Part I

ANTEPARTUM

Chapter 1 A HISTORY: OPERATIVE DELIVERY

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Norwithstanding that I would use all my Endeavours to deter Men from the rash and imprudent Practice of instrumental Operations in Midwifery; yet it is not to be denied, but that such Operations are very useful and necessary, when undertaken with Caution, Skill and Prudence;. . .

Fielding Ould (1710–1789)
A Treatise of Midwifery in Three Parts
Dublin: O. Nelson & C. Connor,
1742: 111, pg 142.

Prolonged or obstructed labor, undeliverable fetal positions, maternal hemorrhage from retained products of conception, delivery of the second of twins, and the problematic extraction of large infants are among the recurring problems in human labor and delivery that do not resolve without intervention. Assistive techniques to manage these and other complications of human parturition are rooted deep in antiquity. Over many years, various manipulations and specialized instruments were developed to expedite delivery of viable infants or to remove the fetus and the other products of conception from the uterus in case of fetal demise or incomplete delivery. A brief historical review of the origins of operative delivery techniques increases the appreciation of modern practitioners for the complex roots of the science and art that have led to modern practice.

THE HISTORY OF CESAREAN DELIVERY

Myth and Legend

Reports of the surgical removal of the fetus from the mother are common in history and legend. Such tales figure in the origin myths for important personalities from many cultures. For example, Brahma is described as emerging from his mother's umbilicus, and in 5636 B.C.E., Buddha is reported to have been delivered from his mother Maya's right flank [1]. Tall tales of preternatural or miraculous births are also common in our western Greco-Roman cultural heritage. Classic Greek mythology includes several descriptions of what could be termed cesarean deliveries of various gods, demigods, and mortals [2]. A representative example is the case of the inconstant princess Coronis. Upon receiving proof of her infidelity with another male suitor, her enraged paramour Apollo (Phoebus Apollo), god of prophecy, music, and archery, dispatched her with an arrow. In some versions of

this tale it is Apollo's twin sister, Artemis (Diana), daughter of Zeus and Leto, who was responsible for this murderous archery. In any event, Apollo next placed the body of the newly dead Coronis on a funeral pyre. As the flames leaped up, Apollo's rage rapidly changed to consternation for the fate of his unborn child. At Apollo's urgent request, Hermes (Mercury), the messenger of the gods and the patron of heralds, thieves, travelers, and merchants, intervened, and the infant was delivered from his mother's body by means of an abdominal incision. This child, who was the product of this unique perimortem delivery, was subsequently tutored in the healing arts by Chiron the centaur, son of Coronos and the nymph Philyra, and eventually became the most famous physician of antiquity, Asclepius. This tale has an ending that should serve as a warning to overly ambitious physicians. In his later life, Asclepius developed his medical abilities to the point where he could resurrect the dead. For his presumption in using his medical talents to thwart the will of the gods, Zeus killed him with a thunderbolt!

In another setting, Zeus prematurely delivered Dionysus (Bacchus), god of wine and ecstasy, from the abdomen of the dying Semele, the daughter of Cadmus and Harmonia. Zeus had actually fathered this child. Unfortunately, complications with the pregnancy led to disaster. In the sixth month of the pregnancy, malevolent advice was given to the young woman by the jealous Hera, Zeus's wife, who was masquerading as Semele's elderly nurse, Beroe. Under this influence, Semele refused Zeus her bed unless he would come to her in his true form. Zeus, trapped by her request, resumed his accustomed form as a thunderbolt, a dramatic process that proved fatal to the hapless Semele. Through the intervention of the ever-present Hermes, however, the unborn and premature Dionysis was removed from Semele's womb, sewn into the thigh of Zeus, and, through this unusual mechanism, carried to maturity as a bizarre type of ectopic pregnancy [3].

There are other unusual tales of obstetric interventions in Greek and Roman mythology. Adonis, famous for his great beauty, was born of his mother, Myrrha of Smyrna, after her transformation into a tree. Myrrha had conceived following an incestuous relationship with her father, Cinyras. Cinyras was a Cypriot king and originally one of the lesser suitors to Helen before her abduction and the beginning of the Trojan War. This unusual relationship between father and daughter developed because of the enmity of Aphrodite, the goddess of love, who punished the unfortunate Myrrha because of her lack of devotion [2]. Aphrodite's intervention caused the poor Myrrha to fall in love with her own father. Under what proved to be a maleficient influence, Myrrha developed a subterfuge whereby she shared Cinyras' bed without his recognizing her. The god's punishment for Adonis's mother was her transformation into a myrrh tree, thus arresting her father's unacceptable advances. Her father's eventual fate was also severe. When he discovered that he had been tricked into impregnating his own daughter, Cinyras committed suicide.

