period until clinical manifestations are present is between 12 and 18 months. However, exceptions are frequently encountered, but rarely the diagnosis is established in adolescents [10].

4. Pregnancy planning in HIV-positive women

HIV-positive women are as fertile as healthy ones. The difference is made by the impact of the active virus on the female organism. Therefore, subfertility, underweight, associated diseases (sexually transmitted diseases, respiratory infections), and illicit drug abuse are the reasons of fertility problems or abortion in this social category [17].

HIV-positive women should be guided through a correct contraceptive method (male or female condom, diaphragms, vaginal cups, progesterone injections, transdermal implants,

and intrauterine devices). An important discussion subject is represented by the effectiveness of every contraceptive method. There are still uncertain data regarding oral or injectable contraceptive. International studies have not established exactly a connection between hormonal changes—vaginal flora—and mucosae modification and an increased risk of HIV transmission. The Mombasa study underlined a higher predisposition of HIV infection in women undergoing oral or injectable contraceptive therapy, but Beaten et al. in a different cohort could not establish a certain connection. Mombasa study revealed that other sexual transmitted diseases (chlamydia) had a higher incidence and the viral load was higher [17–20].

The international guidelines underline the necessity of thorough blood evaluation in women who desire to conceive before pregnancy. The same indication is recommended to male partners. The purpose is to eliminate any transmitted diseases to the future child. HIV diagnosis as early as possible before pregnancy or during pregnancy leads to a proper antiretroviral treatment and a close follow-up, reducing the risk of vertical transmission [21]:

Step 1: Complete medical checkup for both parents. Viral load determination is essential.

Step 2: Establishing the correct antiretroviral treatment. Respecting the doses and clinical follow-up.

Step 3: Gynecological evaluation, ultrasound, and cervicovaginal cultures should be done periodically, as the medical team recommends.

Step 4: Discussing and analyzing the prober birth method to prevent or minimize mother-to-child HIV transmission.

5. Pregnancy evolution in HIV-positive women

HIV infection is characterized by cellular and immune dysfunction and aberrant lymphocyte turnover. Pregnancy is regarded as period of decreased immunity due to reduced levels of immunoglobulin or complement. Viral load remains the main tool of viral turnover. Concerns were induced by the impact of pregnancy on HIV progression. Evidence of pregnancy influencing the HIV evolution was noticed in untreated patients or in advanced/complicated stages of disease. Bordeaux University Hospital (France) issued a prospective cohort study on 57 pregnant women that are HIV positive. It revealed that pregnancy had not influence the natural immunosuppression evolution [15, 17–19, 22]. Madeline Y. Sutton et al. analyzed the immune response (Interleukin-2 low levels secondary determines CD4+ T lymphocyte levels to drop exposing the HIV-positive organism to opportunistic infection) at HIV patients. Sixty-one women were divided in four large groups: 39 pregnant women (20 HIV positive and 19 HIV negative) and 22 nonpregnant equal HIV positive and negative. There were some differences regarding IL-2 production between HIV-positive and HIV-negative pregnant women, but during the third trimester, the differences were insignificant. Therefore, pregnancy does not influence the natural evolution of HIV [15, 22–24].

Preexisting diseases in HIV-positive women could alter the natural pregnancy evolution. Tuberculosis or other pulmonary infections (*Pneumocystis carinii*), urinary tract infections, and parasite infections (*Toxocara canis*) should be mandatorily evaluated or registered in the

personal history of the patients. Immunosuppression induced both by the HIV and pregnancy could lead to certain complications that are life-threatening for the mother and fetus [15, 25].

Tuberculosis is considered the most frequent coinfection in seropositive females. Halichidis et al. presented a case report of a 21-year-old pregnant HIV-positive female presenting at admission severe infection signs (fever, right cervical and submandibular painful adenopathy persistent, dry cough). After sputum analysis it established the diagnosis of acute miliary TB. Adequate therapy for both pathologies was implemented. Mother refused abortion, the treatment, and admission. After 20 days she was again admitted but with more severe symptoms. After undergoing emergency caesarian at 30 weeks, she gave birth to a male child (1000 g, small for gestation age) who lived 5 days. One week later the mother died. After biopsy the following diagnosis was established: acute disseminated miliary TB with meningoencephalitis, tuberculoma of the brain, pulmonary edema, acute interstitial nephritis, cardiomyopathy, and atrophic gastritis. The association between these two pathologies has a poor prognosis. It affects the mother and the child; furthermore the drug therapy side effects are multiple and could lead to morbidity or mortality in a high percentage [26].

Spontaneous abortion is higher in HIV seropositive women than in healthy population. It is link to opportunistic infections, anogenital contamination with other sexually transmitted diseases, drug abuse, smoking, and alcohol use [25].

HIV infection can predispose the human host to opportunistic infections and comorbidities. Reitter et al. evaluated 312 pregnant HIV-positive females (Frankfurt HIV cohort) and monitored them over an 11-year period. Complications encountered gestational diabetes mellitus, preeclampsia, and preterm delivery [27].

The type of delivery is also influenced by coexisting urogenital infections. HIV-seropositive females come from promiscuous environments, with unprotected sexual activity, poverty, and lack of medical healthcare systems or medical education. HIV induces an important immunosuppression predisposing to severe forms of sexual transmitted diseases, especially trichomoniasis, gonorrhea, syphilis, and bacterial or fungus vaginitis. The risk of coexisting infections is the same as in healthy women, but its evolution is more severe making it difficult to be eradicated. Group B *Streptococcus* dominates bacterial urogenital infections. Preinvasive lesions such as different types of neoplasia or inflammatory pelvic disease could be tied to the immunosuppression. Evaluating CIN incidents in 305 HIV-positive females, Ahr et al. underlined its higher prevalence than in healthy women. Human papilloma virus is the frequent responsible agent [24, 28, 29].

A Romanian study evaluated 98 unpregnant HIV-positive female undergoing antiretroviral therapy for cytological modification. Babes-Papanicolau test was performed to determine if there was a connection between immunosuppression and cervical lesions. 73.58% had cervical cytology abnormal results, estimating that squamous cell lesions in seropositive females with peripheral viral load lower than 500 cell/μl are more often encountered than in healthy population ($p < 0.02$) [30].

Preterm delivery (<37 weeks) and premature birth are two important risk factors in transmitting HIV from mother to child. Kjersti et al. analyzed 219 seropositive pregnant women from

Birmingham. It concluded that under the antiretroviral treatment and preterm delivery with ruptured membranes over 4 h, the risk of vertical transmission is minimal. Only two infants whose mother did not receive antiretroviral therapy were seropositive. To reduce to zero, the risk of HIV transmission from mother to child, elective caesarian is the proper attitude [15, 31].

6. Antiretroviral therapy

The main purpose of antiretroviral therapy is to minimize the transmission and to decrease HIV evolution. Diagnosis timing is essential. Seropositive women antepartum should undergo strict blood count and antiretroviral therapy. Intrapartum or postpartum HIV infection benefits on the same medical steps, underlining that the second category could have a better evolution if the diagnosis is established soon after contamination. Seropositive female may present antiretroviral resistance and lower CD4+ levels [32, 33].

Establishing the correct antiretroviral therapy should be guided by:

- Age of the mother and immunity/clinical status
- Treatment compliance
- Comorbidities associated
- HIV viral load
- Possible teratogenic effects [32, 33]

The goal of antiretroviral treatment during pregnancy is to drop viral load to undetectability and to maintain it. Secondary risk of transmitting HIV to fetus is minimum. Through the placenta, the antiretroviral drugs are transported to child. In year 2005, in France, a prospective multicenter perinatal cohort, evaluated 8075 HIV+ mother/infant couples over a period of 11 years. Mothers received treatment during pregnancy, they did not breastfeed and viral load was determined. It concluded that the risk of vertical transmitting HIV is zero if antiretroviral therapy is started before pregnancy and the viral load is suppressed [33, 34].

Establishing the moment of HIV contamination is essential in preventing mother-to-child transmission. An English retrospective multicenter cohort study (Read et al.) evaluated 378 pregnancies undergoing retroviral therapy. After analyzing age of gestation, the start of drug therapy, CD4+ count, and viral load, it underlined the following data: if the viral load was under 10,000 copies/ml until a gestational age of 26.3 weeks, the purpose to achieve 50 copies/ml could be reached. When the viral load was more than 10,000 copies/ml before 20.4 weeks of gestation, the purpose to obtain less than 50 copies/ml until birth was compromised. The level of 50 copies/ml was obtained in 292 pregnancies from a total number of 378 [35].

Zidovudine (dideoxynucleoside reverse transcriptase inhibitors) is the most used antiretroviral drug during pregnancy. Even if there are other types of dideoxynucleoside reverse transcriptase inhibitors (didanosine, zalcitabine, stavudine, lamivudine) with the same action

mechanism, they are differentiated by the intracellular phosphorylation and kinetics which lead to other types of side effects/toxicity [36].

Conner et al. evaluated 477 pregnant women seropositive undergoing antiretroviral therapy with zidovudine (antepartum, 100 mg, orally for 5 days; intrapartum 2 mg/kg intravenously until birth). The infant received Zidovudine as well (2 mg/kg, orally for 6 weeks daily). The conclusion is the reducing risk of vertical transmission by 2/3 (70%) of the cases [15, 32, 33, 37].

7. Caesarian vs. natural birth

At the beginning of the twenty-first century, international study tries to evaluate the adequate pathways to minimize the risk of mother-to-child transmission. In an epidemic period in low-income countries, death prevalence due to HIV was increasing.

Previous study results had yield contradictory results. Caesarian section after 4 h since the membranes are ruptured could lead to microtransfusion with mother's blood to fetus, increasing the risk of HIV transmission. Ignoring the antiretroviral treatment or late diagnosis made it difficult to affirm that caesarian section could or would drop the risk of HIV transmission [2, 38–40].

The idea of caesarian as method of reducing the risk of transmitting started in France. Duliege et al. observed that in twin pregnancies, the first child to be born has a higher risk of being infected than the second child. One hundred and fifteen twin pairs from HIV-positive females born vaginally or through caesarian section had developed HIV in the following order: vaginal birth, twin A 35% and twin B 15%, and caesarian section, twin A 16% and twin B 8%. The first born from vaginal birth is passing through birth canal in a longer period that the second one. Caesarian section eliminates the risk of contact with blood and vaginal secretions. The main conclusion was that caesarian is a safer method to give birth, preventing the mother-to-child transmission of HIV [36, 40].

International Perinatal HIV Group after analyzing 8533 mother-child pairs established that delivery through caesarian section dropped the risk of HIV transmission with 50% compared with other types of delivery. The percentage was even higher if the seropositive female followed antiretroviral therapy correctly. The combination antiretroviral therapy plus caesarian section before or shortly after membrane ruptures had dropped the transmission with 87% [3].

European Mode of Delivery Collaboration in 1999 after evaluating 370 infants from mothers without any type of delivery indication underlined an 80% reduction of the risk of transmitting HIV in females who gave birth through elective caesarian section [5].

American College of Obstetricians and Gynecologists recommended caesarian section as a prompt intervention in diminishing the mother-to-child transmitting HIV, especially when the peripheral blood count is greater than 1000 copies/ml. The intervention should be established at exact 38 weeks (1 week earlier as in healthy pregnancies), preventing labor or ruptured membranes. Viral load would be analyzed at every 3 months or every time the therapy is changing. Amniocentesis should be avoided in HIV pregnant women [41].

8. Personal contribution

Romania continues to have a high percentage of HIV infection. In June 2017 UNAID reported a total number of 9074 seropositive women. Data were collected between 1985 and 2017. The group age 15–39 years is presenting the higher incidence—2147 cases. Regarding mother-to-child transmission, there were 480 cases reported [42].

We conducted a 10-year (January 2008–December 2017) retrospective study on 203 pregnant seropositive women, ages between 15 and 41 (average age 24 years), under surveillance at the Hospital for Infectious Diseases, Constanta County. The HIV rate of transmission was 5.8%. From all HIV-positive children, 11 were birth by vaginal delivery and just 1 by caesarian section.

The main purpose was to establish new ways of preventing mother-to-child transmission and to encourage HIV testing as a normal routine screening during pregnancy, even in healthy women. Health status was compromised in all females included in evaluation; 100% had anemia (laboratory inferior limit is 11.7 mg/dl); 32 had values under 8 mg/dl. Coinfection with human papilloma virus (14) and toxoplasmosis (1) was detected in 7.02%. During the third trimester, only four women had undetectable peripheral blood viral load. Levels of CD4+ had values under 500 copies/ml in 116 cases. The HIV stage during pregnancy had been A1, 14 cases; A2, 15 cases; A3, 2 cases; B1, 16 cases; B2, 26 cases; B3, 5 cases; C1, 40 cases; C2, 51 cases; and C3, 27 cases. Seventy-five percent underwent triple antiretroviral therapy, 20% double, and 3% single, and 2% have never received treatment.

Not all patients had reported to the scheduled evaluation; therefore, only in 188 pregnant seropositive females we collected concrete data. Delivery management was divided in caesarian 160 cases and vaginal birth 28 cases.

Analyzing our patients regarding coinfections, we noticed one HIV pregnant women with syphilis, other three with genital warts, six with HCV, and 24 with HBV.

Caesarian section was elected in 28 seropositive women with HCV or HBV coinfection. Two HIV-positive women with coinfection elected vaginal birth. All 30 children were healthy with no viral infections. Caesarian was elected as the proper method of delivery in genital warts and syphilis coinfection. In order to minimize the risk of syphilis transmission, the newborn and mother received Penicillin G treatment. After receiving the correct treatment, mother and child were declared healthy.

In eight cases children were breastfed after delivery. One was HIV negative and the other seven were HIV positive.

As we analyzed in the previous discussions, preterm delivery is frequently encountered. In our study in 60 cases, the delivery was under 37 weeks. Fifty four had weight under 2500 g (the normal inferior weight limit), 28 were preterm, and 26 were declared small for gestational age (it represents the infants born over 37 weeks but with weight under the inferior normal limit). Nine mothers had died due to HIV complications and lack of treatment compliance, after a medium period of 32 months after birth. Nine infants had died (one at 1 day,

one at 12 days, four at 1 month, two at 27 months, and one at 7 months). In eight cases of vaginal birth, the infants' viral load was >10,000 copies/ml. In caesarian section the medium viral load was <50 copies/ml. In two cases we encountered values over 500 copies/ml. In those two situations, mother presented vaginal coinfections, and compliance to treatment is doubtful. In four cases infants were breastfed; three of them were born vaginally, and their mother even if they underwent triple antiretroviral therapy had peripheral viral load over 10,000 copies/ml.

In a study performed between January 2008 and August 2013, we analyze 124 HIV-positive mothers and their newborns. In the studied period, the maternal-fetal rate of HIV transmission was 4.8%.

The mortality rate for children was 5.6% and for mothers was 7.2%. Around 97.5% of the children received antiretroviral treatment after birth, and 93.1% of the mothers received antiretroviral treatment during pregnancy.

The proper health status evaluation in children is by growth charts. It provides information regarding the weight, length, and cranial perimeter. In this study, 22.76% were under the tenth percentile for length and weight, underlying the improper development during in utero life—small for gestational age. In 11.38% we encountered a symmetrical intrauterine delay, represented by weight, length, and cranial perimeter positioned under the tenth percentile.

In this study, we performed a linear regression to find if some parameters of the mothers correlate with difficulties in intrauterine growth appreciate below the level of tenth percentile. We found that the cranial perimeter of children under the percentile of tenth correlates with the hemoglobin value in pregnancy ($p = 0.027$), the CD4 value in the last trimester of pregnancy ($p = 0.003$), and the Apgar score ($p < 0.0001$). The weight of children under the tenth percentile correlates with the CD4 value in the last trimester of pregnancy ($p = 0.011$), as well as the Apgar score ($p < 0.0001$). The height of children under the percentile of tenth correlates with the hemoglobin value in pregnancy ($p = 0.05$), the CD4 value in the last trimester ($p = 0.05$), and the Apgar score ($p < 0.0001$). In this study cART duration in pregnancy, duration of gestation, type of delivery (C-section or vaginal delivery), and HIV viral load value do not influence the newborn parameters: weight, length, and cranial perimeter related with tenth percentiles of growth.

Intrauterine growth restriction is often encountered in seropositive females. Our data are sustained by the international literature. Cailhol and Dreyfuss obtained the same results [43–45].

The study performed on 124 children (66 males and 58 females) underlined a mean hemoglobin level of 10.37 mg/dl in male children, with a 1.33 mg/dl standard deviation. In female children, the mean hemoglobin was 10.32 mg/dl with a standard deviation of 1.32 mg/dl (**Figure 1**).

There are significant differences between the mean hemoglobin values of the two groups [$p = 0.196$; $df = 122$; $p = 0.845$; the 95% confidence interval (IC) for the average is (−0.42; 0.51)].

The mean CD4 value in male children was 421.15 cells/mmc with a standard deviation of 27.83, and in female children, the mean CD4 was 414.46 cells/mmc with a standard deviation

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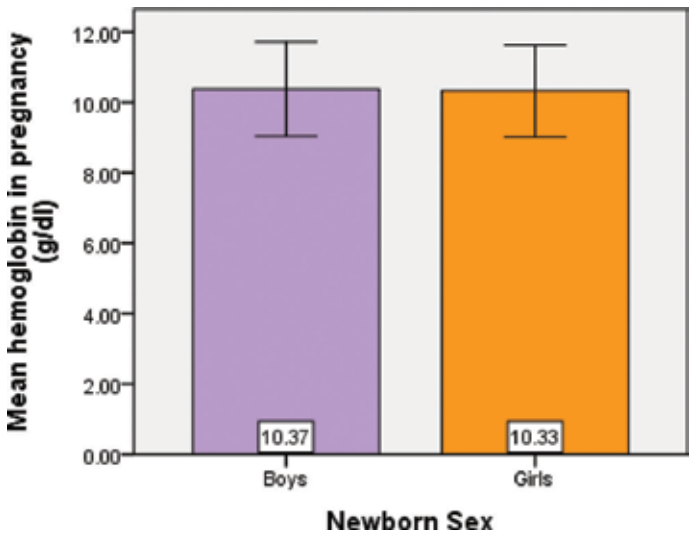

Figure 1. Mean hemoglobin level in pregnancy according with newborn sex.

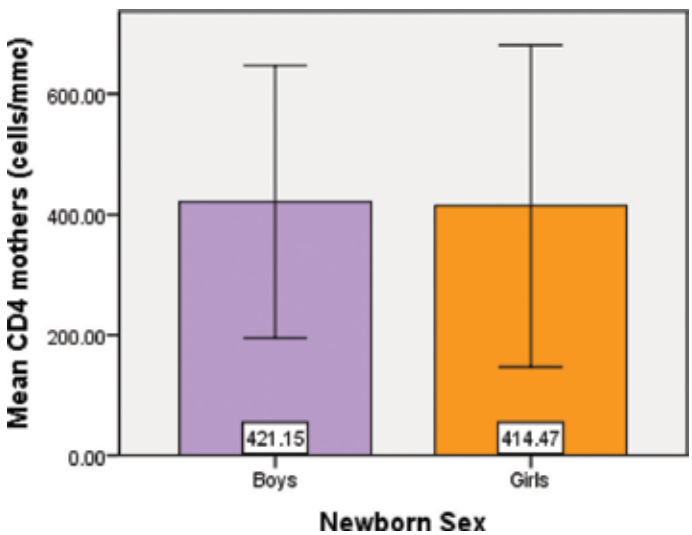

Figure 2. Mean CD4 count in mothers according with newborn sex.

of 35.1 (**Figure 2**). There are no significant differences between the mean CD4 values of the two groups [t = 0.151; df = 122; p = 0.880; the IC 95% for the average is (−81,046; 94,418)].

The mean cART duration in male children was 28.33 weeks with a standard deviation of 14.095, and in female children, the mean cART duration was 26.74 weeks with a standard deviation of 14.81 (**Figure 3**). There are no significant differences of the mean cART duration between the two groups [t = 0.613; df = 122; p = 0.541; the IC 95% for the average is (−3551; 6735)].

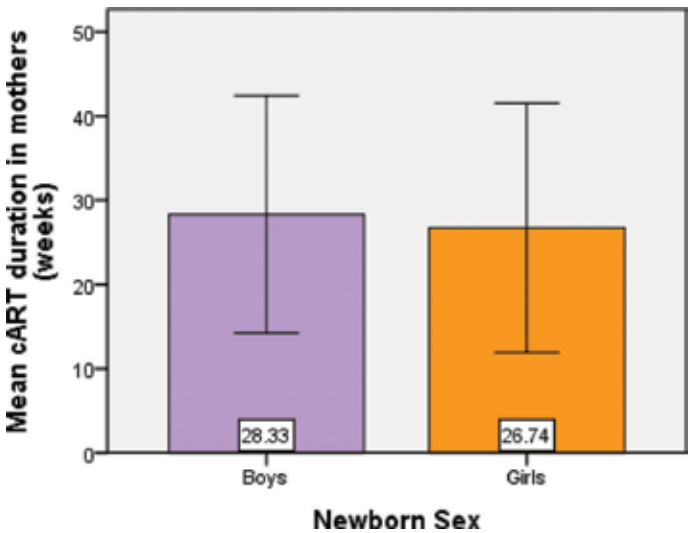

Figure 3. Mean cART duration in pregnancy according with newborn sex.

