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Two Hundred Years of Progress in the Practice of Midwifery

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No specialty shows better than obstetrics the tremendous progress that has been made in medicine in the past 200 years (see timeline, available with the full text of this article at NEJM.org). Progress in that ancient craft has occurred not in leaps and bounds or flashes of inspiration but incrementally by the incorporation of myriad scientific advances into obstetrical practice. These advances include improvements in general medicine such as aseptic technique, anesthesia, the ability to measure blood pressure and recognize its association with eclampsia, the understanding and technical developments that permit the safe transfusion of blood, and imaging technology. Equally important have been changes in attitudes toward women, which have resulted in a more central role for women in society, autonomy in controlling their own reproductive destinies, and an evolution in the nature of the relationship between the physician and patient.

To illustrate these changes, two "lectures" follow — one hypothetically given in 1912, the other in 2012. Each is faithful to the facts of the day, but neither was actually ever delivered by these fictitious speakers.

A Lecture in 1912

A timeline is available at NEJM.org

On a cold, snowy evening in January 1912, Dr. Walter B. Franklin, assistant visiting physician at the Boston Lying-In Hospital, steps up to the lectern to address the Obstetrical Society of Boston in its 51st year.

"Gentlemen, I would like to discuss with you this evening the current status of our specialty, including our experience at the Boston Lying-In Hospital with the first 100 cesarean sections performed at the hospital and reported in considerable detail in the *Boston Medical and Surgical Journal*.[1]

"The first cesarean section in the Boston Lying-In Hospital was performed on July 15, 1894, and the 100th on June 29, 1907. In the present series of cases, the operation has been performed almost exclusively for a pelvic indication, there being only four cases in which pelvic deformity or the repeated loss of children in previous labors has not been the definite indication. The cases can be divided into three groups according to the classification system described by Dr. Reynolds [Table 1].[2] Primary sections were those that were performed before the beginning of labor. Secondary sections were performed after labor had begun but before exhaustion had set in, and late sections were, according to Dr. Reynolds, 'performed after definite arrest of the head at the pelvic brim.'

"In the series of 100 cesarean sections, there were eight maternal deaths. This is an unduly high mortality for any abdominal operation that is usually not absolutely necessary and in which the saving of the life of the child is the chief indication for the operation. But, when we study the results according to the classification of the procedures, interesting conclusions can be drawn.

"There were 43 primary operations in this series, with the death of only one mother. The cause of death was general peritonitis, probably due to some slip in

Table 1. Classification of Cesarean Sections as Described in 1907 by Reynolds in the *Boston Medical and Surgical Journal*.*

Section	Performance	Comment
Primary	"Before the beginning of labor, or with the advent of the first pains"	
Secondary	"After a certain amount of labor had demonstrated its probably unsatisfactory character"	"Performed before exhaustion set in"
Late	"After definite arrest of the head at the [pelvic] brim"	"Often involved a precarious situation"

* Classifications are from Reynolds.[2]

the operative technique. One newborn died from congenital heart disease a few minutes after delivery. Thus, in this group, 2.3% of mothers and 2.3% of children died.

"There were 26 cases of secondary sections, with one maternal death that was due to pyemia on the eighth day after the operation. At the time of the operation, it was known that the mother was a poor risk, since she had chronic nephritis, but the condition demanded operation due to an extreme degree of vaginal atresia after an old laceration in childbirth. Two newborns died after delivery. One was a small, poorly developed baby of a rachitic dwarf, and the newborn died 4 hours after delivery; the other newborn died of inanition 17 days after delivery. Thus, among the secondary sections, there was 4% maternal mortality and 8% child mortality, and complications during convalescence were much more prominent than after the primary sections.

"There were six maternal deaths among 31 late sections (19%). The cause of death in all patients except one was general peritonitis. One woman had been in labor for 56 hours and had a foul vaginal discharge at the time of operation; furthermore, the newborn was already dead, making the operation unjustifiable from every perspective. The only death not due to peritonitis involved a woman with a sponge left in the abdomen after the operation. The abdominal wound broke down on the fourth day, and the sponge was removed from the abdominal cavity. She died on the 25th day from intestinal obstruction due to adhesions. This is clearly a case of faulty operative technique on the part of the surgeon. Five babies died either before operation was begun or shortly after delivery (16%).

"In the late sections, the outcome was much worse than in the primary or secondary sections, with a maternal mortality of 19% and an infant mortality of 16%. After attempts at pelvic delivery, 50% of our patients were more or less seriously compromised and one third of the babies died. Thus, today, given the mortal consequences of failed labor and failed forceps delivery, it must be recognized that the obstetrician who allows a patient to go into labor without a careful study to assess as definitely as possible the probable outcome for both mother and child, and who assumes that everything will probably go well, has failed in his professional duty. When a patient has had a previous cesarean section, some danger always exists that the scar of the uterine wound may rupture during the pregnancy, and it is very liable to rupture during labor. Therefore, it is not advisable to allow a patient who has had a cesarean section to go into labor.