In terms of drama, myth, and legend, classic theater also contains many stories of unusual births. Perhaps the most famous occurs in the denouement of the play *Macbeth*. Shakespeare's protagonist Macduff is free from mortal risk from Macbeth, because Macduff was "from his mother's womb untimely ripp'd . . . . " [4] As he was not of woman born, Macduff fulfilled the prophecy of the witches and thus successfully defeated the regicidal Macbeth. This tale of ambition, greed, murder, and operative delivery has a long pedigree, with its origin well before the sixteenth century. Shakespeare had obtained the material for his tragedy from an earlier text, the *Chronicles of Holinshead*. From this reference, further sources for this Scottish tale can be traced to another text, *Scotorum*, *Historiae of Boece* (Paris, 1526); it can further be followed to a manuscript originally published in 1385! Doubtless, its roots are even earlier than the fourteenth century, in now lost sources.

History also includes many reports of unusual cesarean deliveries involving actural individuals. There are several well-documented cases in which women delivered themselves by conducting their own surgeries. Many if not most of these abdominal surgical deliveries would in current terminology be described as cesareans. Authentic reports from rural settings also describe traumatic deliveries when milkmaids were gored by cattle, the earliest dating back to 1647. In some of these latter cases, the mother, the infant, or both apparently survived [1].

Derivation of Terms *Cesarean* and *Section*

In common parlance transabdominal surgical deliveries are termed *cesareans*. How this nomenclature

came to be employed for abdominal surgical delivery is a long and complex tale. The derivation of the term *cesarean* has been ascribed to several sources. Ancient historians, including Pliny the Elder are largely responsible for the widely believed myth that a Roman emperor or Caesar – either Scipio Africanus (237–183 B.C.E.) or more commonly, the most famous emperor, Gaius Julius Caesar (102?–44 B.C.E.) – was delivered from his mother via an abdominal incision. Unfortunately, it is unlikely that these historical figures or many of the other famous persons reputed to have been delivered by a surgical procedure were actually born in that manner. In reference to the historical Roman Emperor Gaius Julius Caesar, it is virtually certain he was *not* delivered surgically from his mother, since the term *cesarean* predates him by centuries. Furthermore, published letters of Julius Caesar indicate that he corresponded with his mother, Aurelia, while he was in Gaul. Finally, Aurelia is known to have lived until 54 B.C.E., when Caesar, who was then more than 40 years old, attended her funeral [5]. Her long-term survival after an unsterile abdominal surgery in the first century is distinctly improbable. The reports by Pliny and other classical writers of successful abdominal delivery of culturally important people such as the historical Emperor Julius Caesar lack historical support and are best viewed as political fables.

There are various interpretations but no clear evidence to explain how the family of Gaius Julius Caesar received the cognomen *caesar* and how this family name at some point became associated with a surgical procedure. The name of Caesar might derive from several literary sources, such as from the Latin *caedere/caedo*, meaning "to cut, fall, or kill; to cut down or to strike mortally as in conflict," [6] possibly reflecting a traumatic or surgical delivery sometime in the family's past [7]. It is also possible that a legend of an abdominal delivery became associated with the family name simply as an honor. Preternatural births were thought to confer on the child certain special virtues, powers, or abilities – exactly what might be expected of a world leader such as an emperor. After all, the Julian family was noble and from a patrician clan. Caesar's father, once the governor of Asia, had served as praetor, the second most important post after counsul [8].

Another possible origin of the term *cesarean* derives from legal responses to the problem of peri- or postmortem delivery. The first law relating to postmortem delivery is reputed to have been promulgated by the quasi-legendary king of Rome, Numa Pompilius (715–673 B.C.E.), and termed the *lex regia* (and subsequently *lex caesarea*) [1]. This edict concerned the abdominal delivery of a child during an acute life-saving effort in the unusual circumstance of a dying or recently dead mother. The statute was a type of Good Samaritan law, requiring delivery of the unborn child from its mother and forbidding the burial of the dead woman until this was accomplished. The law also protected the person who performed such a perimortem procedure from an accusation of murder or manslaughter, assuming that the amateur surgeon acted in good faith.

Some English words with specialized meaning have their origin in the Latin roots that originally gave us the term *cesarean*. In musical notation, a *caesura* is a set of closely approximated parallel lines in the score that mark a sudden stop, or cut, in the course of the program. This term is also used to indicate an interruption, break, or pause between words within a metrical foot in poetry, or in the middle of a line of text. In a social/political context, both the titles of *Kaiser* and *Tsar* (C*zar*) have their origin in the original Latin C*aesar*. In English, both Kaiser and Tsar either describe an authority figure, usually a tyrannical one, or are used in their historical sense as the traditional titles for a Holy Roman, Austrian-German, or Russian Emperor, respectively.