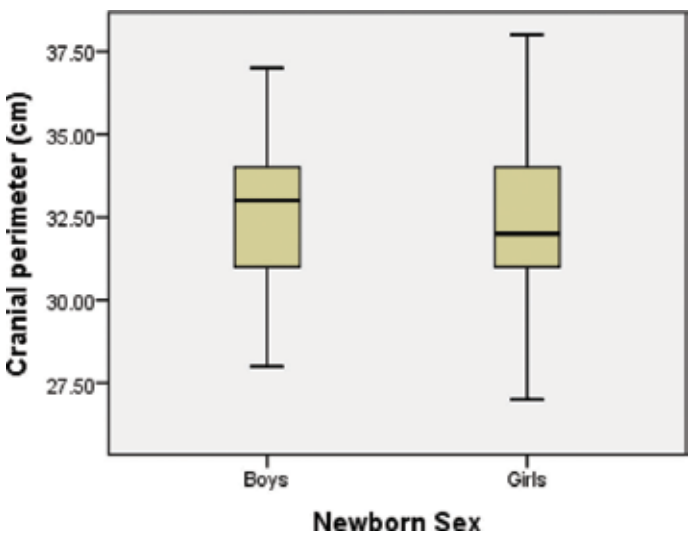

Figure 4. Cranial perimeter according with newborn sex.

The mean cranial perimeter in all studied newborn was 32.5 cm with a standard deviation of 2.13939. In male children the mean cranial perimeter was 32.5 cm with a standard deviation of 1.95503, and in female children, the mean cranial perimeter was 32.5 cm with a standard deviation of 2.34895 (**Figure 4**). The obtained cranial perimeters correspond to 3–5th percentiles on growth charts.

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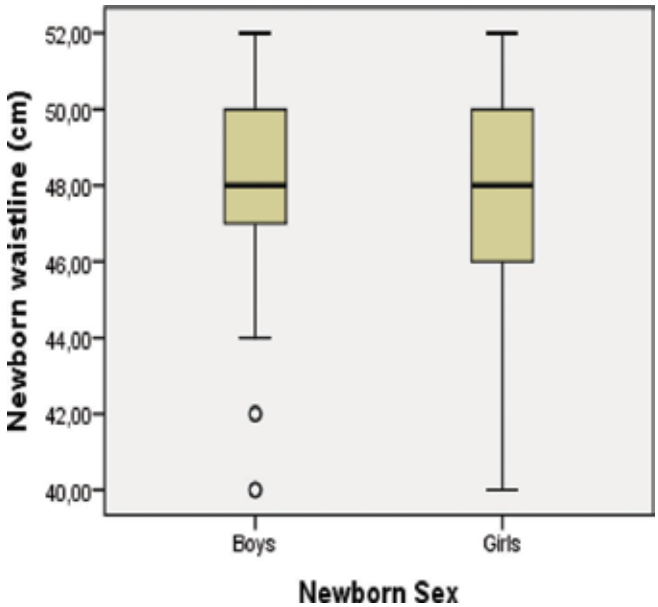

Figure 5. Length according with newborn sex.

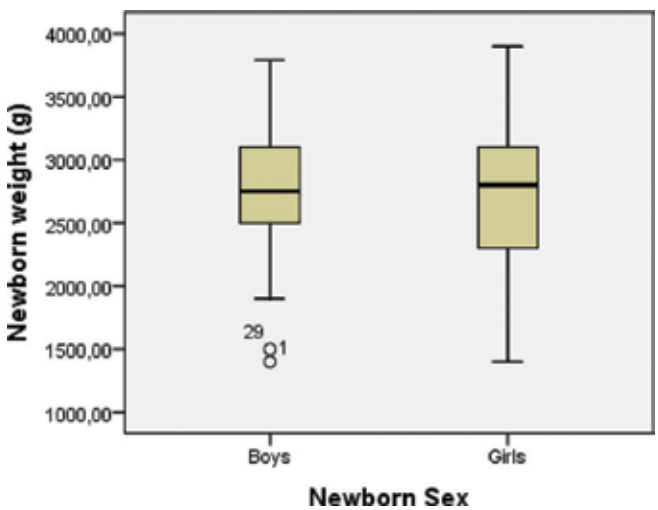

Figure 6. Weight according with newborn sex.

The mean length in newborn from HIV-positive mothers was 47.7258, with a standard deviation of 2.67885. In male children it was 47.9 cm with a standard deviation of 2,66,445, and in female children it was 47.51 cm with a standard deviation of 2.70309 (**Figure 5**). These length values correspond to 10–25th percentiles on growth charts.

The mean weight in male children was 2734.69 g with a standard deviation of 436,65,942, and in female children, the mean weight perimeter was 2677,4138 g with a standard deviation of 542,33,918 (**Figure 6**). These weight values correspond to 5–10th percentiles on growth charts.

9. Conclusions

HIV infection continues to be an important public health problem worldwide due to its cost, morbidity, and mortality. Antenatal screening for HIV should be implemented for every woman as the easier method available to reduce transmission, especially mother-to-child transmission.

Although in our study C-section did not make a clear delimitation between HIV-positive and HIV-negative children, it seems that in children born from HIV-positive mothers with high HIV viral load, delivery by C-section is mandatory.

Although the indication of C-section in HIV-positive women is controversial, in situations in which HIV viral load is high or is not affordable near the time of delivery, and in mothers with poor adherence to antiretroviral treatment, C-section remains one of the most important measures of prevention for HIV mother-to-child transmission.

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Surgical Technique

Chapter 4

The Surgical Technique of Caesarean Section: What is Evidence Based?

Jan-Simon Lanowski and
Constantin S. von Kaisenberg

Additional information is available at the end of the chapter

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Abstract

Caesarean section is the most frequent obstetric operation which is associated with increased maternal morbidity and mortality. Although these risks are low, affected women may suffer from severe consequences and this may affect subsequent pregnancies and deliveries. A variety of surgical approaches have been described, however, on low evidence level. The objective of this chapter is therefore to systematically search the literature and analyse the available evidence including preoperative workup, prophylactic antibiotics, skin disinfection, preoperative bladder catheterization as well as details of the individual steps of the actual operation itself such as skin incision types, preparation of soft tissue and womb, removal of the placenta, cervical dilatation and stitching of the womb, peritoneum, rectus muscle, fascia, subcutaneous fat, and skin. We systematically searched for meta-analysis, systematic reviews, and big studies and evaluated the evidence for each individual step.

Keywords: techniques of caesarean section, level of evidence, meta-analysis, systematic review

1. Various approaches of caesarean section

A caesarean section is a common surgical procedure indicated when complications arise during pregnancy or labour such as suspected foetal distress, breech presentation, failure to progress in labour in macrosomia or in some cases of previous caesarean section. Although maternal and foetal mortality and morbidity have become low, it is associated with substantial short- and long-term maternal and neonatal risks such as bleeding, thrombosis and

embolism, infection and sepsis, and injury to the bladder and bowel. Caesarean section also has the potential for major complications in subsequent pregnancies, in particular uterine scar rupture, placenta praevia totalis, placenta percreta, and placental abruption [1, 2]. But most importantly and of major interest are increased risks for the baby such as asthma up to the age of 12 years and obesity up to the age of 5 years. Also the risks for miscarriage and stillbirth are increased, but not perinatal mortality [2].

The frequency of caesarean sections has increased dramatically worldwide within the last two to three decades, especially in middle- and high-income countries [3]. The reasons are multifactorial and factors such as fear of pain, loss of the preservation of the love channel, the misconception that CS is safer for the baby, convenience for both health professionals and the mother and family, increasing fear of medical litigation, and reduced tolerance of complications or adverse outcomes other than the perfect baby [4]. Improvements in surgical techniques, availability of blood products, anaesthesia, and infection control have reduced the threshold to indicate caesarean section [5].

Recent rates of caesarean sections have been reported with 24.5% in Western Europe, 32% in North America, and 41% in South America [1, 6].

Although one of the most commonly practiced operation a consensus on the most appropriate technique has not yet been reached, mostly because well-designed studies and solid evidence have been sparse.

There are different techniques described such as the classic Pfannenstiel-Kerr technique, the Joel-Cohen method, and the Misgav Ladach technique [7].

There are many ways to perform a caesarean section. The **Pfannenstiel-Kerr** technique consists of the Pfannenstiel incision (**Figures 1–3**), which is a transverse skin incision, two fingers above the symphysis pubis, which is extended in the direction of the anterior superior iliac spine (ASIS), and ends 2–3 cm medial to ASIS on both sides [8]. The subcutaneous layer is opened via sharp dissection followed by a sharp extension of the fascia, a sharp superficial uterine incision, and then blunt entry. The placenta is removed manually, and the uterine closure is made by an interrupted single layer closure. The peritoneum is closed, and the fascia is interruptedly closed, followed by omittance of suturing of the subcutaneous layer and continuous suture of the skin.

In the **Joel-Cohen** technique, the skin incision is placed 3 cm above the original Pfannenstiel incision, the subcutaneous tissue is incised only in the three most medial centimetres, and the lateral tissue is separated manually, before the fascia is divided bluntly with both index fingers inserted in the deep fascial space created by the knife. Then, the peritoneum is opened bluntly with fingers, the uterine cavity is incised, and the incision is extended bluntly laterally by two fingers [9]. The placenta is delivered spontaneously, after delivery of the baby [10]. The uterine closure is made by a single interrupted layer, the peritoneal closure is omitted, and the fascial closure is also interrupted. The subcutaneous suture is omitted, and the skin is sutured continuously (**Figures 4** and **5**). The Joel-Cohen technique is claimed to be faster to

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Figure 1. This is a 37 year old IG0P at 38 weeks and 5 days.

Figure 2. Indicates the skin incision.

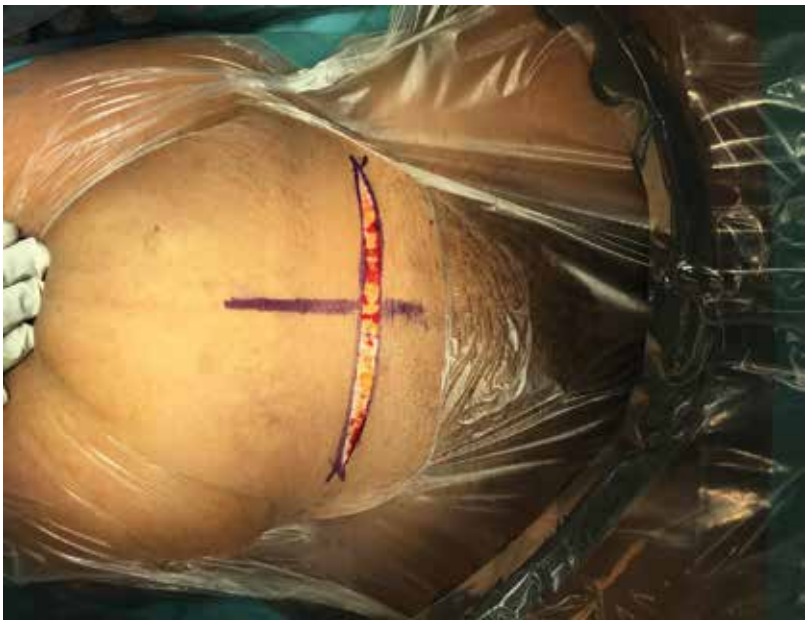

Figure 3. The skin is fully incised.

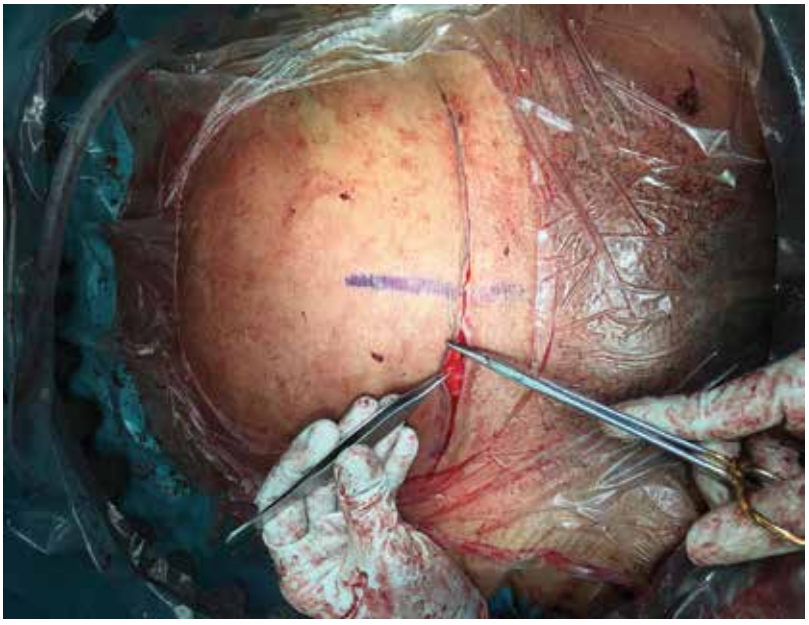

Figure 4. The skin is being closed following the cesarean section.

perform, causes less blood loss, less postoperative pain, shorter hospital stay, less postoperative infection, is more economic, and saves more staff time, and utilises less anaesthesia in comparison with the Pfannenstiel-Kerr technique [11].

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Figure 5. View cesarean section completed.

The **Misgav Ladach** technique for caesarean section was first described by Michael Stark, based on the Joel-Cohen incision. It was initially introduced at Misgav Ladach hospital in Israel [12]. The procedure includes a transverse skin incision 5 cm above the symphysis pubis and blunt dissection of all abdominal walls after sharp superficial incision of the fascia (**Figures 6** and **7**) and uterus (**Figure 8**). The placenta is removed manually after delivery of the baby. One running layer suturing the uterus (**Figures 9** and **10**) [13] and non-closure of the peritoneum were also considered acceptable by many during 1990s [14]. The fascia is closed continuously, the subcutaneous layer is not sutured, and the skin is closed with a mattress suture. A modification of the Misgav Ladach technique was suggested by Stark in 1995 [15].

The Misgav Ladach technique is claimed to have several advantages compared with the Pfannenstiel-Kerr technique. Major differences are digital manual manipulation instead of using sharp instruments which is associated with the least possible trauma to the tissues, less blood loss, faster recovery, shorter anaesthetic time, and using less suture material [16]. A reduced level of antibiotic and narcotic use, faster return of normal bowel function, shorter maternal hospital stay and less postoperative adhesion formation as well as lower incidence of fever, and urinary tract infection has been suggested for that technique. The Misgav Ladach technique is suitable for both elective and emergency caesarean section [17].

The modified Misgav Ladach technique, other than the original Misgav Ladach technique, uses a Pfannenstiel skin incision, a spontaneous delivery of the placenta, a peritoneal closure, and a continuous closure of the skin [7].

Figure 6. Dissection of the fascia and blunt dilatation of abdominal rectus muscles.

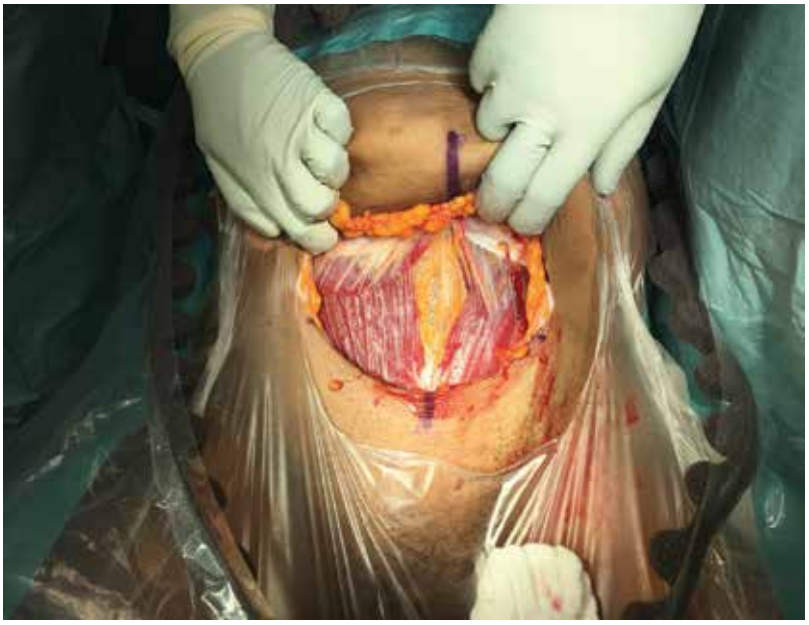

Figure 7. Further digital preparation cranially.

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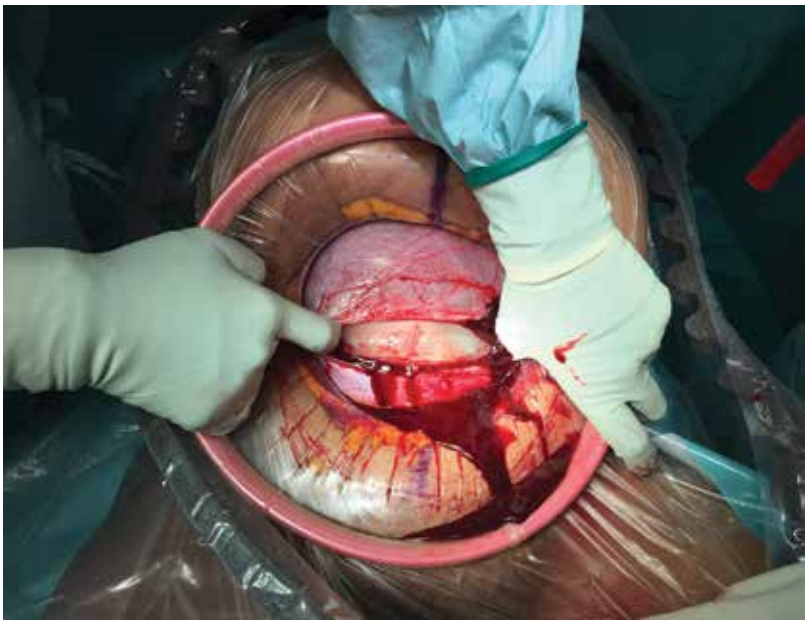

Figure 8. Dilatation of myometrium after uterine incision.

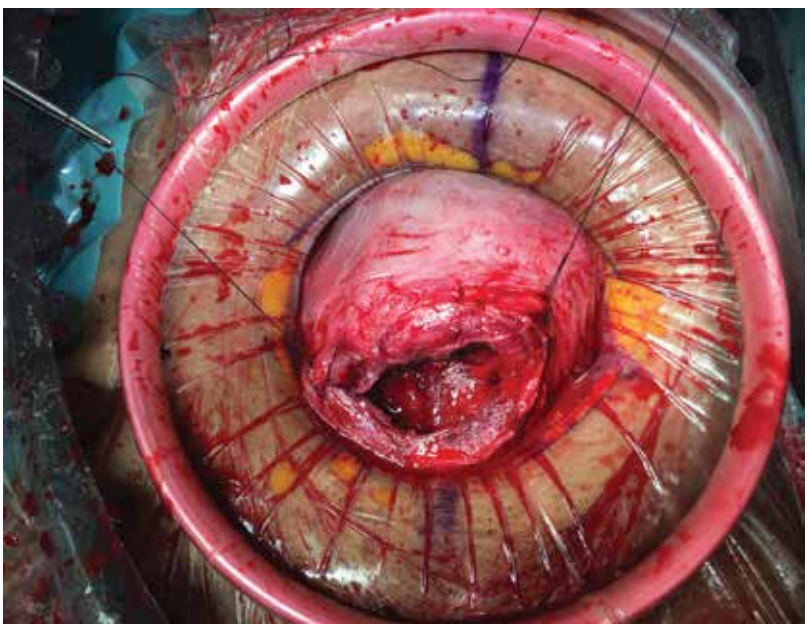

Figure 9. The baby has been removed, the edges are secured, continuous uterine suture is to commence.

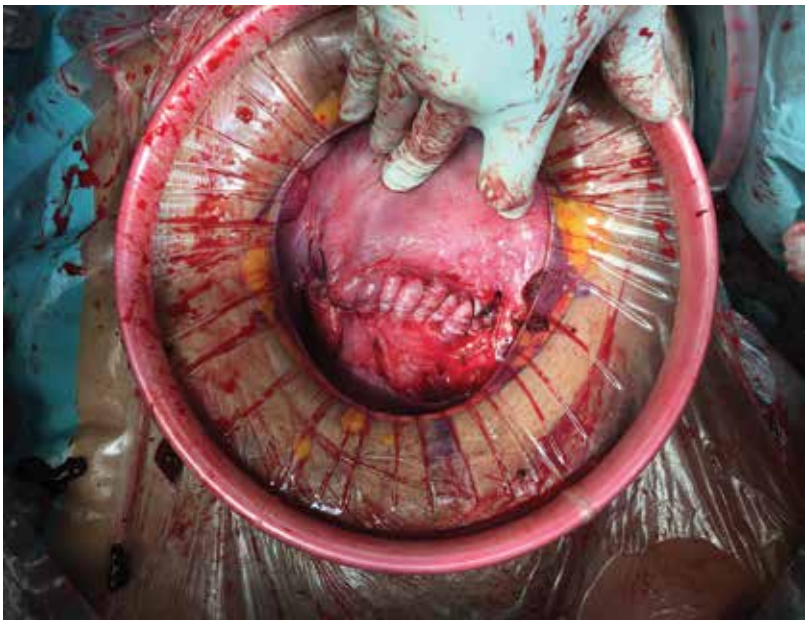

Figure 10. Completion of uterine suture.

It is important that surgeons use techniques which have been shown to be associated with low rates of maternal morbidity and mortality. Therefore, the objective of this chapter is to systematically search the literature and analyse the available evidence for robustness including preoperative workup, prophylactic antibiotics, skin disinfection, preoperative bladder catheterization as well as details of the individual steps of the actual operation itself such as skin incision types, preparation of soft tissue and womb, removal of the placenta, cervical dilatation and stitching of the womb, peritoneum, rectus muscle, fascia, subcutaneous fat, and skin.

2. Data collection

We did a systematic literature review of PubMed and the Cochrane Database in English. Search terms used were techniques of caesarean section, randomised controlled trials, meta-analysis, systematic reviews, Cochrane systematic review, prophylactic antibiotics, skin disinfection, preoperative bladder catheterization, skin incision types, dissection of fascia off the rectus muscles, bladder flap, uterine incision, removal of the placenta, cervical dilatation, closure of the uterine incision, closure of the peritoneum, subcutaneous closure, prophylactic drainage, and skin closure.