"The conditions that render cesarean section unduly dangerous are previous attempts at pelvic delivery and infection of the uterus as shown by increasing temperature or as rendered probable by repeated vaginal examinations without perfect asepsis. In certain rare cases, it may be found advisable to remove the uterus after cesarean section. When the patient with the uterus already infected undergoes an operation for other conditions that render pelvic delivery impossible, a complete hysterectomy should always be performed to provide the patient with the only chance to survive, since the closing of a septic uterus and replacing it in the clean peritoneal cavity practically amounts to signing the patient's death warrant.

"Of the 100 sections in this series, 25 were repeat operations. The reason for this large proportion is that it is the policy of the Boston Lying-In Hospital never to remove or impair the function of healthy organs to prevent subsequent pregnancy. This policy contrasts with the advice of J. Whitridge Williams.[3] He questions the recommendations of some authorities who consider that

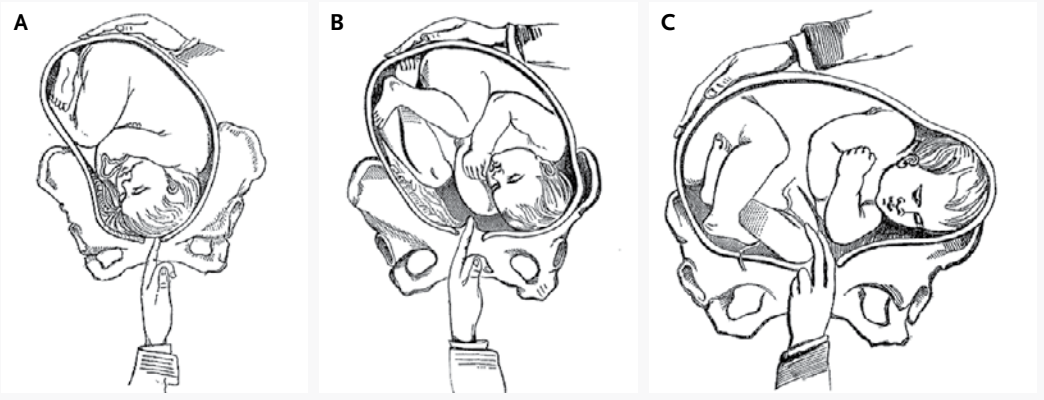

Figure 1. A "New Method of Version in Abnormal Labor" for Managing Placenta Previa, Described by Braxton Hicks.
Panel A shows manual dilation of the cervix and sweeping of the examiner's finger around the cervix and lower uterus to separate the placenta from the cervix to permit it to further dilate. Panel B shows the use of both of the examiner's hands, one on the mother's abdomen and one in the uterus, to turn the fetus into breech presentation. Panel C shows the examiner grasping one leg of the fetus to bring the leg through the cervix to initiate labor and achieve tamponade of bleeding from the placental bed. Illustrations are from Braxton Hicks.[4]

sterilization should form an integral part of every cesarean section. He recommends that, if the patient is intelligent, the decision should be left to her or her family; whereas with the ignorant it is incumbent on the physician to do what he thinks is best under the circumstances.

"Traditionally, placenta previa has been managed as early in pregnancy as possible with examination of the os uteri to determine how well it is dilated and the degree to which it is covered by the placenta. If the os is adequately dilated and the placenta can be palpated to completely cover it, then detachment of the placenta as far as the fingers can easily reach will relieve the os from the restriction that the adhesion of the placenta caused, allowing the os to dilate. If this procedure results in heavy bleeding, then the quickest and surest plan is to turn the fetus according to the method described by Braxton Hicks: bring down one of the legs of the fetus to plug the os to stop the bleeding, and labor pains will generally begin shortly [Fig. 1].[4]

"A great deal has been written in the past few years about the advisability of performing a cesarean section in cases of placenta previa. Tait[5] reported the first such case of treatment of 'unavoidable hemorrhage' by means of Porro cesarean section in Great Britain 13 years ago in the Lancet. [The Porro cesarean section is performed through a vertical midline incision that is 16 to 18 cm in length with the umbilicus at its midpoint. The uterus is incised longitudinally in its midline, and the baby is removed feet first. The cord is clamped, and the child is transferred away from the operative field. The procedure, from skin incision to delivery, should take no more than 90 seconds. The placenta is left in place. As soon as the baby is delivered, an elastic ligature is tied tightly around the upper portion of the mother's cervix. The infundibulo-pelvic ligaments are tied and cut, and the uterus is amputated just above the rubber ligature. The cervical stump is then sewn into the lower end of the abdominal incision. The remainder of the abdominal wound is closed in the usual fashion. The stump and elastic ligature slough off, leaving a wound that granulates closed.]