Whatever the origin of the term, by the mid-sixteenth century, the term *cesarean* was used to describe abdominal surgical deliveries in medical literature. One of the earliest commentators or medical editors to refer to the abdominal delivery of an infant as a cesarean was Richard Jonas, who translated, edited, and expanded one of the many editions of the obstetric textbook usually termed the *Roszgarten*, which was originally authored by Eucharius Rösslin of Frankfurt-am-Main (discussed later in this chapter). First published in 1540 in its English editions as *The Byrth of Mankynde*, this text was thereafter frequently reprinted. In one of these reprintings, Jonas commented in reference to abdominal delivery "...that are borne after this fashion be called cesares, for because they be cut of theyr mothers belly, whervpon also the noble Romane cesar...of that name in Rome toke his name..." [9].

The second part of the usual term for obstetric abdominal surgery, *section*, probably has its origin in the Latin verb *secare/seco*, meaning "to light, strike, or reach," or "to cut into, separate, divide, or part" [10]. Another possibility is *incidere/incido*, meaning "to fall or on, happen, or occur" [6,10].

At some indeterminate time in the past, the terms used to describe the surgical operation for abdominal delivery, *cesarean* and *section*, became inextricably linked. Over time, however, the terms used to describe the surgery for abdominal deliveries have changed. In modern times, such surgical delivery of the fetus was referred to as a c*esarean operation* until the early twentieth century, when the term *cesarean section* became popular [1]. Currently, the term *cesarean birth* is frequently used in both lay and professional literature. Because of the redundancy inherent in the term *cesarean section*, we prefer to describe the surgical operation for the abdomen delivery of a child as a *cesarean delivery*, a *cesearean operation*, or simply as a *cesarean*. These conventions are used in the current text.

Cesarean Delivery in the Historical Record

Beyond the mythology of the origins of the cesarean-related terms is also a long historical record of successful and not-so-successful abdominal deliveries. The oldest reliably recorded operations date back to the Sumerians in the second millennium B.C.E. More than 1,000 years later, Gorgias (483–375 B.C.E.), a famous orator from Sicily, is reputed to have been delivered by a cesarean Records from as early as the second century C.E. report the operation several times, and in early Jewish literature Maimonides (1135–1204) mentioned cesarean surgery and commented on technique. It was not until the seventeenth century, however, that thoroughly documented cesarean deliveries are known to have been performed on living women with occasional maternal or fetal survivals. Many of the earlier reports are incomplete, wildly improbable, or so warped and embellished by multiple retellings that they remain suspect.

Commentary concerning cesarean delivery appears early in obstetric literature; however, many of the classic medical authors fail entirely to mention the procedure, attesting to its rarity. As an example, Soranus of Ephesus (98–138 C.E.) does not include cesarean operations in his review of surgical procedures. Sonanus did describe the management of obstetric malpresentation by version and extraction but did not mention the use of instruments or abnormal surgery for delivery. Aurelius Cornelius Celsus (27 B.C.E.–50 C.E.) in his book *De Re Medica* (c. 30 C.E.) is also silent on abdominal delivery yet provided instructions for the extraction of dead infants by the use of a hook or crochet. Cesareans are also not a part of the corpus of Hippocratic writings. Eucharius Rösslin the Elder's (also Roeslin, Roesslyn, or Rhodion) important, early obstetric textbook *Der Swangern Frawen und Hebammen Rosegarten*, published in Strassburg in 1513 and widely known as *The Roszgarten* (also *Roszgarten* or *Rosengarten*) does not mention the cesarean operation. As earlier noted, however, one of the many later editors or revisers of this book, Richard Jonas, did make such a reference in a commentary included in one of the many subsequent English language reprintings of this remarkably long-lived textbook.

There are various reports of cesarean deliveries from numerous sources before the seventeenth century. Unfortunately, most simply document the danger of the procedure and the extreme risk to the mother's life. In Sweden, a postmortem cesarean operation was first recorded in 1360. Scipio Mercurio (1550–1616?), a surgeon of Padua, claimed several successful cesarean operations in his textbook *La Commare o Riccoglitrice*, published in 1596. In 1578, Giulio Cesari Aranzio (1530–1589) reported a successful postmortem cesarean delivery on a mother who had died late in the third trimester. Jacques Guillemeau (1544–1612) was surgeon to Henry and a student of the noted barber-surgeon Ambroise Paré (1510–1590). Guillemeau included a chapter on cesarean delivery in an obstetric text that was later translated into English by Thomas Hatfield in 1612 and entitled C*hildbirth or, The Happie Deliverie of Women* [11]. Guillemeau stated that he had seen the operation carried out by various surgeons on a total of five women, all of whom had died. In his discussion of the procedure in this book, Guillemeau was among the first to introduce the word *section* into the medical literature.