Before the search, we defined inclusion criteria and exclusion criteria:

Inclusion criteria: randomised controlled trials, cohort, case-control, systematic review, meta-analysis, and the above search terms.

Exclusion criteria: comments, letters to the editor, personal communications, and case reports.

The author selected the articles first through focused review of abstracts. Eligible studies underwent full text review.

We identified a total of 4593 studies.

We excluded 4532 studies for not meeting either the inclusion criteria, for meeting the exclusion criteria or for not answering the question.

The resulting number of studies was analysed (abstract: 61, whole paper were downloaded: 60).

The references of the most important studies were again checked for eligibility as part of the search strategy.

Data from the randomised controlled trials and Cochrane systematic reviews were extracted, and each step of the operation was discussed using the available evidence.

Potential outcomes were: the technique/procedure which should be used, should not be used, no/low evidence available to answer the question.

Thus, the result of this chapter is a summary of the conclusions of each one of the individual steps to perform a caesarean section.

From the abstracts retrieved by our search, we identified 49 studies and 12 Cochrane systematic reviews. All manuscripts were retrieved in electronic pdf format and analysed in detail.

3. Preoperative preparation

3.1. Prophylactic antibiotics

Wound infection and postpartum endometritis following caesarean section are a frequent problem associated with maternal morbidity and mortality. Caesarean section is the most important risk factor for puerperal infection, and the incidence varies worldwide between 2.5 and 20.5% [18]. The infection is mostly polymicrobial involving a spectrum of Gram-positive and Gram-negative bacteria, anaerobes, *Gardnerella vaginalis*, and genital mycoplasmas [19].

Antibiotic prophylaxis is generally recommended for preventing infection after caesarean section. The administration of antibiotic prophylaxis should be effective, safe, and convenient. The route of administrating antibiotic prophylaxis can either be intravenous, orally or by antibiotic irrigation (washing with a saline solution containing antibiotics). Nine studies compared the administration of intravenous antibiotics with antibiotic irrigation and were analysed in a Cochrane systematic review [20]. The differences in the frequency of endometritis and wound infection between intravenous antibiotics and irrigation following caesarean delivery were not significant, but the evidence was of low quality.

Other studies have evaluated different prophylactic antibiotic regimens and compared single dose antibiotics with extended spectrum coverage. Ampicillin/sulbactam [21], triple antibiotic (ampicillin, gentamicin, and metronidazole) [22], and penicillin and cephalothin [23] were compared with standard cephalosporin prophylaxis. There was no improvement shown in giving an extended spectrum coverage compared to a single drug. Thus, a single dose of ampicillin or first generation cephalosporin should be administered as a prophylaxis in women undergoing caesarean delivery. The level of evidence was high.

The timing of antibiotic administration is also discussed in the literature. Some authors claim that antibiotic prophylaxis should be given preoperative, whereas others recommend it after cord clamping. In a Cochrane systematic review, 10 studies were analysed showing that antibiotics given to women before caesarean delivery nearly halved the risks of combined infections (43%), wound infection (41%), and endometritis (46%), compared to giving the antibiotics after clamping the umbilical cord [24]. Urinary and lung infections, febrile illness, and pelvic abscess did not differ in the two groups, nor did adverse effects in newborns. A meta-analysis of 5 RCT's showed that preoperative administration should be given 15–60 min prior to skin incision to reduce the risk of postpartum infection [25].

Antibiotic prophylaxis should therefore be given prior to the operation. The evidence was of high quality.

3.2. Skin disinfection

Women who give birth by caesarean section are exposed to surgical site infections. The rate of post caesarean infection has been estimated to be 10 times greater than that after vaginal birth [26]. The incidence of wound infection following caesarean section ranges from 3 to 15%. Risk factors for a wound infection are obesity, diabetes, immunosuppressive disorders (HIV infection), and chorioamnionitis during labour, anaemia, or women taking corticosteroids [27]. In order to reduce the risk of postpartum infection, adequate preparation of the skin before the incision is mandatory and is recommended by bodies such as the Royal College of Surgeons of England [28] and the Center for Disease Control and Prevention [29]. An application of an antiseptic is necessary to reduce or remove bacteria. Commonly used antiseptics include chlorhexidine, parachlorometaxylenol, iodine or povidone-iodine, and alcohol. They can be applied as liquids or powders, scrubs or on impregnated drapes. The antiseptic and the type of application given should be broadspectrum and fast acting.

A Cochrane review of skin preparations for clean surgery [30] found that preoperative skin preparation with 0.5% chlorhexidine in methylated spirits was associated with lower rates of surgical site infections following clean surgery, than alcohol-based povidone-iodine, but the evidence of two studies was low. A more recent Cochrane review for skin preparation for preventing infection following caesarean section of six trials found no advantage in either one of the techniques used [31]. Only one trial showed that chlorhexidine gluconate, compared with iodine alone, was associated with lower rates of bacterial growth after caesarean section, but the quality of evidence was very low. More high quality research is necessary to answer the question of the most sufficient preoperative skin preparation.

3.3. Preoperative bladder catheterization

Bladder evacuation with an indwelling catheter is a common preoperative procedure prior to CS. Alleged advantages of using catheters include a maintaining bladder drainage that may improve visualisation during surgery and minimise bladder injury. It is also linked with less retention of urine after operation with decreased incidence of postpartum haemorrhage due to uterine atony. But urinary catheters are associated with an increased risk of urinary tract infections, and the prevalence varies from 6 to 80% [32]. Catheter-associated urinary tract infections can lead to such complications as cystitis, pyelonephritis, and septicaemia which are uncomfortable for women and cause prolonged hospital stay, increased cost, and mortality [33].

A Cochrane review for indwelling bladder catheterisation as part of intraoperative and postoperative care for caesarean section included five studies of moderate quality [34]. Interestingly, urinary tract infection as defined by trialists was not different between the catheterised and non-catheterised group. There was also no difference shown in the incidence of postpartum haemorrhage (PPH) due to uterine atony. Given the low incidence of bladder or ureteral injury reported in the literature [35], these trials were underpowered to detect a difference in these outcomes. On the other hand, discomfort due to catheterisation or at first voiding and longer hospitalisation favoured the no catheter group, but there was marked heterogeneity among the included studies. Based on the Cochrane review, there is insufficient evidence to assess the routine use of indwelling urinary catheters for intra- and postoperative care in patients undergoing caesarean delivery [34]. The level of evidence was moderate.

4. Intraoperative techniques

4.1. Skin incision types

Different types of skin incisions of the abdominal wall can be used for caesarean section. Patterns include vertical (midline and paramedian) incisions and transverse incisions (Pfannenstiel-Kerr, Joel-Cohen, Misgav Ladach, and Modified Misgav Ladach). Traditionally, vertical incisions were used for caesarean delivery [36], but the disadvantages of a vertical incision are greater risk of postoperative wound dehiscence and development of incisional hernia as well as cosmetical inconvenience. Nowadays, the lower abdominal transverse incision is adequate for the majority of caesarean operations because of the minimal risk of postoperative disruption, less incisional hernia, and cosmetic approval. Pfannenstiel and Joel-Cohen incision are described above and were analysed in a Cochrane review. Two trials [37–39] including 411 women compared the Joel-Cohen incision with Pfannenstiel incision, whereas all other aspects of surgery in these two trials were identical [40]. In the Cochrane review was shown that postoperative febrile morbidity and postoperative analgesic requirements were less, the operating time, the delivery time, the total dose of analgesia, the estimated blood loss, and the postoperative hospital stay for the mother were reduced in the Joel-Cohen group

compared with the Pfannenstiel group [40]. Altogether, the Joel-Cohen incision is associated with some advantages compared with the Pfannenstiel incision and should be recommended, but is less popular with women for cosmetic reasons.

The level of evidence was moderate.

4.2. Dissection of fascia off the rectus muscles

This question has been evaluated in a randomised controlled trial [41]. Non-dissection of the lower rectus fascia (pulling the fascia slowly manually apart) was associated with lower decline of pre- and post-surgical haemoglobin levels and less pain and should be recommended. The level of evidence was low.

4.3. Bladder flap

The bladder flap development (downwards removal of the bladder from the lower uterine segment) versus omission of the bladder flap has been investigated in a randomised controlled trial with 258 women. Omission of the bladder flap at caesarean delivery (primary and repeat) did not increase intraoperative or postoperative complications such as blood loss, postoperative micro haematuria, postoperative pain, hospital days, endometritis, or urinary tract infection but shortened incision to delivery time [42].

In another trial with 620 patients, it was shown that the visceral peritoneal closure of the bladder flap increased postpartum urinary frequency [43]. Because of those trials, the routine bladder flap development and closure of the visceral peritoneum of the bladder flap cannot be recommended, but trials have been underpowered to assess morbidity such as bladder injury and adhesion formation. The evidence was of moderate quality.

4.4. Uterine incision

A Cochrane review specifically assessed surgical techniques involving the uterus at the time of caesarean section and included the type of uterine incision (lower transverse uterine incision versus other types of uterine incision) and methods of performing the uterine incision ('sharp' uterine entry versus 'blunt' uterine entry) [44]. A transverse lower segment uterine incision, which is favoured by many obstetricians because of less vascularisation of the lower uterine segment, a better closure and less incidence of uterine dehiscence or rupture in subsequent pregnancies [45] is compared with other types of uterine incision (low vertical, 'classical', T-shaped or J-shaped incision). The Cochrane review did not identify any randomised controlled trials assessing the type of uterine incision to be used. But the ACOG stressed that uterine rupture is a significant risk in a subsequent pregnancy or labour, with estimates of occurrence being 4–9% for classical (uterine body and midline) caesarean incision, 4–9% for inverted T-shaped incisions, 1–7% for lower uterine segment vertical incisions, and 0.2–1.5% for lower uterine segment transverse incisions [46].

Methods of performing the uterine incision ('sharp' uterine entry versus 'blunt' uterine entry) were compared in five studies including 2141 women, and the Cochrane review pointed out

that there were no statistically significant differences identified for the primary outcome febrile morbidity following blunt or sharp extension of the uterine incision, whereas mean blood loss and the need for blood were significantly lower following blunt extension, with no other significant differences identified in duration of operative procedure and maternal morbidity. No statistically significant difference was seen in the rate of neonatal injury. Therefore, blunt extension should be recommended. The level of evidence is high.

4.5. Removal of the placenta

The mode of placental delivery contributes to morbidity and determines blood loss during caesarean section [47]. Altogether there are two common methods used to deliver the placenta at caesarean section, by spontaneous delivery with mild cord traction and by manual removal. A Cochrane review compared the effects of manual removal of the placenta with cord traction at caesarean section, and 15 studies including 4694 women were analysed [48]. It was pointed out that the manual removal of the placenta was associated with more blood loss, more endometritis, and longer duration of hospital stay compared with cord traction. No significant differences were shown in fetomaternal haemorrhage, blood transfusion, and puerperal fever. Therefore, spontaneous delivery with cord traction should be used, and the level of evidence was high.

4.6. Cervical dilatation

During elective, non-labour caesarean sections cervical dilatation by using finger, sponge forceps or other instruments are performed by some obstetricians after placental removal. On the one hand, it is discussed that an undilated cervix may cause obstruction of blood or lochia drainage, but on the other hand, mechanical cervical dilatation using a finger or instruments during caesarean section may result in contamination and increase the risk of infection or cervical trauma. One randomised controlled trial [49] and one Cochrane review analysing three trials with a total of 735 women [50] found insufficient evidence of mechanical dilatation of the cervix at non-labour caesarean section for reducing postoperative morbidity. This does not justify cervical dilatation at present. Further, randomised controlled trials with adequate methodological quality are needed.

4.7. Closure of the uterine incision

The traditional approach to uterine suture is double layer closed [13], although a variety of techniques has been discussed in the literature. Haemostasis, wound healing, and possibly a reduced risk of uterine rupture in subsequent pregnancies are discussed as potential benefits of a double layer suture, whereas single layer closure may be associated with reduced operating time, reduced tissue disruption, and less suture material being absorbed in the wound.

In a Cochrane systematic review, 19 studies were identified comparing single layer with double layer closure of the uterus [44], and data of 14 of the studies were analysed in a meta-analysis. The systematic review pointed out that there were no statistically significant differences

in febrile morbidity in both groups. They also found that mean blood loss was reduced in the single layer closure, but heterogeneity was high, and this limits the clinical applicability of the result. No statistically significant differences were also found for the risk of blood transfusion or other clinical outcomes.

One study was identified comparing continuous versus interrupted single layer closure for the uterine incision, but no clinical or maternal outcome was assessed using either ultrasound or hysteroscopy [51].

In a separate meta-analysis, uterine exteriorization for hysterotomy repair was compared with intra-abdominal repair, and it was shown that febrile complications and surgical time were similar between both groups, and the decision should be provided by the surgeon's preference [52].

Closure with catgut was compared with polygactin-910 closure in 9544 women, where a significant reduction in the need for blood transfusion and a significant reduction in complications requiring relaparotomy were seen in the catgut closure group [53–58]; however, there was no significant difference in any other clinical outcome.

Altogether, there is limited high quality information available to suggest that one surgical technique of closing the uterine incision is superior to another, in particular regarding the chances of uterine rupture in subsequent vaginal birth following caesarean section (VBAC), and future randomised trials should be adequately powered to detect important differences in clinically relevant outcomes.

4.8. Closure of the peritoneum

Closure of the peritoneum at laparotomy has been a part of standard surgical practice. Possible advantages of closing the peritoneum after caesarean section include restoration of anatomy, reduction of infection, reduction of wound dehiscence, reducing haemorrhage, and a minimisation of adhesions [59], whereas the suturing of the peritoneum may cause peritoneal tissue ischaemia at the edges, which may delay healing and serve as a cause of intraperitoneal adhesions and febrile morbidity.

In a Cochrane systematic review, different types of the closure versus non-closure of the peritoneum during caesarean section were analysed [60].

We looked at the results of 16 studies including 15,480 women, when both parietal peritoneums were left unclosed versus when both peritoneal surfaces were closed. In four trials, no differences were seen in the postoperative adhesion formation, whereas there were a reduction of operating time, a reduction in hospital stay, and less chronic pelvic pain in the peritoneal non-closure group. No differences were seen in the occurrence of infectious morbidity, endometritis, and wound infection. The quality of the trials was variable with some of the outcomes demonstrating significant heterogeneity.

Three studies including 889 women investigated non-closure of visceral peritoneum versus closure of both peritoneal layers. In two trials, adhesion formation was increased in the

visceral peritoneal non-closure group, but it was at high risk of bias, whereas one study showed a reduction in operating time and postoperative hospital days [61].

Two studies with 573 women compared non-closure of parietal peritoneum only with closure of both parietal and visceral peritoneum and stressed that neither study reported on postoperative adhesion formation, but one study showed that there were no significant differences in endometritis, fever, wound infection, or hospital stay, but the operative time was reduced, and a reduction of pain was seen in the non-closure group [62].

One study examined non-closure versus closure of visceral peritoneum when parietal peritoneum is closed and pointed out that there was reduction in urinary symptoms of frequency, urgency, and stress incontinence when the visceral peritoneum is left unsutured [63].

Altogether, there was a reduction in operative time across all the subgroups with the peritoneum left open, and there was no clear evidence on reduced adhesion formation for the peritoneum closure group. At the moment, there is insufficient evidence of advantages to justify the additional time and use of suture material necessary for peritoneal closure.

The Cochrane review stressed that quality of trials was variable, the results were in general consistent between the trials of better and poorer quality, and further studies are needed to further assess all outcomes [60].

4.9. Subcutaneous closure

In a Cochrane review, 7 trials with 2056 women were analysed showing that the risk of haematoma or seroma was reduced with subcutaneous closure compared with non-closure but no difference in the risk of wound infection or other short-term outcomes was found [64]. A meta-analysis evaluating six randomised studies showed that prophylactic drainage was not associated with decreased wound infection, hematoma, or seroma and cannot be recommended [65].

No difference was seen in the risk of wound infection between blunt needles and sharp needles, and no trials were found investigating suture techniques or materials for closure of the rectus sheath or subcutaneous fat. Closure of the subcutaneous fat may reduce wound complications, especially when subcutaneous fat is >2 cm, but further trials are needed which are adequately powered to detect clinically important differences.

4.10. Skin closure

The skin incision can be closed by subcuticular suture immediately below the skin layer, by an interrupted suture, or by staples. In a review of five randomised controlled trials and one prospective study, staple closure was associated with a two-times higher risk of wound infection or separation compared with subcuticular suture closure [66]. In contrast to this data, a Cochrane systematic review of eight studies stressed that wound complications and cosmetic outcomes were similar among both groups [67]. There is currently no conclusive evidence about how the skin should be closed after caesarean section.

5. Summary (suggested strategy/protocol)

- **Prophylactic antibiotics**: yes, single dose, ampicillin or first-generation cephalosporin, 15–60 min prior to skin incision, LoE: high.
- **Skin disinfection**: yes, always, LoE: high; type of antiseptic chlorhexidine gluconate, LoE: low.
- **Preoperative bladder catheterization**: none or early removal, not enough evidence to assess the routine use of indwelling bladder catheters, LoE: moderate.
- **Skin incision types**: Joel-Cohen incision is associated with some advantages compared to Pfannenstiel, but less popular for cosmetic reasons, LoE: moderate.
- **Dissection of fascia off the rectus muscles**: no, median incision and blunt dilatation of the lower rectus fascia, LoE: low.
- **Bladder flap:** no, LoE: moderate.
- **Uterine incision:** transverse lower uterine segment, LoE: moderate; blunt expansion, LoE: high.
- **Removal of the placenta:** yes, spontaneous (with mild cord traction), LoE: high.
- **Cervical dilatation**: no, does not reduce morbidity from infection, LoE: high.
- **Closure of the uterine incision:** single layer, LoE: high; continuous and unlocked, LoE: moderate.
- **Closure of the peritoneum**: no, generally not recommended, individual decision, LoE: moderate.
- **Subcutaneous closure:** yes, if subcutaneous tissue >2 cm, LoE: high.
- **Subcutaneous drain:** no, does not reduce wound morbidity/infection, LoE: high.
- **Skin closure:** staples or subcuticular suture possible, LoE: moderate.

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Chapter 5

Pros and Cons of Myomectomy during Cesarean Section

Cengiz Tokgöz, Şafak Hatirnaz and Oğuz Güler

Additional information is available at the end of the chapter

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Abstract

Additional surgical interventions apart from emergencies during cesarean section are not recommended in the textbooks; thus, surgical procedures like myomectomy as an adjunct to cesarean section remains a hot topic of discussion. There are many publications supporting serosal myomectomy during cesarean section, but studies published so far are poor in quality of evidence. To clarify the efficacy and safety of cesarean myomectomy, large-scale randomized controlled studies and studies explaining the mid-term and long-term outcomes of the cesarean myomectomy are required. Traditionally, cesarean myomectomy is performed from the uterine serosa as in the usual abdominal myomectomy. Although the surgical technique is the same as intracapsular myomectomy, a novel cesarean myomectomy technique, endometrial myomectomy, introduced into the obstetrics practice for minimizing the risk of adhesion formation and diminishing the blood loss during surgery. Further, strong studies are needed to overcome the controversy on cesarean myomectomy.

Keywords: endometrial myomectomy, cesarean section, serosal myomectomy, complications

1. Introduction

Among the benign uterine diseases, leiomyoma of the uterus seems to be the most common pathology. Though the endometrium is accepted as a dynamic tissue and myometrium is accepted as a silent muscular tissue, the reality is not that and it was understood from the studies that both endometrial processes and myometrial processes play a role in abnormal uterine bleeding.

Uterine leiomyomas, also known as fibroids, are smooth muscle-derived benign masses ranging from millimeters to many centimeters. The investigation of pathological specimens of the uterus revealed that almost 80% of African Americans women and 70% of Caucasian women have detectable leiomyomas [1, 2]. The well-known risk factors for leiomyoma do not explain why racial difference is this much but genetic polymorphisms including increased aromatase activity and signal transducing genes showed that more severe phenotypic pattern may be seen in African Americans [3, 4].

Inadequacy of medical treatment and lack of understanding of molecular physiology and pathophysiological processes make the surgical treatment as the main therapeutic option for leiomyomas [5].

Leiomyomas of the uterus are highly vascular benign tumors, and their volume may increase 9% in 6-month period. Growth rate of the myomas decreases after the age of 35 among Caucasian women and almost all myomas carried to menopausal period without any symptoms shrink in size together with the shrinkage of the uterus [6].

There are only limited options for the treatment of leiomyomas of the uterus, and most of the time leiomyomas are asymptomatic and no treatment is necessary. For asymptomatic patients, menopause itself is a cure factor [7].

There are numerous medical treatment options for the treatment of leiomyoma of the uterus like OCPs, progestins, NSAIDs, androgenic compounds, antifibrinolytics and progestin-loaded IUDs for symptom relief, and they are likely effective in at least a group of patients [8].

Other treatment options related to the use of GnRH agonists, GnRH antagonists and estrogen and progestin add back regimens may decrease the volume of the leiomyomas but after the cessation of medical treatment, leiomyomas resume their volume within 6 months of time [9–11].

Surgical therapy remains the definitive treatment option in symptomatic leiomyomas. Hysterectomy for the patients with no fertility problem increases the quality of the life of leiomyoma patients. Hysterectomy can be done by open surgery, laparoscopy or robotic-assisted surgery. Supracervical or subtotal hysterectomy is a controversial issue [12–14]. Abdominal myomectomy is the first surgical option for those who refuse to lose their uterus and who want to preserve their fertility for childbearing. Myomectomy can be done by open surgery, laparoscopic surgery and robotic-assisted surgery [15, 16]. For those who have submucous myomas, hysteroscopic resection is the gold standard treatment choice.