"The second case of cesarean section for placenta previa was reported by W.J. Gillette from Toledo, Ohio, in the *Boston Medical and Surgical Journal* in 1901,[6] despite the fact that his colleague decried the operation as 'a very unnecessary mutilation.' Although the maternal fatality rate from placenta previa is approximately 50% and infant mortality 66%, my own feeling is that an abdominal operation on a more or less exsanguinated patient for the sake of a premature child is not advisable, except in the rare cases in which a contracted pelvis or a rigid cervix would render a pelvic delivery difficult and dangerous.

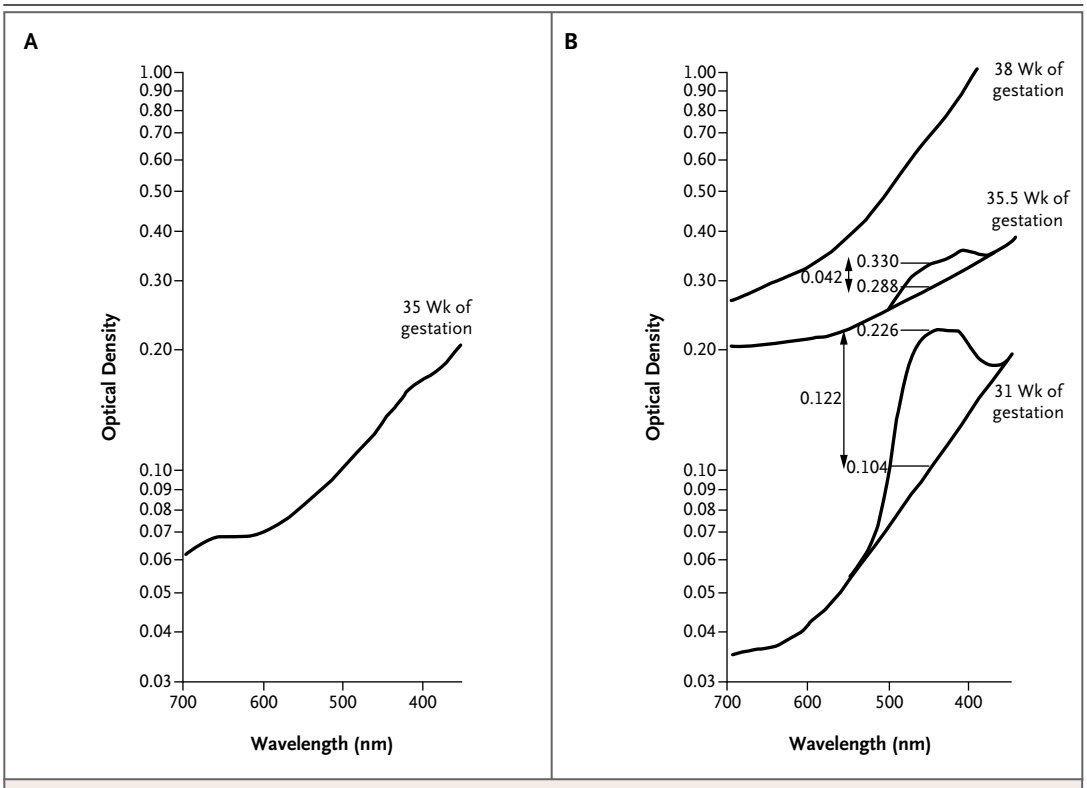

Figure 2. Spectrophotometric Analysis of Amniotic Fluid Showing Absorbance of Light by Bilirubin.

Panel A shows a minimal level of bilirubin in the amniotic fluid from a normal pregnancy at 35 weeks of gestation. Panel B shows deviation in the level of bilirubin from the normal fluid curve in an affected pregnancy at 31, 35.5, and 38 weeks of gestation. Data are from Liley.[13]

"At the present time, the successful performance of a large number of operations for various conditions has led to a gradual extension of the indications for operation until we are now standing on the threshold of one of the most marked changes that has ever to be considered in obstetrical practice. When a definite obstruction to labor, even of minor degree, is regarded as probable, is it not wiser to resort to a primary cesarean section for the benefit of both mother and child rather than to allow the patient to undergo a more or less exhausting labor, to be followed almost inevitably by a difficult pelvic operation, which is doubtful in its outcome, both to mother and child?

