

Anesthesia for Cesarean Section



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Preface

In 1849 Charles Meigs affirmed that “no man has a right to subject a living, breathing, human creature to so great a hazard as that attending the caesarean section.” Nowadays, more than 150 years later, cesarean section is probably the most common surgical procedure in the world and considered so safe and convenient that obstetricians have to deal with the controversial issue of the cesarean section on maternal request. Anesthesia, in parallel, has changed enormously from an “out of label” risky procedure to something that is well established with no, or very minimal, maternal and neonatal side effects.

This book describes the current standard practice of anesthesia for cesarean section through the clinical experience of well-known European experts in this field. The core message throughout is that even if cesarean section is a surgical procedure it is still a “delivery” and not only a “section,” first and foremost a birth not just an operation. The anesthesiologist should provide not only a “pain free” surgery but also a “side effects free” anesthesia by choosing the right drugs and the appropriate techniques tailor made for the parturient. In this way the childbirth experience, even if in the operating theater, will be more human and extraordinary thanks to the holistic approach of the whole clinical team, of which the anesthesiologist is an indispensable member.

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Paolo Mazzarello

1.1 Twin Tragedies

The history of cesarean section is a long chain of tragedies for the mother and the baby [1, 2]. The origins of this surgical procedure—opening of the abdomen to extract the fetus—are lost in the mists of the past and fade into folklore, mythos, and legend of ancient societies [3–5]. According to Greek mythology, the god of medicine, Asclepius, was born directly from the cut of the abdomen of his mother, the nymph Coronis. A similar birth had the god of wine and religious ecstasy, Dionysus, extracted by Zeus from the womb of the mortal Semele, after her death. The legends on the unnatural birth through the abdomen cut pervade also the Eastern Hindu and Buddhist cultures. According to a tradition, Buddha saw the light through a cesarean section performed on his mother Maya. Also in literary Persian culture there are references to this type of operation. In the poem *Shahnameh* the beloved Persian poet Ferdowsi describes the mythical hero Rostam's birth through a cesarean section.

In fact, the first references to an abdominal birth from a deceased woman are probably in the Babylonian world, but we have no technical indication on how the operation could have been carried out [5]. However, it is evident that in ancient time this kind of delivery, when made, was always practised after the death of the mother. In the Roman world, the cesarean section was regulated by the *lex regia* attributed to the king Numa Pompilius although we do not know if and for how long it was applied. This law prohibited “the burial of the corpse of a pregnant woman before the child was extracted.” Among the few Roman historical figures who, according to tradition, would have come to the world via cesarean section, on the testimony of Pliny the Elder, there was Publius Cornelius Scipio Africanus, the general who

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defeated Hannibal at the battle of Zama. Contrary to what has long been believed, there are no real evidences that Julius Caesar was born by a cesarean delivery, a myth that is disproved by the fact that his mother survived for many years after his birth. Caesar's alleged extraordinary delivery was long considered the source of origin of the term "cesarean" and probably was based on a wrongful interpretation of the writings of Pliny the Elder [5]. In fact, both in the Roman world and in the medieval period, the term was never used. In medical, literary, and theological texts, the terms used were "extraction" or "cutting" to describe or indicate the intervention.

The Church elevated to the rank of the patron saint of women in labor Margaret of Antioch, who, according to tradition, lived in the third century A.D. At the age of 15, around 290, the young girl was sentenced to death because of her Christian faith. In the cell where she was held the devil appeared in the form of a dragon and then swallowed her alive. But she defeated the monster tearing his belly with a cross that she held in her hands, freeing herself through a sort of cesarean section *from inside*. For this reason, she became the patron saint of expectant women (especially in difficult labor). Her holy memory survived the generations, and her figure is still venerated by the Catholic and the Orthodox Churches.