The most controversial of the early reports of successful operative deliveries is that involving Jacob Nufer, a sow-gelder who is reputed to have performed a successful cesarean on his own wife circa 1500. The Jacob Nufer story was first related by Caspar Bauhin (1550–1624), more than 80 years after

the supposed event, in the appendix and commentary to Bauhin's Latin translation of a text entitled *Traité Nouveau de l'hysterotomokie ou l'enfantement Caesarienne* printed in Paris in 1581 and originally authored by François Rousset (1535–1590?), physician to the Duke of Savoy [12]. Rousset, although not himself a surgeon, recounted cases of cesarean deliveries performed by others and claimed to have been an observer in still more, including several with maternal and fetal survivals. He argued that a cesarean was not only "a feasible operation" but also could preserve the lives of both mother and infant. As the title of his text reflects, Rousset termed the procedure a *cesarean delivery* or "enfantement Caesarienne" presumably in homage to the legend involving the birth of Julius Caesar [13]. The Nufer story was retold as late as the mid-eighteenth century by the reviewer and critic John Burton (1710–1771) in his textbook of obstetrics, *An Essay towards a Compleate New System of Midwifry*, published in 1751 [14].

As the Nufer tale is usually related, both lithotomists and midwives were called in consultation when the labor of Nufer's wife was obstructed. None of these attendants was able to bring the child forth, however. In desperation, Nufer himself performed a surgical delivery. His wife is supposed to have not only survived the operation but also later to have delivered other children vaginally. Although this entire story is suspect, it might contain a kernel of hidden truth. Because of the nature of his work in animal husbandry, Nufer would have had rough surgical and birthing experience. Such people with a functional knowledge of delivery mechanics were occasionally called on in the sixteenth century to help manage obstructed human labors. This might explain his active involvement in his wife's confinement. But, can the rest of this remarkable story be believed? Perhaps what Nufer's wife had was an advanced abdominal pregnancy. This could explain both her survival following an unsterile laparatomy and her subsequent unimpaired fertility. What actually happened in that Swiss hamlet in 1500, and the degree to which the Nufer story has been embellished and distorted over time, cannot now be determined as no new information is likely to be forthcoming.

In 1610, a physician in Wittenberg, Jeremias Trautmann, conducted the earliest well-documented cesarean delivery [15]. Although a surgery is known to have been performed and a child delivered, the clinical details remain confusing. It is possible that what Trautmann actually found was an anterior uterine sacculation or an abdominal pregnancy. In other accounts the pregnancy was normal and the reason for surgery was a large ventral hernia that precluded normal labor. In fact, whether a pregnancy was even diagnosed before the operation is uncertain, and the infant might have been an unexpected discovery during a surgical exploration to relieve acute abdominal symptoms. In any event, an abdominal procedure was conducted, a child was delivered and is presumed to have survived although the extant records are at best incomplete. Unfortunately, the mother died some 25 days after the original operation, presumably from infection.

From the inception of the operation, controversy concerning the propriety of cesarean delivery has characterized the medical literature. It was recognized very early that postmortem operations on mothers dying in labor or late in pregnancy would rarely result in a normal and surviving child. Owing to the state of development of surgical technique, a cesarean was a virtual death sentence for both mother and infant until the early nineteenth century. To operate on a living woman was thus shunned, owing to the profound maternal risk from surgery and the uncertainty of success in salvaging a living infant. When labor was obstructed, version and extraction, fetal destructive procedures, and later symphysiotomy were the accepted methods for delivery. Whereas the mother often survived these obstetric manipulations and destructive procedures for vaginal delivery, in almost all cases the infant did not.

With this background, including horrific reports in the literature and their own experience with disastrous cesarean results, most of the influential obstetric educators of the sixteenth and seventeenth centuries, including Ambroise Paré (1510–1590), Jacques Guillemeau (1550–1630), Pierre Dionis (1643?–1718), and François Mauriceau (1637–1709), advised strongly against performing a cesarean operation on living women. Mauriceau, the most celebrated obstetrician of the late seventeenth century, discussed known obstetric procedures in his textbooks, *Traité Les Maladies des Femmes Grosses, et Accouchées* (Figure 1.1) [16] and *Observations Sur la Grossesse et l'Accouchement des Femmes, et sur Leurs Maladies, &; celles des Enfans Nouveau – Nez* [17].