2. Cesarean myomectomy

One of the most controversial issues of obstetrics and gynecology is the presence of known or incidental leiomyomas during pregnancy and how to manage patients with myomas together with pregnancy. A total of 10–30% of the pregnancies develop some complications related to leiomyomas [17].

Cesarean section is the most commonly performed procedure globally [18]. Due to more advanced age, pregnancies are more prevalent in developed countries, naturally encountering leiomyoma during cesarean section getting more prevalent as well. The prevalence of the leiomyomas during pregnancy varies from 0.37–12% in the current literature [19–21].

Performing myomectomy during cesarean section is a controversial topic. The main concern is the potential risk of severe bleeding and increased morbidity when it is performed during cesarean section [22]. However, accumulating number of publications to support cesarean myomectomy in recent years is merging.

Potential indications of cesarean myomectomy are listed in **Table 1**.

Contraindications of cesarean myomectomy are listed in **Table 2**.

In contrary to common belief, Tinelli et al. presented that serosal myomectomy has a minuscule impact on blood loss in the light of no difference in blood product transfusion rates when it performed during cesarean section [23]. Ramesh et al. investigated 21 cases of cesarean myomectomy retrospectively and concluded that myomectomy during cesarean section is not associated with intraoperative and postoperative complications [24]. Leiomyomas located at the cornual region were not removed in their study. Mangala et al. compared the blood loss in single fibroid in abdominal and cesarean myomectomy cases and concluded that there is no significant difference between the groups, and it is safe to remove the single leiomyoma during cesarean section [25]. Machado et al. studied eight cases in Oman for the safety of cesarean myomectomy and concluded that in selected patients, cesarean myomectomy is safe and efficient in the hands of experienced surgeons and in the tertiary healthcare facilities [26]. Kwon et al. investigated 165 pregnant women having myomas, and they evaluated the patients whose myomas are over 5 cm in size and concluded that the size of the myoma has no greater impact on the increased rates of complications [27]. Sparic et al. assessed 350 papers on cesarean myomectomy and 38 studies found to be eligible for their evaluation for review of cesarean myomectomy in modern obstetrics. The major risk is intraoperative bleeding ranging

Symptomatic myomas (mild pelvic pain)
Myoma >5 cm
Single myoma
Anteriorly located myomas
Tumor previa
Pedunculated myomas
Avoiding extra surgical procedure
Degenerative myomas
Patient's desire

Table 1. Potential indications of cesarean myomectomy.

Age > 40 years
Multiple myomas
Cornual located myomas
Posteriorly located myomas
Asymptomatic myomas
Tendency to bleed
Previous history of uterine rupture

Table 2. Contraindications of cesarean myomectomy.

from 0 to 35.3%. A potential late complication is the scar quality after the surgery. This may increase the risk of uterine rupture during the next pregnancy, but the literature lacks studies related to scar quality. However, Sparic et al. noted the advantages of cesarean myomectomy as smaller incision on the serosal surface, easy to perform during cesarean section, effortless suture placement and two operations in one. Another important advantage of cesarean myomectomy is the improved quality of life in affected women. However, they concluded that the risk benefit of cesarean myomectomy should be re-evaluated and further research is necessary [28]. Song et al. reviewed myomectomy during cesarean section through the database search and among 2500 studies they found nine studies eligible for their review and concluded that cesarean myomectomy may be a reasonable option in some leiomyoma patients but data driven from the meta-analysis were low quality, and definitive conclusion on this issue cannot be drawn [29].

Synchronous uterine contractions are mandatory for a healthy delivery. The uterus has no triggering mechanism as pacemaker in the heart, instead, uterine muscles have self- oscillators triggered by the changing membrane potentials happening in the pregnancy period and their contractility increases toward the end of the gestation [31]. Myocyte contractility also increased by the facilitation of prostaglandins and myocyte to myocyte connectivity and activated intracellular contractile mechanism, which eventually increase the intrauterine pressure that effaces and dilates the cervix for the babies to be delivered. Any leiomyoma or other uterine pathologies may have negative effect on the uterine contractility and also any surgical procedure related to the uterine musculature might have negative impact on the uterine contractility and may increase the risk of uterine rupture during delivery. Decreasing the myocyte damage during myomectomy should be taken into consideration during any myomectomy cases.

Uterine pathologies including the leiomyoma have negative impact on the implantation and placentation [32]. Submucosal and intramural myomas deforming the endometrial surface reduce the implantation rates and increase the risk of abortion and mallocated placentation. The intramural leiomyoma not affecting the endometrial cavity is still a question. Number, size and locations of the myomas determine their impact. Small leiomyoma without endometrial

impact has no adverse effects [33]. Leiomyoma classified according to new myoma classification from type 0 (submucous myoma) to type 8 (Parasitic myomas) [34]. In this study, the leiomyomas were in the range of type 2 and type 5.

The human uterus may increase in volume and weight, 1000 times and 20 times respectively throughout pregnancy [35, 36]. However, myomas can only grow one in fourth size during pregnancy. Thus, myomectomy during cesarean section produces less tissue damage compared to removal of a symptomatic myoma in normal sized uterus. Serosal scarring and myocyte damage during myomectomy in nonpregnant uterus is more than that of cesarean myomectomy especially endometrial myomectomy. After all cumulated publications about the safety of cesarean myomectomies, severe bleeding and possibility of cesarean hysterectomy still remain controversial issue though these two complications are no common. Conforti et al. described techniques for reducing hemorrhagic blood loss in their study published in *European Journal of Obstetrics & Gynecology and Reproductive Biology* including tourniquet, uterine artery ligation, uterine artery embolization, vasopressin, tranexamic acid and uterotonic agents like oxytocin, misoprostol and dinoprostone, GnRH analogs before the operation, recycling of lost blood during surgery and gelatin matrix [31]. Desai et al. described a novel technique for reducing the blood loss during myomectomy, and they used selective uterine devascularization in nine pregnant patients before myomectomy at the time of cesarean section. The ovarian vessels were ligated on both sides, and the ascending and the descending uterine artery branches were ligated bilaterally after the removal of baby and placental materials. All cases were managed successfully after the selective devascularization, and they found this technique as a safe and effective method [32]. Uterine artery ligation is lifesaving procedure during cesarean myomectomy of big-sized myomas as in the case reported by Ma et al. in *Taiwanese Journal of Obstetrics and Gynecology* [33]. Blood loss due to myomectomy following cesarean section is calculated by the weighing the swabs used during the surgery and volumetric measurement of aspirated blood and recorded. Loss of blood in cesarean section was not recorded but before beginning myomectomy, the uterus and lower uterine segment incision site were stabilized for any major or minor bleeding. In a meta-analysis conducted by Song et al., they searched many databases without language restriction and included only nine studies eligible for investigation and they concluded that though cesarean myomectomy can be a reasonable option, cesarean myomectomy remains still controversial because the data are not satisfactory [29].

Literature search for cesarean myomectomies revealed many publications supporting the cesarean myomectomy. In the retrospective study conducted by Topcu et al., 76 cesarean myomectomy cases were compared with 60 cesarean only cases for blood loss, operation time, the need for transfusion and hospital stay and concluded that size of the myoma is not important and removal of corporal and subserous myomas is safe and feasible in some patients [36]. In a large group of cases in a university hospital setting, Li et al. investigated the efficacy of cesarean myomectomy of 1242 cases by comparing three groups of cases where 200 cases without myoma (group A), 145 cases with myoma but without myomectomy (group B) and 51 cases with myoma during pregnancy resulted in cesarean hysterectomy (group C), and they concluded that myomectomy during cesarean section is a safe and effective surgical method [37]. Sparic et al. analyzed the decision 289 making in cesarean myomectomy and concluded that

surgical skills, age of the patient and type of the myomas are the most important predictors of cesarean myomectomy [38].

Cesarean myomectomy has been consistently applied in our setting for 17 years. Beginning from 2013, endometrial myomectomy has been started and selected as the cesarean myomectomy of choice instead of classical serosal approach because in serosal myomectomy, the bleeding, operative time, myometrial damage and adhesion formation possibilities are higher as compared to endometrial myomectomy [30]. The rate of suturing the endometrium during surgery is very low and uterine involution itself shrinks the surgical site to a lesser size. The surgery raises the question whether the endometrial myomectomy increases the likelihood of intrauterine adhesions or Asherman syndrome. We performed ultrasound evaluation at seventh day postoperation and evaluated the myometrial defect and found totally normal appearance in 22 cases. Also we called all patients 40 days after the surgery for saline infusion sonohysterography (SIS) and SIS outcomes revealed that no single case experienced intrauterine adhesions at any level. SIS has been neglected for long time in infertility, but actually SIS is a simple and important investigation for intrauterine pathologies. Intrauterine adhesions can be verified by simple SIS as an adjunct to other diagnostic tools [39]. CS myomectomy from endometrial approach decreases loss of blood, total operation time and adhesion formation compared to classical cesarean myomectomy.

Hospital stay is no longer than classical myomectomies. Uterine serosa remains intact.

Endometrial myomectomy uses the principles of hysteroscopic myomectomy and supported by the physiological mechanism of uterine involution to decrease the blood loss and suturing during surgery. In this surgical method, unintentional opening of uterine serosa is accepted as complication because the main goal of this surgery is to remove all myomas from the endometrial layer without touching the serosal layer for preserving the uterus from dense adhesions and ease the future surgeries of the patient. All myomas located in anterior or posterior region and even the ones located close to cornual area can be safely removed by this surgical technique.

In the following section, we describe the techniques of serosal myomectomy and endometrial myomectomy in detail.

2.1. Techniques of cesaraen myomectomy

There are two approaches for removing the leiomyomas during cesarean section; one is the well-known serosal myomectomy and second is the novel technique recently published endometrial myomectomy. Both techniques use the same principle of intracapsular myoma removal, but the only difference is the route of myoma removal. Removing myomas by endometrial route have some advantages over the serosal myomectomy and both techniques are explained in the following section in detail.

2.2. Technique of serosal myomectomy

Serosal myomectomy is the removal of the leiomyomas as in abdominal or laparoscopic myomectomy where incisions were made on the surface of the uterus. The only difference

is the enlarged and well-vascularized uterus during cesarean section. Uterine involution squeezes the big vessels in the endometrial cavity, but the surface blood supply is not affected from the involution thus the risk of bleeding during serosal myomectomy is increased. Besides, the incision on the surface remains large which may have greater impact on the adhesion formation. In cases where multiple myoma removal is necessary, the number of incisions increases and the risk of bleeding and formation of adhesions increases. In serosal myomectomy, removal of posterior myomas and myomas close to the cornual region are not recommended. Myomas close to each other may be removed from the same incision to diminish the adhesion formation.

Following removal of baby and the placenta, the uterine cavity is swept by a gauze and incision site is controlled for any bleeding and lower uterine segment incision is closed with a running nonlocked no. 1 Vicryl suture. Uterine surface is evaluated for the locations and the sizes of the myomas present. Leiomyoma close to the low uterine segment incision site was taken out as described in endometrial myomectomy technique. Closed proximity of the leiomyomas was removed from a single incision to diminish the adhesion formation. Leiomyoma located in different locations is removed by incising each leiomyoma surface thus sutures and scarring on the surface of the uterus are prominent in classical technique. While removing the myoma, if myoma base carries a vascular pedicle, then the pedicle is clamped and sutured. The muscular layer is closed by separate no. 1 Vicryl sutures. The serosal surface is closed in either continuous locked no. 1 Vicryl sutures or a baseball suturing technique. After suturing a very hot sponge is placed on the suture line for a short time and then removed to see any bleeding foci. Any resistant bleeding not controlled by electrocautery may be controlled by no. 2 Vicryl U sutures or by figure of eight sutures around the suture line. No antiadhesion material is used for protection. After removal and suturing of all myomas, uterus is placed in the abdominal cavity and the serosal surface of the uterus and the tubes and ovaries are checked for bleeding and following hemostasis and clot removal the abdominal layers are closed according to the general principles.

The long-term effect of this method is the adhesion formation, which makes the latter abdominal surgeries prone to complications. Hemostatic sutures for bleeding result in many suture nodes on the uterine surface and may prolong time of surgery.

In 2013, **Cengiz Tokgöz M.D.** developed a new cesarean myomectomy technique which was named as **endometrial myomectomy**. The main aim of this novel technique is to minimalize the uterine scarring and eventual adhesion formation while using the uterine physiology as the main support for this surgical procedure. Until 2017, more than 30 cases were operated by this technique and 22 of the cases without posterior myomas were drilled into a retrospective study for publishing the preliminary outcomes of this novel technique. The technique was published in the *Journal of Maternal Fetal and Neonatal Medicine* as the first in the world and this study is the first and unique to compare one cesarean myomectomy technique(endometrial myomectomy) with another one (serosal myomectomy).

2.3. Technique of endometrial myomectomy

All myomectomy cases were performed by the same team of surgeons and cesarean section technique and myomectomy techniques used in these surgeries were the same. After removal

of the baby and the placenta, the uterus is taken out from the abdominal cavity. The uterine cavity is swept by a gauze and uterine incision is controlled for any bleeding. Uterine surface and cavity are evaluated thoroughly for leiomyomas and anatomical locations and sizes are evaluated quickly. Those leiomyomas located close to the low uterine incision site (**Picture 1**) are removed from the incision line, which is neither a serosal nor an endometrial myomectomy, and in fact, the myoma (**Picture 3**) is removed from subendometrial-intramyometrial area (**Picture 2**). The death space is closed together with the low uterine incision line suturing thus no extra suturing is necessary in such conditions.

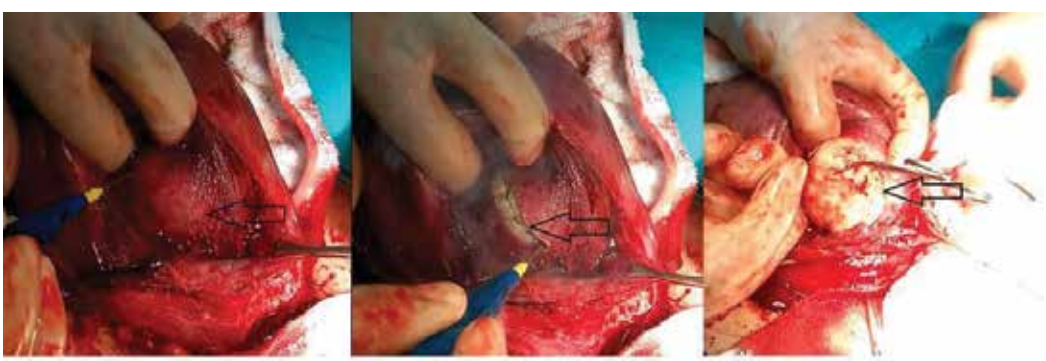
Picture 1: Leiomyoma located close to the low uterine incision site

Picture 2: İncision to subendometrial - intramyometrial area

Picture 3: Removing the myoma

Courtesy of Oğuz Güler M.D. & Cengiz Tokgöz M.D.

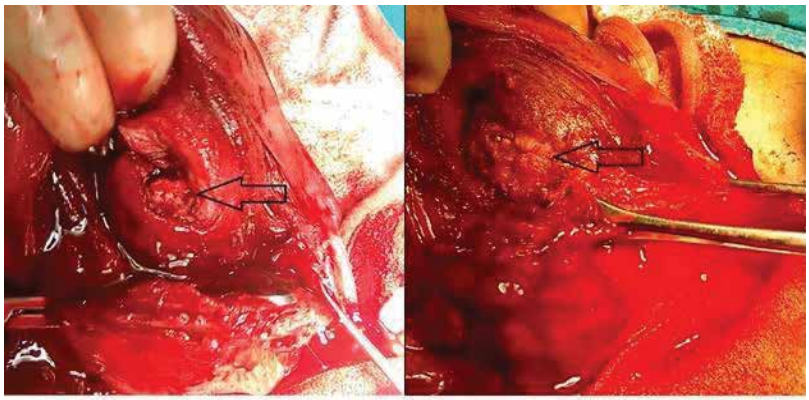
Following palpation and localization, leiomyomas (**Picture 4**) were pushed from the serosal site to be visible and palpable from endometrial site, then an endometrial-transmyometrial incision was made (**Picture 5**) to reach the leiomyoma by a scalpel or electrocautery knife and leiomyoma(**Picture 6**) was removed without its capsule (**Picture 7**) by blunt and sharp dissections.



Picture 4: Palpation and localization of myoma

Picture 5: Endometrial-transmyometrial incision by electrocoutery

Picture 6: Removing leiomyoma



Picture 7: Capsule remains it's place

Picture 8: Sutured endometrial incision

Courtesy of Şafak Hatırnaz M.D. & Oğuz Güler M.D.

Any vascular structures at the root of leiomyoma were clamped and sutured (**Picture 8**). If more than one leiomyoma are present and not close to each other, then all leiomyomas removed from one by one and endometrium is incised for each leiomyoma. However, the endometrium has the opportunity to involute rapidly and the endometria incisions diminish in size, which makes the endometrial scar smaller than the original incision. If the myoma removal site is not bleeding and the diameter of the incision on the endometrial layer <3 cm, no sutures are placed on the endometrial layer to minimalize the adhesion formation within the endometrial cavity. This is what is done in hysteroscopic submucous or intramural myoma resection where suturing is impossible to do. If suturing is necessary for bigger incisions or bleeding, the no. 1 rapid Vicryl separate or continuous sutures are placed on the endometrial incision sites. By this technique, almost all myomas located on the uterus can be easily removed from the endometrium including subserous non pedunculated leiomyomas. Subserous myoma removal from the endometrium may seem to be unnecessary, but serosa of the uterus remains intact and the myometrial tissue damage diminishes while uterus is involuted. Thus, the death space in the myometrial layer is not observed, and myometrial integrity is not affected too much following this surgical procedure. Uterine physiology is the major supporter in this technique.

Following bleeding control, any bleeding sites were sutured if present and if no major bleeding, myoma bed or death spaces are sutured with no. 1 Vicryl in a separated manner. Endometrium is sutured with an absorbable suture in cases where the defect site is bigger than 3 cm. Any serosal opening during subendometrial myomectomy is accepted as complication because the main goal of this surgical method is to keep the uterine serosa intact apart from cesarean lower uterine segment incision scar and by this way to minimize the adhesion formation which is a matter of fact in myomectomies. In cases where reaching myoma is difficult, the team preferred to use bivalves to open the endometrial cavity for a safe surgical procedure. Uterus itself is the major supporter of this surgery since the rapid physiological involution of the uterus diminishes the death spaces and suture sites thus endometrial scarring

minimizes automatically. After inspection and hemostasis, lower uterine segment incision is closed and layers of the abdomen are closed carefully.

Postoperative care was not different from the cesarean section cases, and no additional treatment or follow-up was recommended for endometrial myomectomy cases.

Number of the leiomyomas, leiomyoma sizes, amount of blood lost during this procedure, serosal opening during surgery and operation time are all recorded. Leiomyomas are sent for pathological evaluation in all cases.

All patients are called 5 days after the hospital discharge for postoperative control and the uterus, the endometrium and the surgical sites of leiomyoma removal are evaluated carefully by

Intraoperative bleeding
Postoperative fever
Blood transfusion
Prolonged hospital stay
Adhesion formation
Asherman syndrome
Abnormal placental insertions
Uterine rupture

Table 3. Early and late complications of cesarean myomectomy.

Figure 1. Saline infusion sonohysterography (SIS) 40 days after endometrial myomectomy. Courtesy of Oğuz Güler M.D.

transabdominal ultrasound and recorded. Every single patient is called for saline infusion sonography (SIS) 40 days after the surgery (when the uterine involution is ended and the uterus reaches the normal size) for the evaluation of endometrial damage or adhesion formation routinely and SİS findings are also recorded. Asherman syndrome at any level was not recorded in studied cases.

Among the studied 22 cases, four of them were operated for next cesarean section, and no leiomyoma formation or adhesion formation was observed during their next surgeries.

Both techniques carry some risks and complications during and after surgery. The complications related to cesarean myomectomy are listed in **Table 3**.

A picture of SIS 40 days after the operation is depicted in **Figure 1**.

3. Conclusions

Cesarean myomectomy still remains a controversial issue in obstetrics practice and seems to continue to be debated in the future. Because none of the studies were performed as randomized controlled trials so far, and meta-analyses derived from those studies have weak outcomes to say that cesarean myomectomy is a safe and reliable procedure. The accumulating data, however, diminished the fear of performing cesarean myomectomy.

Though this novel method of cesarean myomectomy, endometrial myomectomy, decreases the adhesion formation by keeping the uterine serosa intact, diminishes blood loss and reduce the operation time compared to serosal myomectomy, large-scale randomized controlled trials need to show mid-term and long-term outcomes of this novel approach. Much safer and technically easier methods may change the steady thoughts on the risks of cesarean myomectomy in future.

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Complications

Chapter 6

Complications of Cesarean Operation

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Additional information is available at the end of the chapter

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Abstract

In the last decades, there has been a huge increase in the incidence of the cesarean section that worldwide became a routine procedure in most hospitals despite the potential complications which in some cases can cause permanent damage or can even be fatal, affecting both the mother and the fetus. In this chapter, we will discuss the most frequent complications that occur in the cesarean section both in the surgical act and after the event.

Keywords: cesarean section, intraoperative complications, postoperative complications

1. Introduction

The progressive increase in the incidence of cesarean section during the last decades has been constant worldwide, increasing; at the same time, the indications, many of them unnecessary, resulting in indiscriminate practice, becoming the most frequent surgical intervention performed in health institutions, both private and public. Currently, the obstetrician is able to more accurately assess the hostility of the intrauterine environment and thus, as the development of fetal medicine is so significant, and it is also safe to perform a cesarean section since there are also factors that facilitate decision-making in favor of interrupting pregnancy through the abdominal route such as new generations of antibiotics with greater coverage, suture materials with less adverse reaction, better surgical techniques and skills, better hospital infrastructure and greater ease of extra-hospital monitoring at the exit.