Only in the late Middle Ages, cesarean section became an operative act on the female body described by medicine. The Catholic Church also expressed interest in this surgical intervention to be performed on pregnant women immediately after death. This created the possibility to save from damnation the souls of unborn children through baptism. The unnatural and extraordinary birth from the womb was thus the precondition of true birth, that is, the spiritual one. Odon de Sully, who was archbishop of Paris between 1196 and 1208, issued an order in this regard which expressly prescribed: "The women who die during childbirth are opened, if it is considered that the child is still alive, providing that it is carefully ascertained their death." [6]. The incision of the abdomen of a pregnant woman after the death was a Christian religious duty even according to St. Thomas author of the *Summa Theologiae* (III, q. 68, a. 11): "si tamen mater mortua fuerit, vivente prole in utero, debet aperire ut puer baptizetur" ("however, if the mother is dead while the offspring is still alive in her womb, you have to open it to ensure that the child is baptized"). The practice of extraction of a postmortem fetus was approved by several religious councils and defined with some details. The woman underwent the operation immediately after her death and the child who showed signs of life had to be quickly baptized, while he had to be buried in unconsecrated ground if stillborn. The ecclesiastical rules on the cesarean section were only expressed on the general indications plane and their practical application depended on local circumstances such as the availability of a surgeon who could operate. However, we have no documentary evidence of its widespread circulation although it is described in the works of several physicians and surgeons of the time. According to Guy de Chauliac, author in the fourteenth century of *Chirurgia Magna*, the operation was performed cutting the left side of the abdomen to facilitate access to the fetus and avoiding the liver. In the work, it is suggested to keep open the mouth of the mother (and her vagina) to facilitate air circulation and respiration of the fetus. The ecclesiastical

regulations advising cesarean section on women who died during delivery were resumed in the climate of sacramental rigor that followed the Council of Trent. In 1582, the practice was made compulsory in his diocese by Carlo Borromeo, archbishop of Milan, and then extended to the entire Catholic world by Pope Paul V in 1614.

The publication in 1745 of the first edition of the work *Embriologia sacra* of the Sicilian priest Francesco Emanuele Cangiamila, gave a great impetus to the spread of knowledge of the *postmortem* cesarean section. The work of Cangiamila—translated in Latin, Spanish, French, Portuguese, and German—was addressed to the civil authorities and especially to the parish priests who were often at the bedside of the pregnant woman in danger of death so that the surgeons and midwives could perform a cesarean section as soon as the woman had died. According to Cangiamila, it was even a duty of the same priests to perform such an operation when no one else was able to perform it. In this way, cesarean section would have saved—both materially and spiritually—a newborn otherwise condemned to limbo (according to the Catholic Church, the afterlife condition of those who died without baptism).

References to cesarean section on a *living* woman began to appear in the medical texts in the sixteenth century. It was the French surgeon François Rousset in 1581 to introduce the “cesarean” expression in the work *Traitté nouveau de l’hysterotomotokie, ou enfantement caesarien*, who intended to promote the operation on a living woman in cases where childbirth was prevented by natural means. It was in this text that the term was placed in relation both to Julius Caesar and to the Latin verb *caedere* meaning “to cut.” According to the surgical technique described by Rousset, the woman, sitting tight on the bed and supported by two strong assistants, was cut on the abdomen to the left along the paramedian line, to avoid the navel hardened by scar tissue. Then, the operator went on to the section of the underlying uterus supporting it with one hand, taking care, when cutting, to not hurt the baby. Finally, the organ was returned to its position without sewing it, while the abdominal wall was sutured. At the basis of this procedure there was the belief that the uterus, for its contraction capacity, was able to stop the bleeding and spontaneously heal: unfortunately this erroneous indication was the cause of many tragedies in the three centuries to come. Rousset actually wrote an entire treatise on an intervention that, apparently, he never performed in the first person, and that did not even exist as a reasonable possibility of physicians and surgeons of the time. His testimonies seem to lack credibility and do not appear to be based on objective reality of the facts. However, his book was rightly seen as a sort of founding act of the cesarean procedure in the living woman and made Rousset as “the inventor of the cesarean section.” The book was translated into Latin in 1586 by Gaspard Bauhin who, in an appendix, told a story from the early sixteenth century, destined to become famous in the texts of the history of medicine. A wife of a pig gelder (i.e., a person who performed castration of animals) named Jakob Nufer, was in labor for several days, but the midwives and local surgeons who had turns at her bedside had not been able to make her give birth. The man was skilled in using knives. Just when the situation seemed desperate and hopeless, he asked his wife, now destroyed by the continuous suffering, for permission to operate on her. The woman, oppressed with grief,