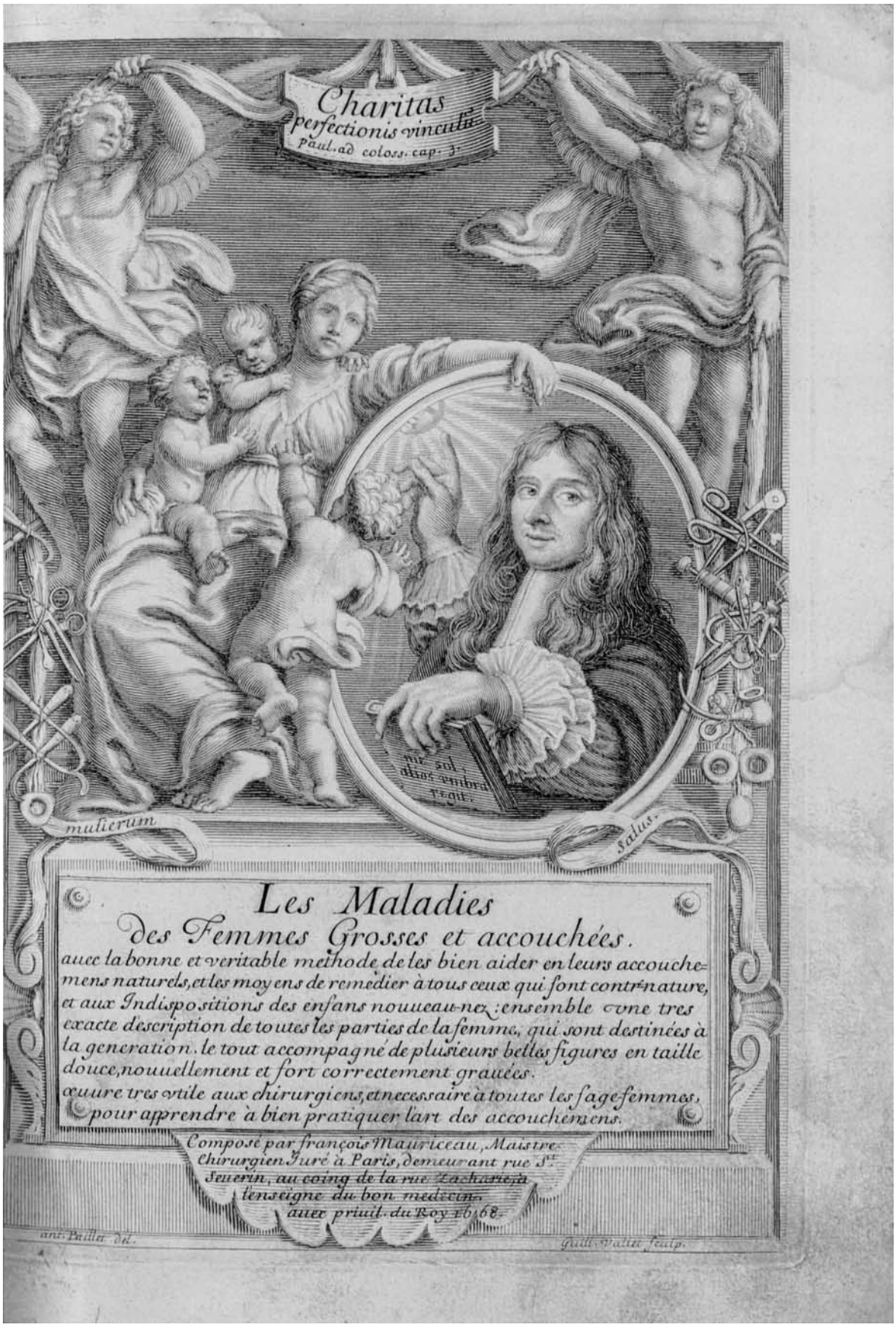

FIGURE 1.1.
Title page of the Traité *of François Mauriçeau (c. 1668).*

Mauriceau argued that only postmortem cesareans should be performed. He was well experienced in serious obstetric complications and knew firsthand of the limitations imposed by the inability of physicians to conduct abdominal deliveries. His own sister had experienced a serious antepartum hemorrhage from a placenta previa. When her attendants recoiled from intervention, Mauriceau had delivered her himself by version and extraction. Unfortunately, she did not survive this procedure [18].

In contrast, some early medical authors did support cesarean delivery. Jean-Louis Baudelocque (1746–1810) and André Levret (1703–1780) advocated cesareans for a contracted pelvis, in preference to the usual procedures of embryotomy, decapitation, or cranial decompression. The maternal and fetal results of most early cesarean operations were disastrous, however, reinforcing the argument for those who opposed such surgeries. According to Baskett [11], on one occasion, the noted French accoucheur Baudelocque was forced to defend himself in court when a contemporary called him an assassin because of Baudelocque's favorable opinions concerning cesarean delivery!