This increase is also favored by non-professional communication in social networks that minimize the surgical risks of cesarean section, promoting false advantages aimed mainly at family comfort; as well as by health professionals not related to obstetrics and although it bother us to recognize it, also by some "obstetricians" who seek personal benefits [1–11].

In addition, we will never finish insisting that medical legal criteria encourage the belief that maternal morbidity and mainly the perinatal observed in the vaginal route, could be avoided with a cesarean section, favoring the growing doctor's fear to be subject of a legal claim thus evading the responsibility that comes with the adequate and justified indication of a cesarean section [11, 13].

A person who has never experienced the effect of surgery can hardly understand the physical effort required by a mother to take care of the newborn during the first months of life and be deprived of a tranquil convalescence and favored by the benefit provided by rest and the attentions that are given to any patient after surgery.

In 2016, it had been 100 years since Edward Craigin suggested that "once a cesarean, always cesarean," a concept that not only continues in many obstetricians but also becoming increasingly popular, so that the same patients increasingly request a cesarean section of repetition without considering the reproductive impact that it entails and without a full knowledge of the possible complications that even in our days have a considerable risk of high morbidity and mortality, both maternal and fetal [1–10].

We can divide the complications into trans-surgical and postsurgical, and the latter one into early and late.

2. Trans-surgical complications

2.1. Hemorrhage

Hemorrhage is the most frequent complication of the cesarean section during or after the surgical event. However, there is no consensus on the actual incidence, worldwide; it is estimated that around 75% of obstetric hemorrhages occur in cesarean section.

In developing countries, obstetric hemorrhage alternates the first and second position with preeclampsia as a cause of maternal death, and the World Health Organization accepts a rate of 10% worldwide in all births with live fetus [3, 4, 14–21].

The physiological changes that occur in the circulatory system during pregnancy act as an important factor, remember that the hypervolemia that occurs progressively from the first trimester reaches a maximum in the third quarter of up to 45% higher than the volume in the non-pregnant woman, which among other functions, and it has to meet the metabolic demands of the uterus which develops a very hypertrophic vascular network and protect the pregnant woman against blood loss related to childbirth. These two functions paradoxically become a risk factor for the pregnant woman undergoing cesarean section since this modification in the vascular network increases the risk of injuring important vessels when surgically affecting or extracting the fetus through the hysterotomy, and on the other hand, hypervolemia favors the tendency of the obstetrician to underestimate the bleeding that occurs during surgery, causing an excess of confidence that ends up in most of the cases causing adverse effects [19].

It is generally accepted to limit the amount of bleeding to a maximum of 500 ml for a vaginal delivery and 1000 ml for the cesarean section, and in case of larger amounts, it is termed as obstetric hemorrhage. It is also accepted as a 10% decrease in hematocrit, although this starts after 4 h with a maximum limit of up to 48 h [19, 21].

It must be borne in mind that the indication of cesarean section "per se" implies a pathological background disorder such as the anomalous insertion of the placenta, maternal hypertension, the infection, prolonged labor, uterine overdistention, and so on, which are factors that significantly alter the vascular network and uterine contractility, increasing the bleeding caused by the same vascular damage during the surgical act which increases when there is difficulty in extracting the fetus since it can easily tear the hysterotomy causing greater vascular damage [3, 4, 14–21].

In **Table 1**, we see the most frequent risk factors that are associated with bleeding as a complication of the cesarean section.

The treatment of the hemorrhage depends on the cause, and hemorrhage can precede the indication of cesarean section as in the low insertion of placenta or the premature detachment of placenta or appear in the course or even after surgery. **Figure 1** shows the placental bed invaded by the trophoblast.

The treatment should start with a quick and precise diagnosis of the origin of the hemorrhage accompanied by measures that maintain an adequate hemodynamics with intravenous solutions of preferably isotonic crystalloids in which blood is obtained for immediate transfusions, taking care not to pass more than 2000 ml of liquids that can cause an acute pulmonary edema or lead to a coagulopathy by dilution, and fresh blood or alternate erythrocyte concentrates should be administered with fresh frozen plasma for the immediate replacement of coagulation factors; immediate cleaning of the uterine cavity at the same time of a uterine massage applied in a uniform and compressive manner. Most of the time, it achieves the

Low insertion of placenta
Placental acretism
Placenta abruption
Hypotonia/uterine atony
Multiple pregnancy, fetal macrosomia, polyhydramnios, Uterine scar
Arterial hypertension
Multiparity
Obesity
Chorioamnionitis
Prolonged labor
Poor technique and prolonged surgical time

Table 1. Risk factor for hemorrhage.

Figure 1. Placenta accreta invading the uterine muscle layer.

adequate contraction of the uterus, and if it is not achieved, it must be started with the administration of the following substances to contract the uterus [3, 4, 14–18, 22–24]:

- Oxytocin. Apply 10 units in a slow intravenous form followed by a continuous infusion with 20–40 units taking care of the hypotension caused by the vasodilatation.
- Ergometrine. It is applied in doses of 0.2 mg intramuscularly and with minimum intervals of every 6 h, the main side effect is hypertension, especially with previous history of the same.
- Carbetocin. It is a synthetic analog of oxytocin with a long-acting synthetic analog of oxytocin that has a rapid and prolonged action, initiating its effect at 2 min and lasting up to 2 h intramuscularly and can be administered in slow intravenous form. It is administered as a single dose of 100 μg.
- Misoprostol. Analog of prostaglandin E1 is administered in a dose of 600–800 μg rectally obtaining an uterotonic effect 10 min after its administration, being possible to repeat doses with intervals of every 6 h.
- Tranexamic acid. It is an antifibrinolytic that is administered at a dose of 1 g in an intravenous bolus and can be continued in perfusion of 1 g for 8 h. Care should be taken in patients with a history of thromboembolic diseases.

If there is no response to the previous measures, it will be attempted to stop the bleeding by applying an intrauterine tamponade that can be immediately with textile compresses and if you have the resource, try latex or silicone balloons of the Sengstaken-Blackmore, Rush or Bakri type that act by increasing intrauterine pressure compressing the vascular network until hemostasis is achieved by hemostatic physiological mechanisms [25, 26].

If there is no recourse to the balloons, a compressive suture will be attempted.

If at the moment of compressing the uterus bimanually, a decrease in the hemorrhage is observed, it can be expected that by maintaining this compression with a suture, the cessation

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of the hemorrhage will be achieved. B-Lynch described in 1997 a simple technique without ligating the uterine artery to control the obstetric hemorrhage that consists of passing a suture of chromic catgut of number 2 beginning under the uterine incision toward the interior of the cavity, later it is incised toward the outside above the incision to surround the uterine fundus and re-enter the cavity through the posterior part at the level of the segment, the same maneuver is carried out in reverse form on the opposite side leaving the cavity from the back to finish in the anterior face below the hysterotomy, nesting firmly and with adequate traction (**Figure 2**).

Since its creation, several authors have described modifications to the original technique; however, all handle the same concept, that is, uterine compression [27, 28].

Arterial ligation is a frequently used resource, especially when it is desired to preserve the reproductive function. Hemorrhage control is carried out by lowering the blood pressure without suppressing the uterine irrigation that continues through the collateral network where there is less pressure, allowing coagulation to be carried out adequately with the subsequent formation of a clot that will not be removed by the arterial pulse. The uterine artery is ligated in a primary form on the side near where the bleeding originates predominantly, if the entire surface is the ligature is performed bilaterally accompanied by the ovarian arteries. This resolves a high percentage of cases of uterine atony; otherwise, it is opted for the ligation of the hypogastric arteries.

Some hospitals have material resources and personnel specialized in interventional radiology with sufficient experience to perform an embolization of the pelvic arteries through an angiogram, being an adequate resource in a very high percentage to stop the hemorrhage and preserve the reproductive function [18].

If all the above is not enough to stop the hemorrhage, then the indication to carry out a hysterectomy appears, which can be performed subtotally given the haste and critical conditions in which most of the patients are, as well as being a surgery which implies greater difficulty due mainly to the vascular changes that arise with pregnancy. With this procedure, if there are

Figure 2. B-lynch technique.

still no significant alterations in the coagulation, the problem is solved in its entirety since the origin of the hemorrhage is removed, although the reproductive function is lost [17, 20, 21].

While there is no new technology and adequate measures to control bleeding, the above described will continue to be the best option for the management of this serious complication.

3. Urological injuries

Often the cesarean section involves careful dissections to reject the bladder, so that it can sometimes be injured. It is the most common lesion in urinary organs, although sometimes the ureter can be damaged by causing obstruction by ligature or angulation and partial or complete section.

Bladder injury can occur when the peritoneum is opened if care is not taken to empty it adequately through a catheter or in cases of previous surgeries that firmly attach the bladder to the anterior side of the uterus where it is also common to find a large engorgement of the venous plexus that easily breaks, complicating the dissection by the hemorrhage provoked. When tears of the hysterotomy occur, they can be prolonged to the bladder damaging it.

It is necessary to identify the bladder lesion well and outline the extension well. The repair is carried out with the inversion of the tissues in two planes with chromic catgut or vicryl 00, and it is important not to leave the suture under tension since it favors the appearance of fistulas. Always immobilize the bladder with a permanent catheter for at least 10 days. The appropriate closure should be confirmed with the instillation of methylene blue or when the resource is available, a cystoscopy is performed at the end of the closure. Sometimes, only the muscular layer is damaged, finding the mucosa intact, in which case, it must be repaired with chromic catgut 000 since they can easily produce fistulas.

The most frequent site of ureteral injury is in the bladder or in the junction with the uterine vessels, especially when the bladder is not rejected properly, being more frequent when a hysterectomy is performed. The injury is mostly possible when the cesarean section is performed urgently.

Bladder injury is easily recognized in the course of surgery, but not the ureteral injury that should be suspected at the time to be diagnosed in a timely manner. When we suspect we have to dissect the path in question to achieve an adequate identification of the problem, in case of section, it is convenient to request the intervention of an experienced surgeon or an urologist to perform the immediate anastomosis, if there is only an angulation by a suture, and it is corrected by removing the latter.

When the repair of damage is done immediate, morbidity is greatly reduced [29–32].

3.1. Intestinal lesions

Intestinal lesions are extremely rare in the cesarean section, and when they occur, they are usually secondary to an urgent abdominal approach with intestinal adhesions to the anterior wall in cases of previous surgeries almost always non-obstetric. When an intestinal lesion is

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identified, it is convenient to "mark" the damaged site with a wet compress since, if it is not done, the injured area is easily lost, and after the uterus closes, it is repaired [1, 6, 10].

3.2. Anesthetic complications

They are very rare but when they occur, they are accompanied by high morbidity, becoming lethal.

In regional anesthesia, the most frequent are hypotension caused by sympathetic nerve block aggravated by aorto-cava compression that produces the pregnant uterus in the supine position, and it is solved with intravenous fluids prior to the event, with change of position to lateral decubitus and the use of ephedrine that has a vasoconstrictor effect without affecting the placental flow.

Another complication is headache by puncture of the arachnoid hard membranes that cause an escape of cerebrospinal fluid with loss of cushioning effect. It is solved with the application of a blood patch in the epidural space.

Finally, there may be a total blockage causing a respiratory arrest that forces to handle the airway with the difficulties that this implies in the pregnant patient.

General anesthesia presents the failed airway intubation as a main problem secondary to the difficulty implied by the pregnant woman due to an increase in body mass and decreased functional lung capacity. In most cases, it is resolved by temporarily deferring the surgery initiating 100% lime oxygenation with a face mask and the appropriate position of the head and neck. However, the deferral of the cesarean section, most of the time, it may not be possible due to the urgent indication of it.

Another complication of general anesthesia is the chemical pneumonitis by aspiration of gastric contents which has an unfavorable prognosis [33–37].

Fetal lesions with the scalpel when the uterus impinges are reported with a very low frequency, on average of less than 1%, and most of the occasions occur when there is an indication to extract the fetus with urgency. This frequency is higher in school hospitals due to the lack of experience of the obstetric surgeon in training [38].

4. Early postsurgical complications

4.1. Hemorrhage

Postsurgical hemorrhage occurs mainly due to hypotonia or uterine atony that is managed with sustained uterotonic medications during the following hours after the surgery; however, when there is no favorable response, the same sequence of treatment of trans-surgical hemorrhage must be followed. Less frequently, it is due to a poor technique in the repair of the surgical planes, favoring the formation of bruises that, when they extend, can dissect the adjacent tissues in an important way. Another cause is the defects in the coagulation either by the pathology previous to the event as in the case of preeclampsia or due to the consumption of

factors when a severe hemorrhage occurs. Finally, in few occasions, it can be due to the retention of placental remains, which is managed with the extraction by means of an instrumental curettage of the uterine cavity [1, 2, 7, 12, 14].

4.2. Infection

The infection in most of the times is the result of a reciprocal action between the defenses of the host and the virulence of the germs, nevertheless in obstetrics unlike the other specialties, the immune state acts only in rare occasions as a factor of important selection. The increase in the number of leukocytes that occurs in pregnancy is maximum at the end of it, increasing the defenses and also has a higher bactericidal activity than in the non-pregnant women.

Most patients become infected with their own microflora, which depends on factors such as duration of labor, time of rupture of the chorioamniotic membranes, multiple vaginal examinations, nutritional status of the patient, deficient aseptic techniques and surgical time. Infection during cesarean section is one of the most frequent complications, and the main reason for hospital re-admission, which consequently increasing costs [39–44].

Almost 30 years after completing two centuries in which Ignatz Semmelweis established his concepts about asepsis in obstetrics and importantly in surgery, we are still surprised that the deficient asepsis, in most of the times due to excess of confidence acquired from the beginning of the antibiotic era, continues to be a risk factor for the appearance of obstetric infection, mainly during cesarean section [45].

It is well known that postpartum endometritis occurs approximately 5–20 times more frequently and with greater severity in the cesarean section than in vaginal delivery, thus becoming the major risk factor mainly due to situations involving uterine manipulation, instrumental contamination and sutures that cause ischemia and tissue necrosis, which favors the development of an infection.

Endometritis has a multiple microbial origin, and more frequently, aerobic Gram-positive cocci and Gram-positive anaerobic bacilli are found. In **Table 2**, we observe the most frequent microorganisms.

The diagnosis is made by clinic where we find the presence of fever, hypogastric pain, fetid lochia and pain to the mobilization of the uterus, the laboratory shows a leukocytosis.

The treatment should be started once the culture samples have been taken, although most of the time, they are not very helpful because of the little reliable information they provide given the vaginal contamination and the delay in reporting.

The antibiotics of choice must be broad spectrum, in the majority of patients, the use of third-generation cephalosporins achieves a good result, and in cases of penicillin allergy, clindamycin can be used either alone or in combination with some aminoglycoside.

Endometritis can occur accompanied by infection of the surgical site or urinary tract, and in these cases, the quinolones become a good treatment option.

Aerobic:
Gram-positive cocci
Streptococcus
Enterococcus
Staphylococcus
Gram-negative
Escherichia coli
Klebsiella pneumoniae
Proteus mirabilis
Others
Corynebacterium vaginalis
Neisseria gonorrhoeae
Anaerobes:
Gram-positive cocci
Peptococcus
Peptoestreptococcus
Gram-positive bacilli
Clostridium
Gram-negative bacilli
Bacteroides bivius
Bacteroides fragilis

Table 2. Most frequent microorganisms in endometritis.

The infection of the surgical site before called surgical wound infection is caused by contamination, being the most frequent germ the coagulase-negative *Staphylococcus*. It occurs in a range of 3–15%. Cesarean section is considered contaminated when there is prolonged labor or rupture of membranes, in addition to various risk factors such as prolonged surgical time, poor tissue management, contaminated instruments, nutritional status and previous anemia or caused by surgery.

Figure 3 shows a sonographic image of pelvic abscesses after obstetric hysterectomy.

Infection happen during the following 30 days of the intervention, and it is classified as follows:

- Surface infection of the incision. It affects only the skin and the subcutaneous tissue at the site of the incision.
- Deep infection of the incision. It affects the aponeurotic fascia and the muscle.
- Organ or space infection. It involves any part of the anatomy other than the open or manipulated incision during the surgery.

Figure 3. Pelvic abscess *after obstetric hysterectomy*.

The treatment is based on adequate drainage performed in the exploration and the use of broad-spectrum antibiotics.

Since the antibiotic era, a significant decrease in the infection in cesarean section is observed, especially with the use of prophylactic antibiotics evidenced through multiple studies, and it is almost universally accepted nowadays, in the same way, there is increasing evidence of better results with the application prior to the incision and not after clamping the umbilical cord, although there is still controversy in this regard. The recommended antibiotic continues to be the first-generation cephalosporins.

However, prophylaxis remains debatable in that, it does not prevent more serious infections such as thrombophlebitis and pelvic abscess, so its use should be limited to cases where there is a high risk of infection such as prolonged labor, the rupture of long-lasting membranes and the indication of cesarean section in urgent form.

The incision in the abdominal wall acquires a great importance in the presence of complications since the transverse incisions restrict the surgical field in such a way that the vertical

Figure 4. Transverse abdominal infected wound.

middle incision seems the most suitable for obstetric approach although it has its esthetic disadvantages.

The prognosis regarding the possibility of infection or dehiscence depends more on performing an adequate technique than on the type of incision, although controversy still exists in this regard. In which does exist an agreement is that the infection in transverse incisions evolves in more torpid form when the subaponeurotic plane is affected [39–44, 46–51].

In **Figure 4**, we observed a transverse abdominal wound infected with purulent discharge at the edges.

5. Thromboembolisms

Thromboembolisms are more frequent in the cesarean section than in the vaginal delivery and are favored by the triad relatively common to the gestational term of venous stasis, hypercoagulability and endothelial injury. Symptoms at the site of thrombus formation are usually minimal or absent until detached and manifest as a pulmonary or pelvic embolism. The diagnosis is usually made by exclusion in those patients who have insidious fever accompanied by tachycardia and an inadequate response to treatment with antibiotics most of the time already established.

In the cases of pulmonary thromboembolism, the picture manifests suddenly with tachypnea, dyspnea, general malaise, severe chest pain and hemoptysis, and in severe forms, it progresses to the state of shock with a high percentage of mortality.

In the pelvic presentation, there is no local pain or malaise, and its manifestation is usually delayed, producing septic emboli mainly to the lung, manifesting initially as micropulmonary infarcts.

The treatment consists of immediate anticoagulation to end the obstruction and avoid new emboli. Unfractionated heparin is used in necessary doses until the activated partial thromboplastin time is lengthened up to 1.5–2 times over the control time. Most of the time, the recovery is amazing only with anticoagulation; however; it is necessary to modify the antimicrobial treatment with a double scheme that covers both Gram-positive and Gram-negative bacteria. Surgical intervention is rarely necessary to remove the clot [6, 39, 42, 52–56].

In **Figure 5**, we observed a contrast tomographic image of a major pulmonary thrombosis.

Postoperative ileus rarely occurs in the obstetric patient since little is manipulated in the intestine due to the pregnant uterus, and when it occurs, with fasting, parenteral solutions and the placement of a nasogastric tube is usually enough to solve it [4, 57].

Fetal complications are rare, and the most frequent is respiratory distress syndrome in terms of newborns mainly in elective cesarean section. The immediate transition required by the fetal lung filled with fluid to change it by air at birth occupies physiological mechanisms that accelerate with labor, so in the absence of this, a dysfunction of these mechanisms occurs and

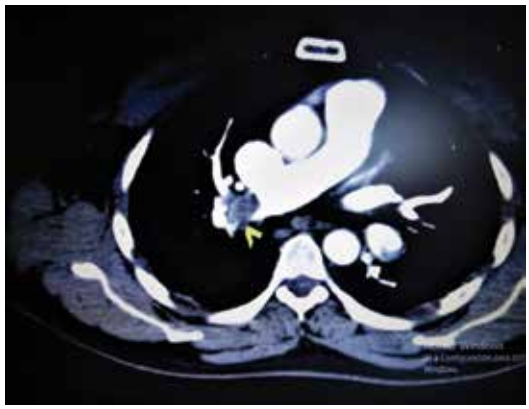

Figure 5. Pulmonary thromboembolism.

with a probable failure of the action of pulmonary surfactant. In some cases, mechanical ventilation with supplemental oxygenation and surfactant administration is required until the aforementioned adaptation is achieved [58–61].

6. Late postsurgical complications

Late postsurgical complications include endometriosis of the abdominal wall in the surgical scar, the formation of adhesions, and as an important sequel, the high possibility of low placental insertion, placental accreta or uterine rupture in later pregnancies.

Endometriosis is defined as the ectopic presence of tissue, whose histological and functional characteristics are identical to the endometrium. Secondary endometrial transplantation is performed secondarily to the surgical incision site manually, with instruments or through sutures during cesarean section with a frequency of less than 0.5%. The diagnosis is made by the antecedent of cesarean section accompanied by cyclic pain and is confirmed by the histological study. Cabinet studies are only useful for deep localization of lesions. The treatment consists of the surgical removal of the lesion in its entirety. Medical management does not provide good results in these cases [62, 63].

Adhesions that occur during abdominal surgeries tend to occur with a high frequency, and there is increasing evidence of long-term morbidity that results in intestinal obstruction as a more severe sequel, chronic pelvic pain and infertility, and in the case of later surgeries, difficulty in carrying them out increasing their morbidity.

In our case, there is important evidence that the greater the number of cesarean sections, the greater the possibility of developing adhesions, although a single cesarean section is not exempt in fact. The presence of adhesions becomes more important when the indication for gynecological causes of performing a hysterectomy appears since it increases morbidity.

Modifications to surgical techniques have not yet been adequately evaluated in the long term such as the decision not to close the peritoneum, and more conclusive evidence is needed regarding the formation or not of adhesions [64–73].