exhausted and discouraged, welcomed as a sort of liberation the dramatic proposal. Nufer laid her down on the kitchen table, then cut the engraved belly with a knife or a razor and pulled out a live child. The woman was saved and, as reported by Bauhin, continued to give birth in the following years. Another indirect testimony of a cesarean section is found in the famous work *La comare o ricoglitrice* (1596) written by the Italian physician Scipione Mercurio who claimed to have visited two women—during a trip to France—who presented abdominal scars as a consequence of the operation. A documented case of cesarean section was performed in Wittenberg on 21–22 April 1610, by the Saxon surgeon Jeremias Trautmann assisted by two midwives [5, 7]. Initially, the operation went well: the child was saved (and later lived at least nine years), and the woman seemed to recover. But then, some terrible delayed complications appeared that led to the death of the mother by infection or embolism, almost 25 days after birth. Autopsy, however, revealed that the uterus was repaired and healed. Subsequently, there were other documented cesarean operations on living women; however, this surgical intervention was considered an exceptional experience and remained in the deep memory of those who had done it. In fact two complications were almost always fatal: the early *postpartum* hemorrhage and the development of infections. Despite the tragedies that came with it, the intervention of cesarean section on a living woman slowly became widespread throughout Europe. But its primary purpose was to save the baby and to free the mother from acute suffering even though she did not have much chance to survive. Anyway cesarean delivery, although rarely, could also lead to a double success: the safety of mother and child. These cases with a favorable outcome appeared, however, to be accidental events, inexplicable, real strokes of luck that happened to some obstetrician or surgeon marked by a lucky star. According to statistics compiled for Italy between 1780 and 1875 by the historian of medicine and pharmacologist at the University of Pavia, Alfonso Corradi, the global maternal mortality rate, estimated in 158 cesarean interventions, was approximately 67%, but deaths in the hospital arrivals touched 88% of the operated pregnant women [8]. Terrible statistic that certainly overstated the successful cases because it was based on medical reports that tended to particularly emphasize the safe interventions, which gave fame and prestige to surgeons. Of course, the examples in which both protagonists of the birth, the baby and the mother, were saved together, were very few. It is also likely that in some registered successful cases, the statistics did not take account of the negative evolution after few days from the operation. The dangerousness of the intervention frightened the best surgeons. When they were found to face difficult situations, with pregnant women belonging to influential families, they preferred to avoid the risks of the cesarean cut. Called in the summer 1790 in the presence of the governor Johann Joseph von Wilzeck, minister plenipotentiary for the Austrian Lombardy, that had the prey wife to the pains of a difficult birth, the famous surgeon Giovanni Battista Palletta refused to intervene with a cesarean cut. At the end, the woman, imploring to be freed by the pains, succeeded in making herself operated, but owed succumb to the intervention, as it happened to her child [9]. Despite the positive cases, or partially positive in which only one of the two protagonists had survived, the birth with cesarean cut was the ghost that wandered in the mind of

every obstetric, a sort of “synonymous of death for the woman.” It was “an *extrema ratio* that aroused terror,” and to avoid it the obstetricians didn’t hesitate to sacrifice the fetus, with embryotomy, as soon as it was possible. Because sometimes the embryotomy also was difficult or unattainable as a consequence of the difficulties of access along the narrow passages of a basin seriously deformed. It doesn’t surprise therefore that, in an important university obstetric clinic as that of the San Matteo Hospital in Pavia, “not a mother had been saved in one century with the cesarean cut” [10].

Things began to change, just in Pavia, in May 1876.

1.2 The Revolutionary Intervention of Edoardo Porro

In April 1876 a 25-year-old woman, Giulia Cavallini, reached the obstetric clinic of San Matteo Hospital Pavia, 8 months pregnant. Born in Adria, a small Italian town in the province of Rovigo in the Veneto region, the woman had met a singer from Pavia who had made her pregnant and married her on the same day she was admitted to hospital. Physical examination immediately disclosed a dramatic situation: the woman was 1 m 48 cm tall and had a severely deformed pelvis that made natural delivery impossible. Edoardo Porro, professor of obstetrics at the University of Pavia, took charge of operating on the woman and tackled her clinical situation as a scientific and human challenge. Suffering from syphilis contracted in Milan during an obstetric operation on a woman with the illness, Porro was quite a character. He had fought with Garibaldi in Trentino (1866) and in Mentana (1867) near Rome before deciding to devote his life to practising obstetrics in the most deprived areas, but he still found time to pursue his research activity [1, 11]. In 1875, Porro had been appointed to the chair of obstetrics at Pavia University and was head of the maternity division when Giulia Cavallini appeared on the scene. Instead of giving up, as other obstetricians would have done in similar circumstances, undertaking a cesarean section with the main purpose to save the baby, Porro managed to reverse the woman’s tragic destiny with surgical ingenuity, adopting a simple innovation that allowed him to save both mother and baby. In his early years as obstetrician, Edoardo Porro had been intrigued by a surgical paradox: the strange contrast between the high mortality rate of cesarean section and the generally positive results of laparotomy outside the period of pregnancy. Why opening the abdomen at the end of pregnancy was mortal, whereas cutting a non-pregnant woman meant saving her life? Porro was impressed by these contradictory experiences. It was logical to wonder where this difference stemmed. Strangely no obstetrician had clearly posed the question, or maybe no one had drawn the right conclusions. Instead the mind of Porro began to take shape of a response. Indeed, when placed correctly, the solution of the question seemed almost automatic. The uterus left in place was the source of origin of the chain of tragic consequences for the life of the woman. It became a wounded body inside the abdomen, the front door of the septic processes and source of unstoppable hemorrhagic manifestations. In addition, “the uterus section surfaces” could still come into contact with the infected air “by the