Cesarean deliveries were sporadically reported in the medical literature from the eighteenth through the mid-nineteenth century with generally poor results and often the loss of both mother and infant. In the early to mid-1700s cesarean deliveries were performed in Paris at a rate of approximately 1 per 4000 births. Unfortunately, the associated maternal mortality was 70% to 80%! A few successful abdominal deliveries did occur outside of the French capital between 1760 and 1814, however [19]. There were similarly grim statistics from the British Isles. There was not a cesarean delivery with documented maternal survival in Ireland until 1738, when a midwife, Mary Donally, operated on a 33-year-old multipara. In this case, Donally made a right paraumbilical incision with a razor; the incision subsequently closed with a tailor's needle and silk thread. The patient survived but later developed a ventral hernia. A cesarean delivery following a 6-day obstructed labor is also known to have occurred in England in 1737, but neither mother nor infant survived. In fact, a cesarean operation in England in which the mother is known to have survived did not occur until 1793 when the first case was reported. The mother in this instance had been in labor for three days when a surgeon, James Barlow delivered a dead child through a left paramedian incision [1]. From the same era there is an incompletely documented report of a successful cesarean delivery from America. Dr. Jesse Bennett (1769–1842) is supposed to have performed the procedure on his own wife in 1794 in Staunton, Virginia, following an unsuccessful effort at vaginal instrumental delivery. The details of this case are sketchy, and the documentation is poor. Thus, this claim is not generally considered credible. The first well-documented American report dates from 1827, when Dr. J. Cambert Richmond (1785–1855) performed an operation on a nulliparous eclamptic woman. Although the mother survived, the infant did not [20]. Another cesarean with maternal survival was performed before 1821 (exact date unknown) by the physician and surgeon James Miranda Barry in South Africa. Barry holds the unique distinction of being both an Edinburgh graduate and a woman who successfully masqueraded as a man from 1809 until her death in 1865 [18]. Africa is also the source for a report of another successful cesarean delivery performed by an unknown indigenous surgeon. In 1879, R. W. Felkin, a Scottish medical traveler in what later became Uganda in East Africa, witnessed and later published his observations concerning a cesarean delivery [21]. Preoperatively the surgeon cleansed his hands and the mother's abdomen with banana wine. The same fluid was administered orally to the mother before the surgery began, presumably to induce a degree of insensibility. After the delivery, which the surgeon performed through a midline incision, the uterus was not sutured. The abdominal incision was pinned together with iron needles and then secured by a bark-cloth string. Bleeding was controlled by cautery. Felkin claimed that the woman made a full recovery and noted the apparent expertise of the surgeon, concluding that the procedure was well established in that part of Africa.

In the late eighteenth century and into the early years of the nineteenth century, because of the serious risks of surgery, symphysiotomy vied with cesarean delivery as the best procedure for obstructed delivery. Intentional incision of the pubic symphysis was introduced to medical practice in 1768, when Jean René Sigault (1740–18??) described the technique in a single case [1,11,25]. Sigault successfully delivered a multiparous woman (a Madam Souchot), whose first child was lost owing

to an obstructed labor and a fetal demise, eventually terminated by an embryotomy. Her other deliveries had been equally unfortunate, resulting in stillbirths. For his efforts, Sigault received both a medal from the Facility of Medicine in Paris, and a government pension. A medal was given to his assistant, Alphonse LeRoy (1742–1816), and to complete the awards, a pension was provided for the patient, who, despite a rocky postpartum course, including abscesses and a vesicovaginal fistula, survived! Despite such occasional successes, because of the manner in which symphysiotomy was performed, maternal morbidity and mortality were high. For these reasons, the procedure soon fell into disfavor and was not revived until the twentieth century. Symphysiotomy is still occasionally performed in parts of the nonindustrialized world as an alternative to a cesarean [23,24].

Prior to the late nineteenth century, several serious technical problems precluded safe cesarean deliveries. First, the operation was viewed as the last resort. It therefore usually was not performed until after prolonged labor, multiple examinations, manipulations, and various unsuccessful efforts at vaginal instrumental delivery. Inevitably, many of these women were exhausted and dehydrated, and most were infected. Surgical procedures at that time were also primitive. Before the invention of inhalation anesthesia in the late 1840s, surgery needed to be rapid. Only laudanum and alcohol were available as analgesic agents and the patient had to be actively restrained during the procedure. Furthermore, nothing was known concerning aseptic methods of surgery, ensuring a serious risk of infection. In the usual technique, the maternal abdomen was opened by a vertical incision, lateral to the rectus muscle. Attendants restrained the mother and, once the abdomen was entered, endeavored to hold back the intestines with their hands. The uterus was incised vertically and the child removed. Usually, the uterine wound was specifically not sutured because sutures were believed to predispose to complications, but the edges of the abdominal wound were usually reapproximated. Because of the timing of the operation, the absence of aseptic technique, and the failure to close the uterus, mothers usually rapidly died of hemorrhage or, if they lingered for several days, of peritonitis.

Progress was slow. The first reported instance of the successful use of uterine sutures at a cesarean was by the surgeon Jean LeBas (1717–1787). In a 1769 delivery, he applied silk thread sutures to a uterine incision to stop hemorrhage. The patient subsequently recovered. Inevitably, LeBas was heavily criticized by his contemporaries. After LeBas' report, several attempts at routine uterine suturing occurred in individual cases, usually with disastrous results [11].