The surgical scar of the cesarean section is considered the main risk for low placenta insertion and placental accreta in subsequent pregnancies. It is also the main risk factor for uterine rupture when a labor test is performed, increasing the possibility of rupture by five times when there are two previous cesarean sections compared to when there is only one.

It can be concluded that the best way to prevent complications in cesarean section is not to indicate an unnecessary one. It is a reality that the inevitable increase in the frequency of the operation worldwide and increasingly with new indications motivated by the most known factors such as better techniques and surgical concepts, surgical materials, the best hospital infrastructure, greater pressure in medical treatment for a high incidence of legal demands but also exist popular concepts that favor the request of completion of pregnancy through the abdomen, whether for esthetics, poorly understood comfort or some other medical justifications that are enough to convince the obstetrician to perform it.

All of the above lead us to question the following: is the cesarean section performed by a justified indication or by a justified concern?

There are also more and more situations around pregnancy that imply an increase in the risk of pregnancy itself such as the tendency to postpone the first pregnancy at a later age, obesity, treatments to promote fertility and others that go beyond the hand with an increase in risk in case of indicating a cesarean section.

When complications occur, the impact on cost is truly important not only because they affect maternal health, but also because of the psychological damage that occurs in the mother-child relationship by prolonging hospital stay and altering home convalescence.

The tendency to limit the number of cesarean sections must be considered seriously for the benefit of the patient since, in addition to preventing the complications that potentially exist in each event, they have a favorable impact on economic, social and reproductive aspects.

It will never be stopped insisting that the identified risk factors may not be so important if proper precautions are taken and a real responsibility is assumed, first in indicating the cesarean section and then when doing it.

Knowledge of the gestational pathophysiology gives us the ability to make appropriate decisions, and when the intervention is timely and accurate in most cases, the possibility of harm is avoided. For the abovementioned intervention, basic concepts such as the careful management of tissues, use of appropriate instruments and minimize surgical time should be kept in mind as much as possible [1, 2, 4, 6, 8–10, 75].

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Section 5

Future Considerations

Chapter 7

Caesarean Section: Reasons for and Actions to Prevent Unnecessary Caesareans

Ylva Vladic Stjernholm

Additional information is available at the end of the chapter

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Abstract

According to data from 150 countries, the worldwide caesarean section rate increased from 7% in 1990 to 19% in 2014. Latin America and the Caribbean region reported the highest CS rate 42%, followed by North America 32%, Oceania 31%, Europe 25%, Asia 19%, and Africa 7%. This trend is accompanied by increasing reports of severe adverse outcomes, such as invasive placenta, peripartum hysterectomy, and massive obstetric bleeding. The World Health Organization stated in 2015 that caesareans are effective in saving maternal and infant lives only when they are required for medically indicated reasons and that caesarean rates higher than 10–15% at a population level are not associated with reduced maternal or newborn mortality rates. More than 90% of women claim that they want to give birth in a natural way. In contrast, recent studies suggest that the majority of planned caesareans are carried out for psychosocial or nonmedical reasons. Knowledge about the indications for caesareans is a prerequisite in order to define actions to prevent unnecessary caesareans. The aim of this chapter was to present a review of the history behind, and to evaluate the indications for, caesarean sections in order to suggest appropriate actions to prevent unnecessary caesareans.

Keywords: caesarean section, complication, delivery, fear, fetal distress, indication, labor, team

1. Introduction

1.1. Caesarean section rates

Caesarean section (CS) rates continue to rise, particularly in middle- and high-income countries without evidence for maternal and perinatal benefits from the increase. According to

data from 150 countries, the worldwide CS rate increased from 7% in 1990 to 19% in 2014. Latin America and the Caribbean region reported the highest CS rate, 42%, followed by North America, 32%, Oceania, 31%, Europe, 25%, Asia, 19%, and Africa, 7% (**Figure 1**) [1] .

1.2. Definition

A CS is the delivery of a fetus through an abdominal incision (laparotomy) followed by a uterine incision (uterotomy), regardless of whether the fetus is alive or dead.

1.3. Categorization

A CS is categorized as planned (elective) when performed 8 h or more after the decision, usually before labor onset, and urgent when carried out between 30 min and 8 h after decision. Immediate caesareans are performed within 15–30 min due to an immediate threat to maternal or fetal health.

1.4. The Robson classification system

The lack of a standardized classification system to monitor and compare CS rates between obstetric units, regions and countries has hindered a better understanding of the increasing trend. In 2011, a systematic review of classifications for CS concluded that the Robson

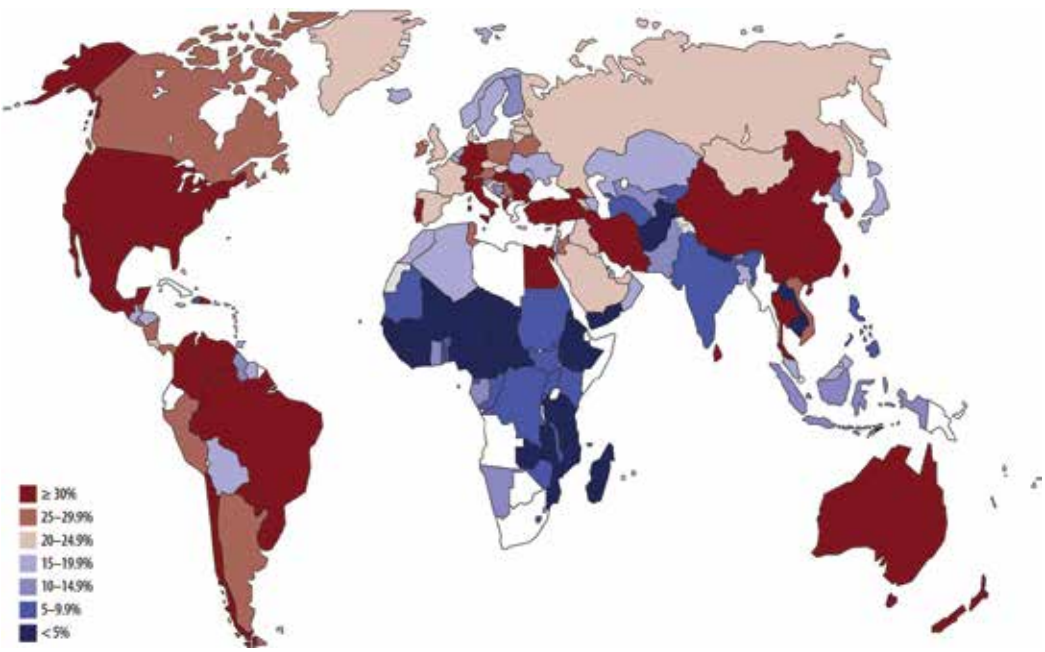

Figure 1. Worldwide caesarean section rates. From Betrán et al. [1].

classification would be the optimal system. Proposed in 2001, the Robson system classifies women into 10 groups based on their obstetric characteristics—parity, gestational age, onset of labor, fetal presentation, previous CS and the number of fetuses. The system can be applied prospectively and every woman who is admitted for delivery can be classified based on these characteristics [2, 3].

2. Historic background

2.1. Ancient cultures

Referrals to abdominal delivery appear in the Indian epos *Ayurveda* (Knowledge of Life), 3300 BC, as well as in scriptures and pictures from ancient Persia, Egypt and China. Evidence that CS was performed arises from legal texts, such as a tablet describing the adoption of a little boy during the 23rd year of the Babylonian king Hammurabi (1795–1750 BC).

The ancient Jewish scriptures Talmud and Mishna, the collection of ancient Jewish laws (200 BC–600 AD), describe caesareans on living women who survived the operation. Postmortem caesareans were also performed [4].

The Roman *Leges Regiae* (Royal Laws) from 600 BC forbids the burial of a pregnant woman before extraction of the child from the uterus. When Rome became the Roman Empire, the law was named *"Lex caesarea."* According to Greek mythology, Asclepius, founder of the medicine cult, was removed from his mother Coronis´ abdomen by his father Apollo. [5]. The origin of *caesarean* is commonly believed to be derived from the surgical birth of Julius Caesar (100–44 BC), which has been considered unlikely since his mother was reported to have lived to hear of her son's invasion of Britain. Other possible Latin origins include the verb *caedare*, to cut, and the term *caesones* for infants born by postmortem operations (**Figure 2**) [6].

2.2. The medieval period

In the early medieval period, a CS was often performed by midwives [7]. Postmortem caesarean section was encouraged in order to secure baptism of the child. The Catholic theologian and philosopher St. Thomas Aquinas (1225–1274) stated that the mother must not be killed in order to deliver the child [8]. Islamic authorities favored postmortem caesareans, according to Imam Abu Hanifeh (699–767) . However, there are no referrals to caesareans in "The book of enabling him to manage who cannot cope with the complications" by Albucasis (Abul Qasim Al-Zahrawi, 936–1013), a leading book of surgery in Europe during five centuries.

2.3. Renaissance and modern ages

In 1500, a successful caesarean on a living woman who survived the operation was reported performed by Jacob Nufer, Switzerland. The woman (his wife) was unable to deliver her baby

Figure 2. The extraction of Asclepius from his mother Coronis´ abdomen by his father Apollo. Woodcut from De Re Medica (1549) Alessandro Beneditti.

after several days in obstructed labor and despite help from many midwives. Her desperate husband gained permission from the local authorities to attempt a caesarean. The mother survived and subsequently went through several deliveries. The caesarean child lived until an older age. Success factors were that the caesarean was performed at an early opening stage, that it was performed in the house and that Nufer must have had anatomical knowledge because of his work with animal care. The story was not recorded until 1582; its accuracy has been questioned [9]. In 1581, the French physician François Rousset published a book with the subtitle "The extraction of a child through a lateral incision of the abdomen and the uterus of a pregnant woman who cannot otherwise give birth. And that without endangering the life of the one or another and without preventing subsequent fertility," where he suggested caesareans on living women for indications such as large fetus, dead fetus, twins, malpresentation, extremely young or elderly mother or narrow pelvis. In support of this proposal were 10 observations, of which he personally took part in a few without operating, as he was not a surgeon [10].

In the early 1500s, the British Chamberlen clan introduced instrumental forceps delivery to pull the fetus from the birth canal during obstructed labor. During the following 300 years, the male midwife and obstetrician gradually wrested influence over deliveries from female midwives [9, 11].

Until the 1600s, the procedure was known as a caesarean operation. In a book on midwifery, 1598, published by the French surgeon Jacques Guillimeau, the term "section" was introduced and thereafter replaced "operation" [12].

2.4. Industrialization and malnutrition in Western countries increase the need for caesareans

Increasing urbanization due to industrialization in Western countries in the 1800s led to an increased need for caesareans. City children suffered from malnutrition and lack of sunlight,

which caused vitamin D deficiency and rachitis. Still, at the early 1900s, women commonly died in childbirth due to rachitic pelvis. When pasteurized milk became available in the 1930s, insufficient bone growth became less common [13].

2.5. Africa

In Uganda, 1879, the catholic missionary Robert Felkin observed a caesarean [14]. He concluded that the operative technique was well developed and had been used for a long time. The surgeons used anesthesia and antiseptics (banana wine), a low abdominal midline incision and a blunt uterine incision with the assistant holding up the sides of the abdomen wall with two fingers into the uterus. The child was removed, the cord cut and the child handed to an assistant. The placenta was removed, the cervix manually dilated allowing for blood to escape, manual compression of the uterus was carried out without suturing it and red irons were used to coagulate bleeding points. The peritoneum, abdominal wall and skin were approximated and closed with seven iron needles, which were removed within 1 week. A root paste was applied over the wound and covered by a cloth bandage. Felkin observed the woman for 11 days, and when he left the mother and infant both were alive and well. Similar reports are known from other African regions, where botanical preparations were also used to anesthetize the woman and promote wound healing.

2.6. Centralization of obstetric care, mobilization, blood transfusion, antibiotics, uterotonics and anesthesia

Since the 1940s, the trend toward medically managed pregnancy and childbirth has proceeded. Centralization of obstetric and neonatal care has led to decreasing maternal and perinatal mortality. In Sweden, 1900, approximately 10% of births took place in hospitals, which increased to 75% in the 1940s [15]. Maternal mortality declined when early mobilization after childbirth was practiced and after the introduction of blood transfusions, uterotonics, antibiotics and anesthesia.

Mobilization: Maternal mortality due to pulmonary embolism declined when early mobilization instead of bed rest during 1–2 weeks after childbirth was advised.

Blood transfusions: The main blood groups A, B and O were distinguished by the biologist and immunologist Karl Landsteiner, 1900. Based on these findings, the first successful blood transfusion was performed in 1907 in the United States [16].

Antibiotics: Sulfonamide drugs were introduced as the first antibiotics in the 1930s. Penicillin was generally available in the 1940s after its discovery by Fleming in United Kingdom, 1928, and subsequent purification [17].

Uterotonics: Ergometrine has been the most important drug for treatment of postpartum hemorrhage, a major cause of maternal mortality. "Ergot of rye has been known to possess deleterious and poisonous qualities for more than 800 years, and it has been used on the continent by female midwives as a promoter of labor pains for nearly 150 years," according to Francis Ramsbotham, founder of the Obstetrical Society of London 1841. In 1954, the uterotonic octapeptide amide oxytocin was described by Vincent du Vigneaud in the United States, and 1 year later oxytocin was synthesized [18].

Anesthesia: Nitrous oxide (laughing gas) was used as an anesthetic, 1799, and ether was demonstrated in 1846. Chloroform/ether was introduced in obstetrics, 1847, by Sir James Young Simpson, Professor in Midwifery in Edinburgh, Scotland, after self-experimentation and despite the criticism from many obstetricians in Europe and the United States. Anesthesia was often provided by nurses, of whom many were recruited among nuns from the convents [19]. In the 1900s, regional anesthesia and the general anesthetic halothane became available after being tumultuously developed with self-experiments. The initial enthusiasm was followed by skepticism and development of new drugs from the 1930s to 1950s [20].

3. Operative techniques

As anesthesia and aseptics developed, obstetricians were able to concentrate on improvement of the operative techniques for cesareans.

3.1. Classical caesarean

Until the 1800s, caesareans were performed with midline laparotomy and vertical corporal uterotomy without closing the uterus, which resulted in mortality rates of 85–100% among women delivered by caesarean. The main reasons for caesareans were obstructed labor, often for days with a dead fetus. The main reasons for maternal mortality were hemorrhage, "exhaustion," septicemia and eclampsia [21].

3.2. The Porro technique

In 1876, the Italian obstetrician Eduardo Porro suggested a caesarean technique performing a subtotal hysterectomy with extirpation of the ovaries after delivery of the infant, in order to reduce hemorrhage and infection. This method claimed to result in more than 50% maternal survival [22].

3.3. Vaginal cesarean

Between the 1880s and 1925, surgeons suggested transverse incisions in the lower uterine segment. Also, vaginal caesareans were carried out, in order to reduce peritonitis and septicemia. The need for vaginal caesareans ceased after World War II by the development of antibiotics [9].

3.4. The Pfannenstiel-Kerr method

In 1897, Johannes Pfannenstiel in Germany documented a transverse abdominal incision just above the symphysis pubis [23]. In 1926, the British obstetrician John Munro Kerr reported a low transverse uterine incision, double-layer uterine sutures and peritoneal closure. This technique reduced maternal mortality and lowered the risk for uterine rupture in a subsequent

pregnancy. It was combined either with a low midline or a transverse abdominal incision, known as the Pfannenstiel-Kerr procedure, and gained acceptance in the 1940s [24].

3.5. The Misgav Ladach method

In 1972, Joel-Cohen and colleagues reported a new method for CS, which had first been used for hysterectomy, with a transverse laparotomy 5 cm above the symphysis pubis and blunt dissection of the abdominal wall. In the 1990s, one layer suture of the uterus and nonclosure of the peritoneum were recommended [25, 26]. This technique was first evaluated by Stark and colleagues in 1995 and was named after the Misgav Ladach Hospital in Jerusalem, Israel, where it was developed [27]. Today, many clinicians practice a modified Misgav Ladach method, with a skin incision 3–4 cm above the symphysis pubis. This technique reduces the risk of bladder injury, bleeding and pain compared with the Pfannenstiel method (**Figure 3**) [28].

Uterine closure: The idea to close the uterus was introduced by Lebas in France in the 1700s, suggested in certain situations by Harris in the Unites States in the 1800s, and first reported in 1882 by Max Sanger (Saumlnger) in Germany. Uterine closure with silver and silk sutures reduced maternal mortality significantly [29]. Silver threads had been launched into the gynecological field by the American surgeon James Marion Sims, who performed experimental surgery on postdelivery vesico-vaginal fistulas on enslaved, unanesthesized women in Alabama, United States.

The role of a single- or double-layer uterine closure for reducing subsequent uterine rupture has long been debated. According to randomized trials, the short-term complications are similar with either technique, but long-term follow-up is missing [30–32]. Locked sutures shall not be used, since they increase the risk of uterine ischemia and dehiscence [30, 33]. A single-layer suture of the uterotomy has been recommended by several authors [32]. However, a

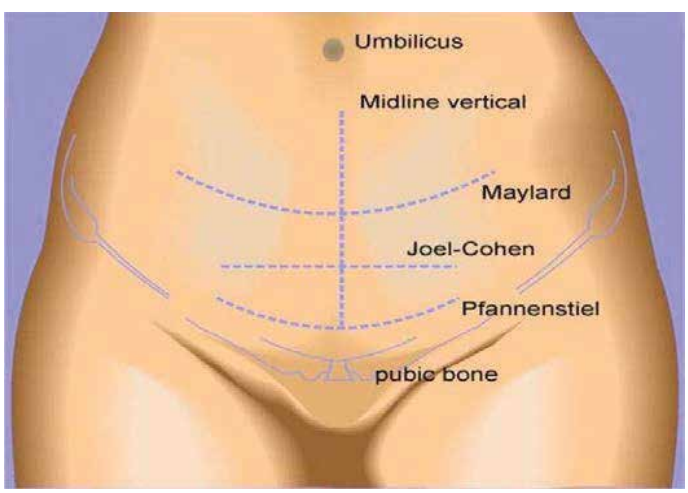

Figure 3. The Joel-Cohen, Midline and Pfannenstiel abdominal wall incisions.

double-layer closure is related to a 4-fold reduction of subsequent uterine rupture compared with a single-layer closure [34]. Also, ultrasound investigations show a higher myometrial thickness after a double-layer closure [35, 36]. It is noted that besides the uterine closure technique several factors influence the risk of subsequent uterine rupture, such as labor progress [37], increasing maternal age and body mass index (BMI) [38, 39], short interpregnancy interval [40]; induced labor and method for labor induction [40–43] as well as fetal weight [38, 44].

Removal of the placenta: External compression of the uterus at caesarean, rather than manual removal of the placenta is recommended to reduce bleeding. The risk of postoperative endometritis was comparable with the two techniques and independent of whether the uterus was externalized or not during surgery. Manual or instrumental dilatation of the cervix did not reduce the risk of postoperative endometritis. Hematometra was not evaluated in the studies [31, 32].

Closure of the abdominal wall: Historically, both the urterovisceral and parietal peritoneum were closed during caesarean. This strategy was abandoned when it was shown that non-closure of the peritoneum results in short-term advantages, such as shorter operative time, reduced risk of intra-abdominal hematomas and adhesions, postoperative analgetic requirement and shorter hospital stay [45, 46]. However, adaptation of the rectus muscle reduces the risk of rectus diastasis and may also reduce the risk of adhesions between the uterus and abdominal wall [46]. Closure of the external fascia of the abdominal wall with resorbable PDS suture is recommended to minimalize the risk of abdominal wall hernias [47]. Closure of the subcutaneous fat regardless of thickness reduces the risk of hematomas [48]. Skin closure of a transversal skin incision with sutures reduces the risk of wound complications as compared to staples. However, a midline laparotomy requires a robust closing technique [49].

Uterotonics: Low-dose oxytocin 2.5 U reduces preoperative bleeding during caesarean as efficiently as a high dose of 15 U. Oxytocin must be administered with care, because of the risk for cardiac arrhythmias, heart incompensation and pulmonary edema, particularly after doses of 30 U or more [50].

Prophylactic antibiotics: The effectiveness of prophylactic antibiotics depends on their presence in adequate concentrations during the operative period. Prophylactic antibiotic administration is recommended during emergency and immediate caesareans and by some authors also at elective caesareans. A single dose of cephalosporin is as effective as repeated doses of broad-spectrum antibiotics [51]. Preoperative administration within 15 min − 2 h before surgery is associated with a lower incidence of endometritis and wound infection as compared to intraoperative administration. It is noted that *in utero* exposure of a fetus to antibiotics is related to the development of allergy during infancy [52].

4. Indications for caesarean section

More than 90% of pregnant women claim that they want to give birth in a natural way [53]. In contrast, recent studies suggest that the majority of planned caesareans are carried out for psychosocial or nonmedical reasons [54, 55]. Interestingly, 80% of women who experience obstetric complications neither consider the birth a negative overall experience nor develop fear of vaginal delivery [56].

4.1. Planned caesareans

Historically, the primary indications for planned caesareans have been malpresentation, previous uterine scar, narrow pelvis and twin pregnancies with the first twin in a breech presentation [54, 57]. According to recent studies, the most common indications today appear to be psychosocial/nonmedical reasons, defined as fear of vaginal birth or maternal request without any co-existing medical indication in women with simplex cephalic pregnancy at a normal gestational age [54, 55]. Secondary fear of vaginal delivery after a negative birth experience was reported by 60% of these women (2.7% of all deliveries), primary fear of vaginal delivery by 34% (1.5%), whereas 5% (0.2%) was related to a pre-existing psychiatric health disorder such as severe depression, bipolar disease or an attention deficit disorder, and 1% (0.04%) was carried out on maternal request without further explanation. Fear of vaginal delivery is related to psychosocial burdens such as anxiety, depression, abuse, violence and a negative birth experience [53, 56, 58, 59]. The dominant Robson Classification Groups in Sweden 2015 were Group 2 (primiparous women with single cephalic pregnancy 37 weeks or more, who either had labor induced or were delivered by CS before labor) and Group 5 (multiparous women with single cephalic pregnancy 37 weeks or more and at least one previous uterine scar) [60].