way of the vaginal canal” as a result of the woman’s movements. From this source it was unleashed peritonitis. If these were the facts, almost automatic was the practical conclusion. After the cesarean section, it was necessary to remove the “uterus-ovarian mass,” thus eliminating a terrible septic focus and an uncontrollable source of bleeding. The secret was to remove the fetus, then to constrict the neck of the uterus with a *serre-noeud* of Cintrat in order to stop the circulation to the organ, then to perform a (subtotal) hysterectomy and a bilateral salpingectomy-oophorectomy. Finally, Porro sutured the stump of the neck at the abdominal wall, between the wound edges, to avoid infecting the pelvic cavity with septic fluids. In this way the two causes of post-cesarean death were eliminated or decreased: the source of hemorrhagic extravasation and, moreover, the likelihood of infections. So, a scientifically planned and well thought-out cesarean section, programmed to save both the mother and the child, was fully successful and gave to the world of medicine an obstetric procedure immediately adopted in hospitals all over the world. Nonetheless, Porro’s operation made the woman sterile because her uterus has been removed during surgery. This fact raised some criticisms as the operation was deemed immoral by those who claimed it was ethically justified to jeopardize a woman’s life given the poor chances of saving her, as long as her reproductive ability was preserved. So Porro turned to the bishop of Pavia, Lucido Maria Parocchi (later cardinal vicar of Rome), as a moral authority of the town, for his ethical opinion. The prelate skillfully solved the question claiming that as many theologians had tolerated the castration of young men destined to be choir singers in Roman chapels (e.g., the Sistine Chapel), for the obstetricians there were even more reasons to allow the sterilization procedure that Porro had adopted to save two human lives [20, 1].

The new era of obstetrics under the sign of a double healing for cesarean section had, however, a difficult initial development. Porro’s success with the double safety of the mother and child was a guarantee that the operation could constitute a real solution. But the first obstetricians that applied the method, after its inventor, had unfavorable results because the patients came to the operating table in a desperate condition: they were cachectic or childbirth was retarded by too many hours of labor. However, the surgical technique rapidly spread all over Europe, the United States, Russia, and Mexico; particularly successful was the application in England where it was adopted by Russell Alexander Simpson, Clement Godson, and Lawson Tait [12–15]. The method continued to be widely used in the 25 years after its invention. In 1901 a pupil of Porro, the obstetrician Ettore Truzzi, compiled a detailed table with the number of maternal deaths, year after year, following the intervention devised by his master, gathering in total 1097 cases. In the first 15 years he recorded high rates of mortality, but since 1890 there was a sharp decline, with annual rates ranging from 9% to about 20% [16]. Often the unfortunate result was due to the poor condition of women undergoing cesarean section, according to Porro. The operation became safe if performed in a planned way early in labor. Despite these impressive results, the frequency with which they used the method decreased significantly after 1900. Another technical innovation made him progressively obsolete: the *conservative* cesarean section.

1.3 The Conservative Cesarean Section

From the origins of the cesarean section on a living woman, to suture a uterine breach was considered an arduous and harmful operation. The obstetrician thought that the uterine motions were able to produce a spontaneous hemostasis and so he left the free organ to develop its spasmodic movements. But sepsis or severe bleeding complications were the rule.

Attempts to suture the uterine incision after cesarean section, however, date back to the eighteenth century. The obstetrician Jean Lebas, who was teaching in Montpellier, was one of the first—if not the first—to suture the uterus in 1769; the woman survived and returned to her occupations. The example of Lebas however, was not followed except occasionally and with disappointing results. Uterine suture “was prescribed by the obstetrics and the operation was equivalent to almost a condemnation of the mother.” [17]

The essential progress in modern obstetrics of the cesarean section is due to the German obstetrician Max Sänger, who in 1882 introduced the efficient sutures with silver threads of the muscular plane that induced only minimal tissue reaction and avoided affecting the mucosa. His merit was also to awaken the community of obstetricians about the possibility of performing the cesarean surgery without irreversibly mutilating the woman generating capacity. A turning point had, however, already occurred in 1881 when Ferdinand Adolph Kehrer, based on a precise anatomical and histological study, decided to perform a cross-section in the lower segment of the uterus, thinner and less vascularized, along the trend of muscle fibers. With this surgical choice the bleeding was minimized. The double contribution on suture procedures and the site of cutting by Sänger and Kehrer, and the diffusion of asepsis, generated a progress to which concurred many obstetricians with a drastic reduction in mortality from cesarean delivery during the twentieth century [1, 5, 18, 19].