From our vantage point, it is hard to understand why suturing of the uterine wound during a cesarean was considered inappropriate until almost the beginning of the twentieth century. This practice followed then-contemporary clinical experience and well-established surgical technique, however. A common reason given for not suturing the uterus routinely after a cesarean was the belief that rapid uterine involution would inevitably loosen any stitches, rendering them ineffective. Another problem was infection. In the eighteenth and well into the nineteenth century, sutures placed by a surgeon were routinely left long, protruding from the wound. This was believed necessary to facilitate drainage and to provide access for the eventual removal of the sutures, which usually were not absorbable and, of course, not sterile. Conventional wisdom and clinical observation held that deeply placed sutures invariably became infected, leading to abscess, cellulitis, or sepsis. A wound left open, with the suture ends exiting the skin, would eventually begin to develop what was termed laudable pus, however. With time, progressive tissue necrosis would eventually release the sutures. The usual practice was that several days after the surgery the surgeon would begin intermittently to pull gently on the suture ends. This process was subsequently repeated once or twice daily until local necrosis was sufficient to permit the extraction of the sutures without eliciting a hemorrhage. For patients who survived to the point of suture removal, eventual recovery was likely. After suture removal, the wound would slowly heal by secondary intention. Once the process of granulation was well advanced such wounds were quite resistant to infection and unlikely to lead to cellulitis or sepsis. Unfortunately, when such standard surgical techniques were used in cesarean deliveries, hemorrhage and infection were routine, with serious and usually fatal consequences for the mother.

When uterine reapproximation was finally introduced, silver wire became the initial suture material of choice, mirroring its use in nineteenth century

gynecology. Frank E. Polin of Springfield, Kentucky, first reported the use of silver wire in the closure of a uterine wound in 1852. Other than silver wire, many other types of suture were in use, derived from a wide range of materials including silk, carbolized gut, horsehair, and even hemp. What would now be considered as appropriate uterine approximation with nonpermanent suture materials was not introduced until the early 1880s.

Many important surgical innovations begun in the mid-nineteenth century eventually made safe cesarean deliveries possible. Ether was first used during labor in Boston in 1847 and subsequently popularized by the socially prominent New England obstetrician Walter Channing (1786–1876). The anesthetic properties of chloroform were discovered by James Young Simpson (1811–1870) and first employed by him in deliveries in Edinburgh beginning in 1847 [11].

A major breakthrough in the technique of cesarean surgery occurred in the early 1880s. Max Sänger (1853–1903), then an assistant to Carl Siegmund Franz Credé (1819–1892) in Leipzig, introduced an operative procedure in 1882 that is now considered the classic cesarean operation. In doing so, Sänger revolutionized standard cesarean surgical technique [26]. In a general review for a monograph concerning the cesarean operation, Sänger had collected published case reports of prior deliveries that he carefully reviewed and critiqued. Based on these data from the literature and his own experience, Sänger argued that operative complications from cesareans would occur less frequently if the myometrium were closed and a concerted effort made to avoid the spillage of intrauterine secretions into the peritoneal cavity [26]. His procedure featured a meticulous, water-tight reapproximation of the uterine wound, employing buried sutures. Sänger also exteriorized the uterus before delivering the infant and attempted to improve postoperative drainage by passing a drain from the fundus out through the cervix.

Although maternal morbidity and mortality from cesarean deliveries remained high even with Sänger's improvements, statistics were substantially better with his technique than the levels previously experienced. It was only after Sänger's 1882 paper that closure of the uterus was finally recognized as both a feasible and necessary part of cesarean technique [1].

Horatio R. Storer, of Boston, Masschusetts, first performed a cesarean hysterectomy in 1868, on a woman with a large leiomyoma that obstructed the birth canal. He removed the uterine corpus and adnexa during this procedure. The child was stillborn and "in an advanced state of decomposition." The mother died three days later. The first maternal survivor following cesarean hysterectomy occurred in 1876, when a woman with rickets and pelvic contracture was delivered by Eduardo Porro (1842–1901) [1,27]. What later was termed the *Porro operation* was a unique surgical procedure originally suggested by the Florentine surgeon Joseph Cavallini in 1768. Cavallini and later Porro had experimented with pregnant hysterectomy in animal models. Cavallini had operated on dogs and sheep; Porro had used rabbits. Each had proved to his satisfaction that the uterus was not necessary for life and that its surgical removal was technically possible.