4.2. Urgent caesareans

Most urgent caesareans are carried out because of prolonged labor (labor dystocia) [54, 55, 61–64]. Prolonged labor is related to fetal malpresentations such as occipital posterior presentation or asynklitism in approximately 15% [55, 62]. Lack of support during delivery, high maternal age, high BMI and induced labor are risk factors for prolonged labor [39, 65, 66]. The second most common reported indication for urgent caesareans is imminent fetal distress [37, 54, 55, 62, 67].

4.3. Immediate caesareans

Immediate caesareans are performed because of immediate threats to maternal or fetal health, which include signs of immediate fetal distress according to cardiotocography (CTG) or fetal scalp blood lactate sampling, placental abruption, umbilical cord prolapse and severe preeclampsia [55, 62, 67].

4.4. Preterm caesareans

The rate of preterm caesareans has increased during the 2000s as a result of altered clinical guidelines recommending referral of women with threatening preterm birth to a tertiary hospital and active management including urgent caesareans at an earlier gestational age [68]. This development motivates long-term follow-up of maternal and child health, since preterm caesareans between 24 and 33 weeks reduce neonatal mortality and morbidity only when performed because of urgent fetal distress or a breech presentation [69]. Preterm caesareans more often require a high uterine corporal myometrial incision than term caesareans, due to an inadequately developed lower uterine segment in preterm gestation. This technique increases the risk of subsequent pathological placentation and uterine rupture compared with a low-transverse uterine incision [70].

5. Vaginal birth after caesarean

By the quote "once a caesarean, always a caesarean," 1916, the American physician Edwin Craigin urged his colleagues to avoid unnecessary caesareans and emphasized that one of the risks of a primary caesarean is that repeat operations might be required [71]. This piece of advice is more actual than ever in today's obstetric care, when the rate of vaginal birth after caesarean (VBAC) is less than 10% in some countries [55, 63, 64, 72]. Trial of VBAC after one CS results in successful vaginal delivery in 80% with a 0.5–1% risk of uterine rupture as compared to a 0.05% risk of uterine rupture among women without a previous caesarean. The success rate is as high as 90% if the woman has a previous vaginal birth [43, 73, 74]. The risk of uterine rupture is increased by an interdelivery interval of less than 16 months [40]. Trial of VBAC is possible in most situations except after two situations, a high corporal uterine incision or three previous caesareans. The success rate of VBAC after two caesareans is approximately 70%, and the risk of uterine rupture may be higher, 1.5–2%, after 2 previous caesareans than after 1 previous caesarean [73, 75, 76].

6. Complications after caesarean

6.1. Short-term complications

6.1.1. Maternal

Mortality: A WHO global survey on maternal and perinatal health found that all caesareans including antepartum CS without medical indications are associated with severe maternal outcomes, such as an increased risk of death, admission to intensive care unit, blood transfusion and hysterectomy, as compared to vaginal delivery. In addition, this association is stronger in Africa, as compared to Asia and Latin America [77].

Amniotic fluid embolism: The risk for amnion fluid embolus is 2–5 times higher after CS compared with vaginal delivery [78].

Venous thromboembolism: The risk of venous thromboembolism increases by 10–15 times from early pregnancy, and further 2–8 times during caesarean, more during urgent CS in general anesthesia than planned CS in regional anesthesia [79].

Infections: Infections such as endometritis, urinary tract infection and wound infection are more common after caesarean than vaginal delivery [52].

Traumatic injury of bladder or intestine: Intraoperative traumatic bladder or intestine injury occurs in less than 1%, and the risk increases with increasing number of caesareans [80].

Postoperative pain: Postoperative pain after caesarean is shown to be more intense and persistent than was previously presumed [81].

6.1.2. Neonatal

Breast feeding: The onset of breast feeding is slower, and breast complications are more common after CS compared to vaginal delivery [82].

Neonatal breathing disturbances: Neonatal breathing disturbances are five times more common after caesarean (3.7 per 1000) compared with vaginal birth (0.7 per 1000). The risk diminishes if a planned CS is performed by 39 completed gestational weeks rather than earlier [83, 84].

6.2. Long-term complications

6.2.1. Woman

Abdominal adhesions: The risk of intra-abdominal adhesions increases with the number of caesareans [85, 86].

Placenta praevia: The risk of *placenta praevia*, where the placenta implants in the low uterine segment, covers the internal orifice of the uterine cervix (or internal os), through which the uterine cervix communicates with the uterine cavity and hinders vaginal delivery, increases with the number of scars in the lower uterine segment, mostly after caesarean section, vacuum aspiration or in vitro fertilization. The rate of *placenta praevia* increases from 0.5–1% after 1 caesarean and 2% after 2 caesareans [80].

Placenta accrete: Placental implantation in the lower uterine segment, which is composed mainly of connective tissue in contrast to the dominating smooth muscle in the uterine corpus, is the primary risk factor for abnormally invasive placenta *(placenta accreta).* This severe obstetric complication comprises a high risk of massive obstetric bleeding, complicated surgery and peripartum hysterectomy. Abnormally invasive placenta includes several types of trophoblast invasions into the uterine wall, in 70% invasion into less than 50% of the wall (*placenta accreta*), in 30% invasion in more than 50% of the wall (*increta*) or through the uterine wall (*percreta*) perhaps into adjacent organs such as the urinary bladder, abdominal wall or intestine [80, 87]. The rate of *placenta accreta* has increased during the past 30 years and is reported in 2–90 per 10,000 births [87]. The prevalence of *placenta accreta* among women with *placenta praevia* is 3% after 1 caesarean, 11% after 2 caesareans and 40% after 3 caesareans [80].

Peripartum hysterectomy: The reported prevalence of emergency peripartum hysterectomy, primarily because of abnormally invasive placenta, secondly because of atonic bleeding and thirdly uterine rupture, in the Nordic countries is 3–4 per 10,000 births, as compared to 7 per 10,000 births in Germany and 23 per 10,000 births in the United States [88]. The risk of peripartum hysterectomy due to *placenta accreta* increases with the number of caesareans, rising markedly after three caesareans to 2–3% [80].

Uterine rupture: The risk of uterine rupture during delivery is estimated to 0.05% among women without a previous caesarean, 0.5% after 1 caesarean and 1.5% after 2 caesareans [73]. Prolonged opening stage after 6–7 cm cervical dilatation was related to an increased risk of uterine rupture (**Figure 4**) [37] .

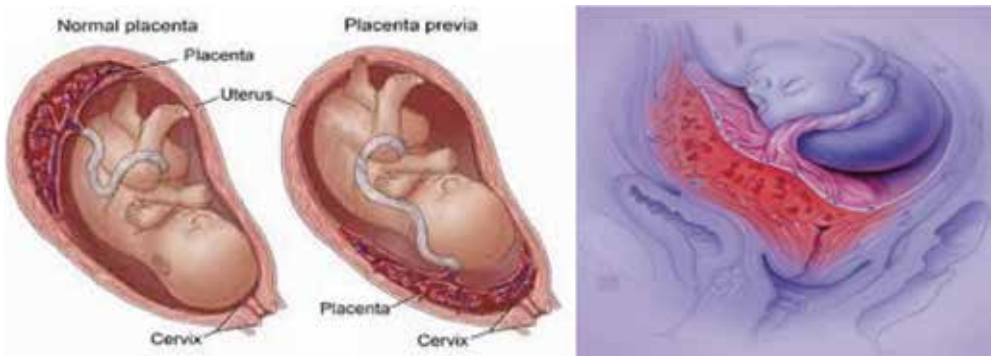

Figure 4. Placenta previa and abnormally invasive placenta, here *placenta percreta*. Source: Wikipedia.

Urinary and bowel incontinence: The prevalence of postpartum stress urinary incontinence is similar following spontaneous vaginal delivery and caesarean section performed for obstructed labor. It is quite possible that pelvic floor injury in such cases is already too extensive to be prevented by surgical intervention. Antepartal caesarean section was found to be associated with a lower rate of stress urinary incontinence. There is no difference between the groups after 2 years, and there is no difference at menopause between women with a previous vaginal delivery and women who never gave birth. It has been concluded that the pregnancy in itself leads to distension of pelvic ligaments and tissues. Caesareans do not protect against bowel incontinence [89, 90].

6.2.2. Child

Intestinal microbiota and obesity: Mode of delivery influences gut microbiota. Infants born by CS are exposed mainly to their mother's skin bacteria, in contrast to infants born vaginally, who become exposed to their mother's vaginal and intestinal microbiota. Thus, infants born by caesarean harbor more staphylococci and less bacterial diversity in the intestinal microbiota colonization. Such a pattern is linked with increased capacity for energy harvest and risk of overweight and obesity that persists throughout early adult life [91].

Allergy, diabetes mellitus and other autoimmune diseases: Delivery by CS has been associated with increased prevalence of asthma, allergies, diabetes mellitus, gluten intolerance and leukemia [92, 93]. Epigenetic changes of the genome have been suggested as possible molecular mechanisms for perinatal contributions to the later disease. It has been shown that infants born by CS exhibit higher DNA methylation in leucocytes compared with infants born with vaginal delivery [94].

7. Prevention of unnecessary cesareans

Actions to prevent unnecessary caesareans should focus on the main indications for caesarean sections' prolonged labor, imminent fetal distress, psychosocial/nonmedical

reasons and previous uterine scar [54, 55, 62, 72]. Recent studies have shown that normal labor progress during the opening stage is slower than 1 cm/h in all women, which was suggested by Emmanuel Friedman in the United States in the 1950s. Therefore, a slower progress than 1 cm/h is during the first stage of labor, which is not an indication for emergency caesarean in the absence of signs of fetal or maternal distress (**Figure 5**) [63, 64, 95].

Evidence-based management of labor, structured support during delivery, reduced labor induction and developed ability to perform instrumental deliveries instead of caesareans could be achieved through systematic theoretical education and team training programs on labor progress, fetal monitoring and delivery skills [55, 67, 96]. Such actions, taken together with structured counseling and support during pregnancy, would reduce planned caesareans due to psychosocial/nonmedical reasons or previous uterine scar. An increasing amount of evidence show that pregnancy-related anxiety is common and increasing with advancing pregnancy. A standardized definition of fear of vaginal delivery including an evidence-based scale for assessment of fear has been suggested [97]. Recommended systematic counseling and support for women fearing vaginal delivery include repeated meetings with a psychosocial team during pregnancy, objective information about benefits and risks related to different delivery modes including the influence on future reproductive health as well as support during delivery and planned follow-up after a negative birth experience [65, 98, 99].

Importantly, the attitudes among midwives and obstetricians influence a patient's choice [100]. A "coping attitude" rather than an "autonomy attitude" is strongly associated with a change in desire for a caesarean in women fearing vaginal delivery [59, 101].

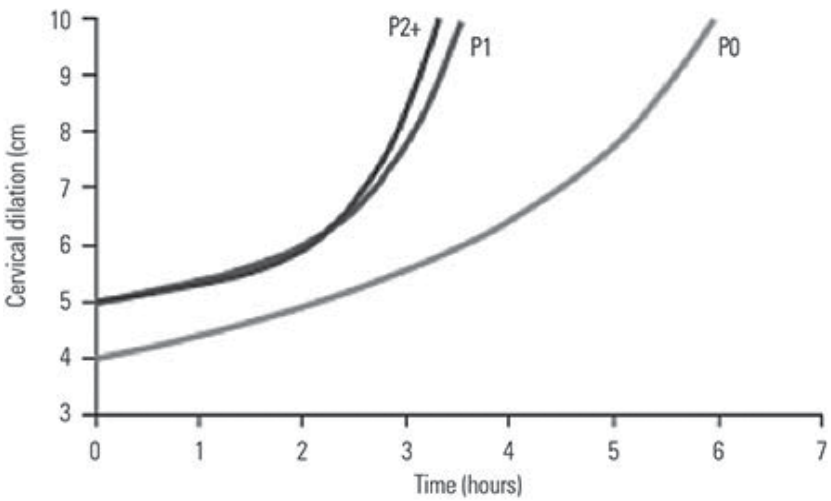

Figure 5. Average labor curves. From Zhang et al. [63].

8. World Health Organization recommendations

The World Health Organization (WHO) stated in 2015 that caesareans are effective in saving maternal and infant lives only when they are required for medically indicated reasons and that CS rates higher than 10–15% at a population level not associated with reduced maternal and newborn mortality rates [102].

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Chapter 8

Improving Obstetrical Outcomes in Cesarean Sections, by Utilizing Evidence-Based Strategies

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Additional information is available at the end of the chapter

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Abstract

Cesarean sections are the most commonly performed surgery in the USA. Changing policies and clinical information have resulted in improved outcomes for both mothers and babies. We describe evidence-based best practices for a multi-strategy approach to reduce cesarean section rates, increasing safety and success of vaginal births after cesarean section, decreasing complication rates in higher order cesarean sections, and accurate estimations of blood loss. In addition, we present a novel approach of utilizing venous lactate levels to identify the need for blood transfusions in the resuscitation of women with postpartum hemorrhage. Given that pregnancy is a life event, we describe increased self-reported stress levels in women during pregnancy and after the birth. In summary, adoption of the best practices outlined herein will greatly enhance the safe practice of cesarean sections.

Keywords: evidence based, best practices, cesarean section

1. Introduction

Cesarean sections are the most commonly performed surgical procedures in the USA, and account for approximately one-third of the 4 million annual live births. Cesarean sections can cause significant complications, disability or death, particularly in settings which lack the facilities to conduct safe surgeries or treat potential complications. Due to their increased cost, high rates of unnecessary cesarean sections can pull resources away from other services in overloaded and weak health systems.

The World Health Organization (WHO) recommends that medical practitioners should not undertake cesarean sections purely to meet a given target or rate, but rather focus on the needs of patients.

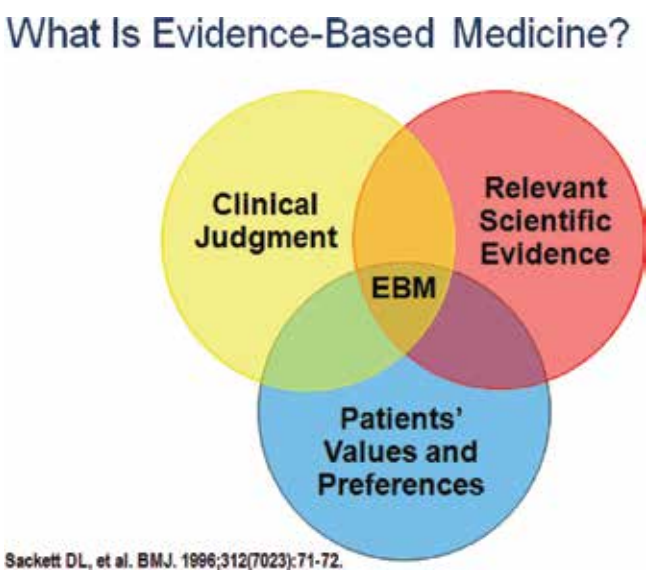

Figure 1. Evidence-based medicine (EBM).

Improved understanding of cesarean section rates has been hindered by the lack of a consistent, internationally accepted classification system to monitor, and compare cesarean section rates. To address this lack, WHO proposes the adoption of the Robson classification system, which can facilitate the comparison and analysis of cesarean rates within and between different facilities, and across countries and regions.

The World Health Organization (WHO) suggested rate is 10–15% [1], and the Healthy People 2020 recommends that the annual rate should decrease in low risk women with a singleton, term live born fetus with vertex presentation (STLV), from the current rate of 27–24% [2]. However, the US rate is much higher, being approximately 32% [3].

Utilizing evidence-based, best practices for the management of patients undergoing cesarean sections has contributed greatly to the improved outcomes in these clinical settings. This approach allows combining a patient's values and beliefs and the clinician's best judgments in addition to the relevant scientific evidence (**Figure 1**).

In this chapter, we outline several evidence-based best practices regarding the management of women who are undergoing cesarean sections so that they may have minimal morbidity and the safest outcomes possible.

2. Current cesarean section practices

Over the past several decades, clinicians have followed the progress of labor based upon the information that had been collected mainly from primiparous females who were undergoing labor with a singleton fetus at term. This information was compiled into the now ubiquitous Friedman Curve and patients were delivered by cesarean delivery if their labor progress did not

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follow the trajectory of the Friedman Curve. New evidence suggests that this method of tracking labor progress is no longer appropriate and applicable to contemporary labor practices. In their observational review entitled, Consortium on Safe Labor, Zhang et al. [4] presented the outcomes of 228,668 women, having 233,844 newborns, who were delivered at 12 US Clinical Centers. These included 19 hospitals of which 8 were University Teaching, 9 were Community Teaching, and 2 were Community non-Teaching. All had EMRs. The review encompassed 2002–2008. The overall C section rate was 30.5%, which matched the National rate. Of these, 31.2% were nulliparas, 30.9% were women undergoing scheduled repeat C sections. The Trial of Labor after C Section (TOLAC) rate was 28.8%, and of these, the Vaginal Birth after Cesarean (VBAC) rate was 57.1%. Induction of labor was the admission diagnosis in 43.8% of the women and the pre-operative diagnosis was Dystocia (≤6 cm dilation), in 50% of the patients. The investigators also found that many parturients did not have a clear pattern which would indicate an active phase of labor and that this phase likely did not commence until after the cervix was dilated to at least 6 cm, versus the previous beliefs of active phase of labor commencing at 4 cm dilation of the cervix. The total duration of labor was found to be longer than previously thought. Several factors were found to affect the overall progress and therefore the likelihood of a successful vaginal delivery. These included maternal obesity, medical conditions such as diabetes and hypertension, timing and dosage of epidural analgesia. Thus, this information helped to define the current practices of labor management and how best to manage labor in various patients with and without medical and other confounding complications.

2.1. Reducing the C section rate

While the ideal rate for C sections cannot be easily determined, several opportunities to safely decrease the rate currently exist. In the Executive Summary of the WHO Statement on Cesarean Section rates [1], the experts have stated that when medically justified, a C section can effectively prevent maternal and perinatal mortality and morbidity. However, there is no evidence showing the benefits of a C section for women or infants who do not require the procedure. They state that at population level, C section rates higher than 10–15% are not associated with reductions in maternal and neonatal mortality. Therefore, clinical practices contributing to the higher rates (e.g., 31% US rate) should be carefully analyzed, in an attempt to identify opportunities for reduction, without incurring compromise to mother and/or neonate.

Spong et al. [5] in a joint statement with the National Institute of Child Health and Human Development (NICHHD), American College of Ob/Gyn (ACOG), and Society for Maternal Fetal Medicine (SMFM), described several opportunities for reducing the primary C section rate in an attempt to affect favorably, the overall C section rate. One of the most important suggested opportunities included allowing for longer than traditionally estimated times for normal latent and active phases of the first and second stages of labor, thus allowing women to greatly increase their chances of undergoing a successful vaginal delivery.

We published our findings related to instituting a multi-strategy approach towards reducing cesarean section rates at an urban Community Hospital [6]. We initially calculated a target (reduced) cesarean section rate of 29%, which was a 10 point drop from the existing rate of 39%, which we deemed as unacceptably high for our Institution and patient demographics. Four specific interventions were rolled out, and consisted of:

a. Prior approval by the Chair or Obstetrics Service Chief was required for every scheduled cesarean section.

b. All patients who had one or two prior cesarean sections were considered as candidates for a trial of labor in order to achieve a vaginal birth after cesarean delivery. Therefore, all patients had to receive information about VBAC either by attending a class taught by qualified midwives or by reading an ACOG approved patient education pamphlet regarding VBACs. This information was recorded into the patient's chart.

c. All intrapartum cesarean sections required a second opinion. This was obtained by any clinician/colleague who was present on labor and delivery at the time the decision was made. If a difference of opinion occurred, the Director of Maternal Fetal Medicine reviewed the situation and made the ultimate decision.

d. Individual cesarean section rates of all providers were prominently displayed on labor and delivery. This resulted in healthy competition amongst attendings especially when patient demographics and practice groups were similar.

Over the study period, the overall cesarean section rate decreased to 29%, without any compromise in maternal or neonatal outcomes. An additional finding was that, regardless of the indications for the cesarean sections, the overall rates of the Service attendings had a statistically significant decrease, most likely due to the implementation of Items b and c which allowed for other colleagues to weigh in to the decision-making process and to encourage patients to also participate in their own obstetrical management due to having attended VBAC classes (**Table 1**).

2.2. Rates of vaginal birth after cesarean section

A large contributor to the overall cesarean section rate is the category of elective repeat cesarean sections, because the overall number of trials of labor after cesarean section is very low. Although, rates of vaginal birth after cesarean have fluctuated markedly over the past two decades, currently, women who attempt a trial of labor after cesarean delivery have a 60–80% success rate. Several factors have contributed to these outcomes. These include Craigin's dictum, "once a cesarean, always a cesarean," [7] the ACOG practice bulletin that allows elective cesarean delivery upon maternal request, and the document that states in order for a patient to attempt a trial of labor, anesthesia and surgical capabilities must be "immediately available,"

	Control group	Study group	p Value
	N = 1380	N = 993	
Private attendings	200	170	0.163
Service attendings	150*	79*	0.002*
Dystocia	424 (11.9%)	561 (16.4%)	NS
Non reassuring fetal tracings	225 (6.3%)	247 (7.2%)	NS

*Statistically significant.

Table 1. Cesarean sections: private versus service attendings and indications.