From a destructive intervention that “extinguished the sources of life” [17], cesarean delivery had now turned into a conservative procedure that left substantially intact the possibility of future fertility. So, this operation came in the twentieth century, beginning a story of progress and reduction in mortality up to the current situation that could almost be described as the era of the cesarean section “on demand” [5].

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Epidemiology, Indications, and Surgical Techniques

2

Paolo Gastaldi

2.1 Epidemiology

The labour room is a multiprofessional environment; it is complex by definition. The woman and the fetus are the main players on the scene. The midwife, gynecologist, anaesthetist, neonatologist, nurse, and the assistant share critical decisions about two human beings' lives.

Until half a century ago, cesarean section was rare. It was a dangerous operation for at least three reasons: poor surgical technique, risk of sepsis, and no anesthesia. Many women died during or soon after a cesarean section. Evolution of medicine changed this practice.

The World Health Organization declared in 1985, in Fortaleza, Brazil, that '*there is no justification for any reason to have a cesarean section rate higher than 10–15%*' [1].

An appropriate cesarean section prevents maternal and perinatal complications. There is no benefit for women or infants who do not need the procedure. The complications have a negative effect on a woman's health.

In 2015, WHO published a systematic review of the studies in the scientific literature to analyse the association between cesarean section rates and maternal, perinatal, and infant outcomes. A panel of international experts agreed on this statement [2].

Caesarean sections are effective in saving maternal and infant lives, but only when they are required for medically indicated reasons. At population level, caesarean section rates higher than 10% are not associated with reductions in maternal and newborn mortality rates.

Caesarean sections can cause significant and sometimes permanent complications, disability or death particularly in settings that lack the facilities and/or capacity to properly conduct safe surgery and treat surgical complications.

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Caesarean sections should ideally only be undertaken when medically necessary. Every effort should be made to provide caesarean sections to women in need, rather than striving to achieve a specific rate. The effects of caesarean section rates on other outcomes, such as maternal and perinatal morbidity, pediatric outcomes, and psychological or social well-being are still unclear. More research is needed to understand the health effects of caesarean section on immediate and future outcomes.

An historical study on graphic analysis of labour in 1954 included 100 women with spontaneous labour. Of these women, 64 had an operative vaginal birth with forceps and one had a cesarean section [3].

The rate of cesarean section increased steeply during last decades. Urbanization, childbirth in hospital, reduction of homebirths, consultant-led maternity and the exclusion of midwives from clinical decisions, and induction of labour are possible causes of the increase of this operation [4, 5].

The obstetric population has changed. Many women live their pregnancy later in life. Average body mass index of the mother and fetal weight have increased [6].

The proportion of births by cesarean section has been proposed as an indicator for measuring access, availability, or appropriateness of medical care, as well as for monitoring changes in maternal mortality. A study of births by cesarean section estimated in 2007 at national, regional, and global levels with data from 126 countries, 89% of world live births. The global rate of cesarean section was 15%. In more developed countries, it was 21.1%, in less developed countries 14.3%, and in least developed countries 2% [7].

Repeat cesarean deliveries in the United States account for one third of the cesarean sections.

The most common indications for primary cesarean delivery, in a recent population study, were labour dystocia, abnormal or indeterminate fetal heart rate tracing, fetal malpresentation, multiple gestation, and suspected fetal macrosomia [8].

WHO proposed in 2014 the Robson classification system as a global standard for assessing, monitoring and comparing cesarean section rates within healthcare facilities over time, and between facilities [9].

2.2 Indications

2.2.1 Introduction

During pregnancy every woman is eager to know whether natural childbirth is possible for her. The obstetrician, midwife or doctor, has the duty to plan childbirth with her.

There are situations in which natural childbirth is contraindicated but most of the time the decision is difficult. Often it is necessary to wait for labour to decide.

The childbirth is natural or operative (Fig. 2.1). Natural is vaginal. Operative is both vaginal or abdominal. Operative vaginal childbirth is performed with forceps or with vacuum. There are more devices but these are universal. Operative abdominal childbirth is cesarean.