In early 1876, Porro encountered a 25-year-old nullipara with a rachitic pelvis and a true conjugate of 4 cm or less, precluding vaginal delivery. Following careful consideration and preparations, including preliminary handwashing with carbolic acid, Porro performed a classic cesarean delivery by means of a midline abdominal incision, with the patient under chloroform anesthesia. After delivery of the baby, an iron-wire snare was passed around the uterus, tubes, and ovaries. All these structures were then amputated and the remaining cervical stump was bought out of the abdomen through the lower end of the midline incision. Drainage tubes were inserted and the abdominal wall was then closed around the residual stump with silver-wire sutures. The snare was removed on the fourth day and the sutures on the seventh. The exterialized cervical stump and lower portion of the abdominal wound were then permitted to heal by secondary intention. Six weeks later, the woman left the hospital with her infant. Remarkably, she was the first to survive a cesarean delivery performed at that clinic!

The Porro operation rapidly gained acceptance in Europe because it radically solved the problems of both hemorrhage and infection. Maternal losses with the Porro operation remained high but were substantially below those experienced before the procedure was introduced. By 1884, approximately 140 of these operations had been reported in Europe, with a maternal mortality rate of 56%. After 1882, the classic cesarean operation without

hysterectomy as popularized by Max Sänger began to replace Porro's operation as the surgical technique of choice because the rates of maternal morbidity and mortality were lower. By the onset of the twentieth century, the Porro operation had been entirely superseded.

Despite these and other innovations, cesarean delivery did not gain popularity with practitioners until well after the introduction of aseptic technique by Joseph Lister (1827–1912) and others in the latter decades of the nineteenth century. Drawing upon the new discoveries in bacteriology and the development of the germ theory of infection,the combination of improved anesthesia and new surgical methods finally blunted the horrific rates of maternal morbidity and mortality associated with cesarean operations [28]. The great safety of cesarean delivery still awaited changes introduced during the twentieth century.

The rapidly falling mortality rate of cesarean hysterectomy expanded the potential indications for the operation. Cesarean hysterectomy became progressively popular during the period from the late 1940s to the mid 1960s, and was often performed for sterilization. In recent decades, because of the substantial morbidity of the operation, cesarean hysterectomy has fallen from favor as an elective method of sterilization. At present, this procedure is generally restricted to management of uncontrolled hemorrhage, the rare case of nonreparable uterine injury, or for other reasons of severe uterine or cervical pathology. In recent years, the availability of potent uterotonics and broad-spectrum antibiotics, the development of embolization techniques, and new methods of vessel ligation have markedly reduced the need for emergency cesarean hysterectomy, although it still remains an important and potentially lifesaving procedure (See Chapter 18, Cesarean Delivery).

Other innovations in surgical technique lessened the risks of surgery. Maternal complications from cesarean deliveries were reduced by the development of the lower-segment cesarean operation, a procedure originally suggested by Johann F. Osiander of Goettingen (1759–1822). In 1805, Osiander opined that entry into the uterus through a vertical lower-segment incision could avoid the complications of the usual surgical technique, which then involved a vertical incision in the upper and thicker portion. More than a century later, Bernard Krönig (1912) revived this idea and proposed dissecting into the vesicouterine space and subsequently using the bladder serosa to cover the uterine incision, to protect the peritoneal cavity from exposure to the lochia. This combined technique of a lower-segment uterine entry and sequestration of the myometrial wound behind the peritoneum resulted in less immediate surgical morbidity and substantially reduced the risk of uterine rupture in subsequent pregnancies.

The extraperitoneal cesarean operation has an interesting history [20]. This procedure was first proposed by W. E. Horner in 1824. Such procedures were not performed until Alexander Johnston Chalmers Skene (1838–1900) successfully delivered a woman with a rachitic pelvis by this technique [7]. In 1909, the extraperitoneal operation gained support when Wilhelm Latzko of Vienna reported only two maternal deaths among thirty such procedures. Latzko's paravesical, extraperitoneal operation was later popularized in the years prior to World War by E. G. Waters [29] and J. F. Norton [30]. The theoretical advantage of this operation was to isolate the entire operative site retroperitoneally and thus potentially avoid the risk of peritoneal contamination. The progressively increasing safety of the transperitoneal approach, the rapidly decreasing incidence of protracted, dystocic labors, and the advent of antibiotics markedly reduced the importance and advantage of the extraperitoneal operation, however. It is now uncommonly attempted.

In recent decades, additional modifications in cesarean operative technique have been introduced. New and less tissue reactive suture materials are now available. In routine operations contemporary surgeons now frequently omit the serosal or vesicouterine flap closure and closure of the parietal peritoneum in an effort to reduce adhesion formation. The standard methods for both opening and closing both the fascia and uterus also have changed, at least for many surgeons, replacing the traditional sharp entry by techniques of blunt dissection and employing running as opposed to interrupted sutures for closure. Perhaps the most marked change in cesarean practice in the last 75 years has not been in surgical technique, however, but in the remarkable reduction in serious maternal morbidity and mortality associated with the operation by the administration of prophylactic antibiotics, the rapid