[8, 9] and the medicolegal climate. However, in a push toward increasing the VBAC rates for eligible women, several payers (Government and Private) adjusted the payments for cesarean sections and vaginal deliveries according to patients' eligibility for trials of labor and successful VBAC, hoping to maximize this option for management of a patient's birth [10].

Roberts et al. [11] published the results of a survey of 227 Obstetric Care Hospitals regarding the availability of VBAC services after ACOG's statements regarding the need for having obstetrical emergency services readily available. The average number of deliveries per hospital was 811 per year. Approximately two-third of the hospitals (154 of the 224 responding hospitals) did not change their VBAC policy regardless of any "external" factors, including ACOG statements. However, one-third of the responding hospitals (68/229) had discontinued offering VBACs due to external factors, including the ACOG statements. Thus, the women receiving care in such facilities would be prevented from having this option, and unfortunately, many of these facilities were in remote and underserved areas.

Whenever a patient wishes to attempt a trial of labor, in order to achieve a VBAC, she should be made aware of the risks and complications of this plan. The discussion should include the risk of possible harm to mother and baby (uterine rupture, hemorrhage, injury to adjacent organs, severe fetal hypoxia or death). Additionally, the mother should be informed about the likelihood of success in this clinical setting. We published our findings regarding the effect, if any, of the extent of cervical dilation at cesarean delivery upon the subsequent VBAC rate [12]. Relevant records of the index pregnancy (Group 1) were reviewed for maximum cervical dilation at cesarean delivery and compared to the VBAC success rate of these patients in the subsequent pregnancy (Group 2). Of the 1917 patients, if the indication for a cesarean section in Group 1 was malpresentation, non-reassuring fetal heart rate tracing, and arrest disorder, the overall success rate of a subsequent VBAC was approximately 71%. However, in the subset of patients who had undergone the original cesarean section for arrest of descent (after achieving full dilation), the success rate was statistically significantly lower, being only 13%. Thus, patients who attempt a VBAC should be counseled about their reduced rates of a successful VBAC in situations where the prior cesarean delivery occurred when she was fully dilated.

2.3. Higher order cesarean sections

One of the known consequences of a patient undergoing a cesarean section delivery is the higher than baseline rate that she will undergo a repeat cesarean section, either as a scheduled repeat or after a failed trial of labor. If patients choose to have more than three subsequent cesarean deliveries, there is a greater likelihood of serious morbidity to the mother and baby. Higher order cesarean sections have variously been described as >3 or >4 such procedures. Some investigators have described increased intraoperative and postoperative morbidity in these cases, whereas others have not found any increase in complications [13–16]. The complications included increased rates of hemorrhage, injury to adjacent organs, blood transfusions, longer hospital stays, and peripartum hysterectomies.

We retrospectively reviewed the complication rates of patients undergoing higher order cesarean deliveries at our Institution, in the setting of a unique program wherein a senior Obstetrician is always present 24/7 with the intent to assist with any surgery and/or manage complications [17]. The 826 patients who had undergone a higher order cesarean section

were divided into four groups according to the number of previous cesarean sections. The incidence of intraoperative complications (injury to adjacent organs) and length of hospital stay were not increased in patients undergoing higher order (≥3) cesarean sections. In the patients who had ≥3 prior cesarean sections, there was a statistically significant increase in total operating time, rate of blood transfusions, and peripartum hysterectomies. There were no differences in neonatal outcomes amongst the four groups (**Table 2**).

We attributed these "improved" outcomes to the presence of a 24/7 senior Obstetrician who was available to assist in prevention and management of complications in these high acuity clinical scenarios.

2.4. Quantification of blood loss and resuscitation in postpartum hemorrhage

Postpartum hemorrhage is one of the leading complications in a cesarean section. Therefore, accurate knowledge of the amount of postpartum blood loss is essential for the appropriate and safe management of these patients. Visual estimations of blood loss (EBL) are known to be incorrect by as much as 50%, with larger volumes of blood loss being underestimated and smaller volumes being overestimated. This inaccuracy in visual determinations of blood loss is known to be independent of the provider's age and clinical experience. [18].

We quantified blood loss (QBL) after delivery by actual measurements of the total blood lost [19]. During and after each delivery, trained Nursing personnel weighed all the blood soaked materials and blood clots and measured the amounts in the under-buttock drapes. Specially labeled weighing scales depicting pre-calculated dry weights of patient gowns and items such as towels, sheets that are commonly used to soak up blood, were all measured.

Morbidity	Group 1 Sec Rpt. C/S	Group 2 Sec Rpt.C/S Failed TOLAC	Group 3 3rd/4th Rpt. C/S	Group 4 ≥ 5th Rpt. C/S	p value
Placenta accreta (%)	3.1%	2.9%	3.3%	3.3%	NS
Intra-op adhesions (Significant) (%)	41%	43%	52%	51.6%	NS
Cystotomy (%)	0.7%	0.9%	1.1%	1.1%	NS
Bowel injury (%)	0.1%	0.1%	0.1%	0.1%	NS
Total (Quantitative) blood loss (cc) ≥ 1 u	922±43	980±51	1355±186	1416±92	<0.05
Blood transfusions ≥ 1 u	10.3%	11.2%	21%	21.6%	<0.05
Total operating time (min.)	121±18	129±21	165±43	173±26	<0.05
Hysterectomy (peripartum, %)	2.1%	4.1%	3.2%	4.3%	NS

Table 2. Maternal morbidity of patients in the four groups.

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This standardized objective method of quantification of the blood loss at delivery revealed a mean value of 300 cc after uncomplicated vaginal delivery and 900 cc after uncomplicated cesarean section. These findings were similar to the estimated blood loss measurements that had been performed prior to instituting this approach and were consistent with findings in the literature (**Figure 2**). Thus, we suggested that the standard definition of partum hemorrhage of >1000 cc blood loss after a cesarean section could reliably be used as a trigger for the occurrence of this serious complication.

A major component of the management of postpartum hemorrhage is aggressive volume repletion. Serum lactate levels are used in the management of trauma patients because they reliably indicate tissue hypoperfusion [20]. However, their predictive role in the management of PPH for appropriateness of volume resuscitation remains to be elucidated.

We reviewed the outcomes of 1314 patients with postpartum hemorrhage in whom the blood loss was ≥1500 cc [21]. As an initial step in their management, all patients received a second IV line for increased fluid administration. When this IV line was inserted, blood was initially drawn for a CBC, coagulation profile, and venous lactate level. All results were obtained within 30 min of blood draw. The venous lactate levels were "normal" (≤2), more than 93% were hemodynamically stable (no hypotension and no tachycardia) and only 9% required a blood transfusion. When the venous lactate levels were "elevated" (≥4), 68% demonstrated hemodynamic instability and 91% received 1 or more units of blood transfusion based on their clinical symptoms or ≥10 point drop in hematocrit (**Table 3**). We suggest that venous lactate levels are a reliable indicator of tissue hypo perfusion in obstetrical hemorrhage and should be used as a trigger for blood transfusions when resuscitating these patients regardless of the hemodynamic status or hematocrit levels.

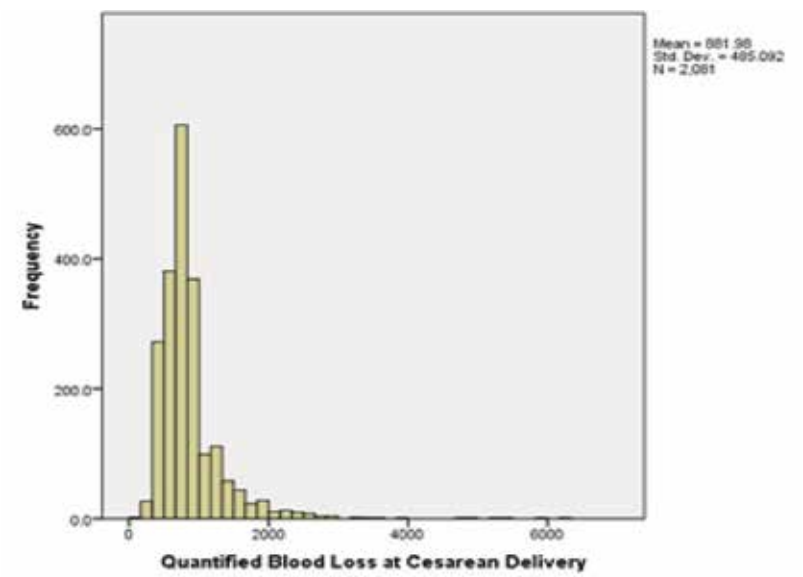

Figure 2. Quantified blood loss at Cesarean delivery.

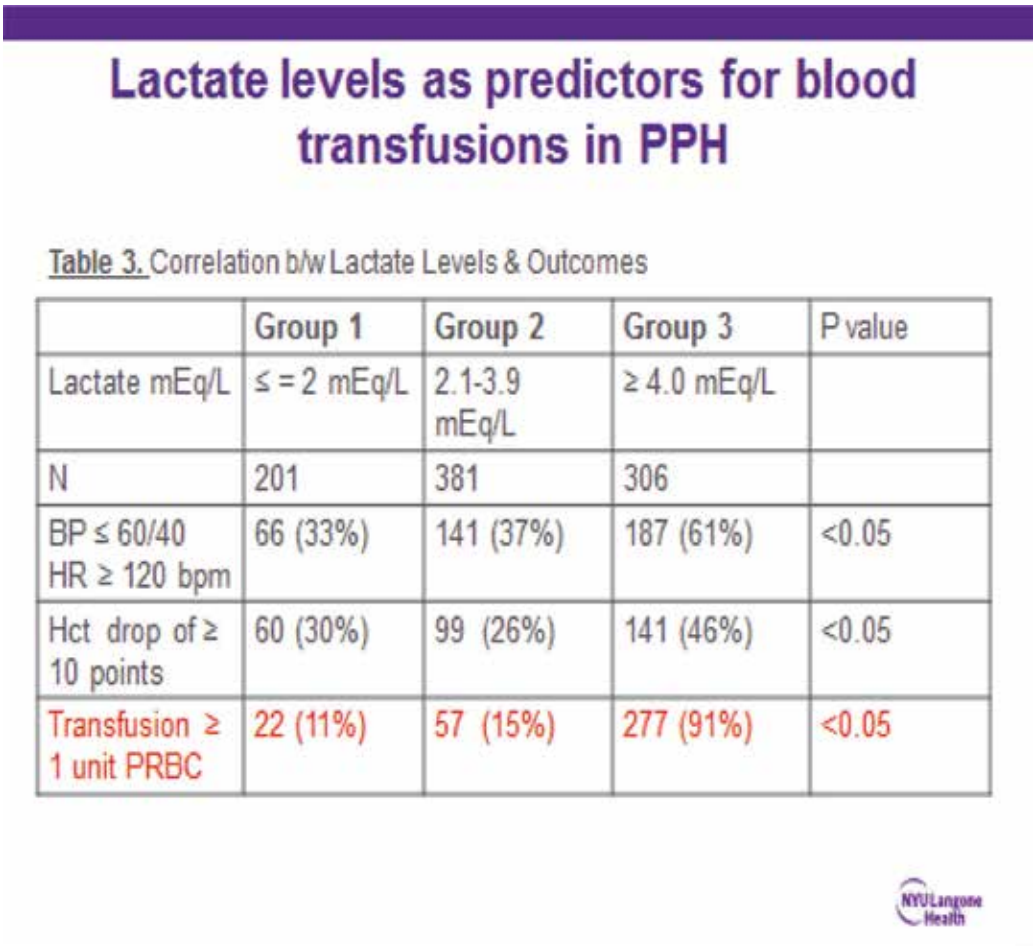

Table 3. Lactate levels as predictors for blood transfusions in PPH.

2.5. Self-perceived stress during pregnancy

Women experience different types of stresses during their lifetimes. Even though pregnancy and the postpartum period are universally considered to be a joyous event, it is paradoxically recognized as a stressful time in a woman's life. Psychological stress is known to have negative effects on maternal mental health, including depression and anxiety [22, 23]. This situation can be exacerbated when a woman is undergoing a cesarean section because of her concerns regarding her own recovery and also regarding the availability of support systems for her. We studied whether socioeconomic status affects a patient's self-perception of her own stress levels during the pregnancy and postpartum period, including in the setting of her undergoing a cesarean section [24]. There were 1006 patients with uncomplicated pregnancies, who were administered a validated questionnaire to assess stress levels at three study points: 1st trimester, 2nd trimester and at the 4–6 week postpartum visit.

The majority of patients self-reported high stress scores during the 1st trimester, likely due to fears and concerns about the pregnancy outcomes. The women reported lowest stress levels during the 2nd trimester, most likely due to their having a sense of wellbeing, especially in the absence of complications. Regardless of socioeconomic status, many women reported high stress levels during the postpartum period, likely due their concerns about their own recovery in addition to addressing the needs of their newborns.

3. Conclusion

Given that cesarean sections are the most common surgical procedures performed in the USA, we suggest that applying the above mentioned evidence-based techniques and criteria, in the management of these operations, will greatly assist in ensuring safe and improved outcomes in these patients.

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Section 6

Necessary Measures

Chapter 9

Vaginal Delivery after Cesarean Section

Zaheera Saadia, Nadiah AlHabardi and Ishag Adam

Additional information is available at the end of the chapter

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Abstract

Cesarean delivery is needed (indicated) for many reasons such as failure to progress, cephalopelvic disproportion, antepartum hemorrhage, preeclampsia, and repeated cesareans. The increase of the cesarean delivery rate is accompanied with an increase in the maternal and perinatal morbidities and increase in maternal mortality such as complications of anesthesia, injury to the nearby structure, respiratory distress syndrome, childhood allergy and childhood obesity. Vaginal delivery after cesarean section (VBAC) is one of the tools that aimed to reduce the rate of cesarean delivery. Here in this chapter we would like to highlight the different guidelines for VBAC, the success rate of VBAC, the determinant of the success rate, maternal and perinatal outcomes of VBAC. Then the arena of using oxytocic drugs in VBAC is discussed in details too.

Keywords: cesarean section, trial of labour, uterine rupture, induced labour, oxytocin, prostaglandins, misoprostol

1. Introduction

Childbirth is a special event in every woman's life and the occurrence marks the beginning of a new role of being a mother. In the past, individuals relied on the traditional vaginal birth method which sometimes ended up in fetal loss, maternal death or long term maternal morbidity in the form of perineal injuries and fistula formation. Fortunately, advancement in technology has revolutionized the healthcare industry and in particular, childbirth process [1]. Cesarean delivery refers to child delivery through abdominal cut [2].

2. Vaginal delivery after cesarean section

2.1. Indications for cesarean delivery

There are various maternal and fetal indications for cesarean delivery (**Table 1**) [3–6].

2.2. Complications of cesarean delivery

There are various complications of cesarean delivery (**Table 2**) [7–10].

Maternal indications	Fetal indications
Failed progress of labor	Presentation of the fetus
Cephalopelvic disproportion	Large size babies/fetal macrosomia
Antepartum hemorrhage	Higher order multiple pregnancies
Preeclampsia	Preterm births
Infection	Fetal distress
Repeated cesareans	Precious baby
Maternal request	

Table 1. Indications of cesarean delivery.

Maternal complications	Fetal complications
Complications of anesthesia	Preterm delivery
Hemorrhage	Respiratory distress syndrome
Injury to the nearby structure	Delayed initiation of breast feeding
Infections	Childhood allergy
Deep venous thrombosis	Childhood obesity
Abnormal placentation	
Infertility issues	

Table 2. Complications of cesarean delivery.

3. Vaginal birth after cesarean section

Trial of labor after cesarean delivery (TOLAC) refers to a planned attempt to deliver vaginally by a woman who has had a previous cesarean delivery, regardless of the outcome. This method provides women who desire a vaginal delivery the possibility of achieving the goal

"a vaginal birth after cesarean delivery (VBAC)." It is one of the tools to decrease or avoid the rising rate of cesarean delivery. In general, good candidates for planned TOLAC are those women in whom the balance of risks (as low as possible) and chances of success (as high as possible) are acceptable to the patient and obstetrician.

It is possible for women to have vaginal delivery even after a previous cesarean delivery. It has been shown 55–67% of women, who had previously delivered through cesarean delivery, had successful vaginal delivery afterward [11, 12].

Primarily, the success of vaginal childbirth is dependent on different factors. When the procedure is handled by unqualified individuals, it can result in complications which can reduce the rate of successful delivery.

High success rates have been attained when the amniotic fluid does not contain meconium. In addition, vaginal birth should not be prioritized when a patient, who had given birth previously through cesarean delivery, has prolonged labor [11, 12]. Importantly, the characteristics of the cervical regions are crucial in ascertaining if a woman can give birth without necessary undergoing another cesarean section operation [11, 12].

Notably, studies have established that women that have given birth through the vaginal childbirth process are likely to show high success rate when compared to others that were operated during the same process.

4. Factors affecting success rate of TOLAC

4.1. Antepartum factors

4.1.1. Indication for prior cesarean delivery

The rate of successful TOLAC by indication for prior cesarean delivery was higher when the fetal malpresentation was the indication compared with non-reassuring fetal heart rate pattern, and failure to progress (**Table 3**) [11–15].

4.1.2. Prior vaginal delivery

Vaginal delivery before or after the cesarean delivery is the good sign for successful TOLAC.

4.2. Demographic factors

Some ethnicity, e.g., Hispanic, African American, and Asian women are less likely to have a successful VBAC.

Increasing maternal age, women with less education and high body mass are also having a reduced likelihood of successful TOLAC.

Indication for prior cesarean delivery
Prior vaginal delivery
Demographic factors
Maternal medical disease
Intrapartum factors
Fetal macrosomia
Type of hospital

Table 3. Factors affecting success rate of TOLAC [11–15].

4.2.1. Maternal medical disease

Maternal medical disease such as hypertension, diabetes, asthma, renal disease, and heart disease have been reported to reduce the likelihood of successful TOLAC.

4.3. Intrapartum factors

4.3.1. Admission labor status

Women in spontaneous labor or with a high bishop score are more likely to have successful TOLAC than women who are being induced or who have low Bishop scores.

4.3.2. Fetal macrosomia

A fetus weighing more than 4000 g reduces the likelihood of successful TOLAC.

4.3.3. Type of hospital

University hospitals or those affiliated with obstetrics and gynecology residency program have higher rates of TOLAC and successful VBAC. Women who deliver at a private or rural hospital have a decreased likelihood that TOLAC will be attempted, and if attempted, a decreased rate of successful VBAC when compared to a tertiary care or perinatal center.

5. Potential benefits and risk of VBAC

5.1. Potential benefits of VBAC

In addition to fulfilling a patient's preference for vaginal delivery, at an individual level, VBAC is associated with decreased maternal morbidity and the expected complications in future pregnancies as well as a decrease in the overall cesarean delivery rate at the population level.

Maternal complications	Perinatal complications
Failure of the trial	Mortality
Uterine rupture	Hypoxic ischemic encephalopathy
Hemorrhage and transfusion	Respiratory problems
Peripartum hysterectomy	Others
Infection	
Pelvic floor injury	

Table 4. Maternal and perinatal complication of VBAC and ERCS.

Compared to CS, women having a VBAC have [15–17].

Fulfilling a patient's preference for vaginal delivery.

Shorter stays in hospital and recovery period.

Avoid major abdominal surgery.

Lower rates of hemorrhage, infection, deep vein thrombosis.

Enhanced mother-infant bonding, including the long term wellbeing of the infant.

Lower maternal morbidity.

5.2. Potential risks of VBAC and TOLAC

VBAC is associated with fewer complications than elective repeat cesarean delivery, whereas a failed TOLAC is associated with more complications (**Table 4**) [15–17].

6. Induction of labor after cesarean section pros and cons

Induction of labor is possible even after delivering a first child through the cesarean. However, the chances of a successful birth are dependent on whether a woman delivered through the vaginal process in an earlier pregnancy. Ideally, there are both pros and cons of labor induction after cesarean section.

6.1. Pros

One of the key advantages of induction of labor after cesarean section is that it allows a woman to give birth through the vaginal process. Induction is recommended, by professionals, once a woman reaches the 41 weeks of gestation. Induction reduces the likelihood of having meconium in the amniotic fluid. Significantly, precaution has to be taken given that labor induction, for instance, when dealing with women with past cesarean section experiences can be risky [18].

6.2. Cons

Labor induction, among women that have delivered through the cesarean section, have been found to be risky and it can result in the rupture of the uterine walls [18]. Basically, this is because the process put pressure on the lower abdomen which could be having scars. Fortunately, the uterine rupture is not a major issue given that it occurs among four to five women in every 1000 operations [19]. However, the issue has to be addressed adequately to avoid further complications.

Besides this, complications can be registered when dealing with mothers that are diabetic. It is estimated that diabetes is the major cause of obstacles in 2–3% of all pregnancies [30]. The mentioned disease can derail the healing of scars in the uterine area. As a result, induction of labor and vaginal delivery in this group, even after a first successful cesarean section, can be risky and the effectiveness rates are lower when compared with other women without the similar condition [20].

Furthermore, considerations have to be made when dealing with obese mothers. Research indicates that obese mothers have a low rate of 13% of having children through the vaginal process after undergoing cesarean section in previous pregnancies [19]. The infection morbidity rate is considered to be high in obese women when judged against non-obese. In short, there are numerous disadvantages when an obese woman decides to give birth through the vaginal process after a past successful cesarean section.

In the end, the cesarean section has been a major boost in reducing child and mother mortality after birth. The process has been refined since its earlier inception ancient times. At present, it is a safe method of childbirth, especially, when a mother has health-related complications. Notably, parameters have to be observed when dealing with special groups, for instance, obese and diabetic pregnant women. Indeed, there are various indications and contradictions of cesarean section. Despite this, the process is fast and it has various advantages.

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In this book, we present recent advances in surgical techniques as well as the most common perioperative complications in patients that undergo a cesarean section. Moreover, we discuss appropriate measures to reduce unnecessary procedures.

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