"Gentlemen, thank you for your kind attention this evening."

PROGRESS IN THE 20TH CENTURY

After the era in which this lecture took place, tremendous improvements in the practice of obstetrics occurred. Riva-Rocci developed a practical sphygmomanometer during the 1890s, and the availability of this device led to the widespread practice of blood-pressure measurement. Although the association between proteinuria and eclampsia had been known for centuries, the association with elevated blood pressure was not appreciated until the early 1900s. Between 1905 and 1907, case series involving women with eclampsia began to describe their elevated blood pressures.[7] The concept of routine prenatal care was developed during the 1920s, when it seemed that eclampsia might be predicted by routinely measuring blood pressure in pregnant women. Initiation of prenatal care for this purpose was immediately rewarded with reductions in maternal mortality.

The major blood groups were defined during the first 40 years of the century, and the harsh realities of World War II brought major advances in blood banking and transfusion.[8] Pregnant women benefited tremendously from the ready availability of transfusion to treat obstetrical hemorrhage. By the early 1930s, the pathophysiology of

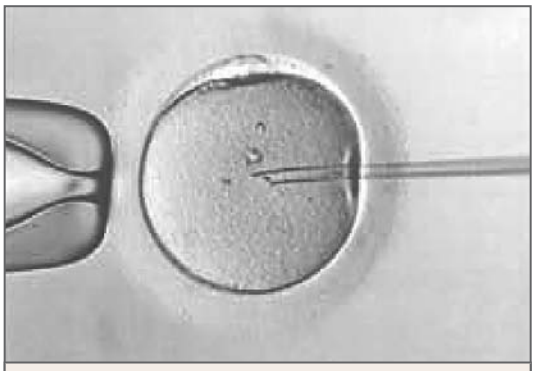

Figure 3. Photomicrograph of Intracytoplasmic Sperm Injection.

The ovum is held in position with negative pressure by a pipette (left) while a single sperm is injected with a micropipette (right). (Photomicrograph courtesy of Van Voorhis.[23])

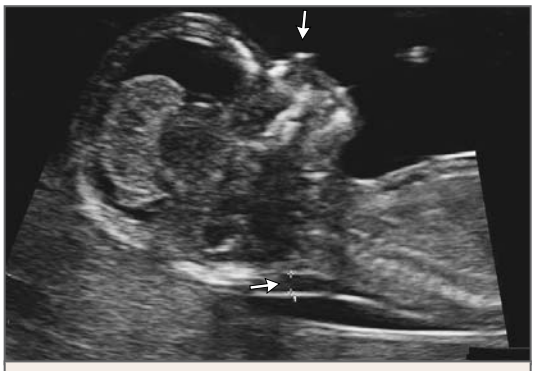

Figure 4. Diagnostic Ultrasonographic Midline Sagittal Image of a Normal Fetus at 12 Weeks' Gestation.

Both the nasal bone anteriorly (top arrow) and measurement calipers on the nuchal translucency posteriorly (bottom arrow) are shown. (Image courtesy of Dr. Jeffrey L. Ecker.)

erythroblastosis fetalis was understood to involve massive destruction of fetal red cells, fetal anemia, extensive extramedullary erythropoiesis, and the release of immature nucleated red cells into the circulation.[9] By the late 1930s, immune destruction of fetal erythrocytes with an antibody resulting from maternal–fetal blood-group incompatibility was suspected as the likely cause. There was consternation, however, over the fact that many of the cases seemed to involve mothers and babies with the same ABO group. By 1941, shortly after Levine and Stetson[10] and Landsteiner described the rhesus red-cell antigen, there was the strong suspicion that much of the disease was based on incompatibility between an Rh-negative mother and an Rh-positive fetus.[11] This understanding, in turn, resulted in the rapid abandonment of the previously routine practice of the use of the husband's blood in a woman undergoing transfusion.[12] Care of affected fetuses by appropriate timing of early delivery was improved tremendously by a 1961 study reporting spectroscopic analysis of amniotic fluid to detect bilirubin [Fig. 2].[13] It was not until the late 1960s, however, that anti-Rh(D) immune globulin was developed as an effective prophylaxis against Rh isoimmunization.[14]

Undoubtedly, the most important technical innovation of the last 30 years of the 20th century was the development of high-resolution real-time diagnostic ultrasonography. It has permitted early diagnosis of potentially life-threatening ectopic gestations.[15] It has also led to prompt, definitive diagnosis of fetal death, thus eliminating the potentially lethal problem of disseminated intravascular coagulation resulting from a retained dead fetus.[16] It has permitted accurate diagnosis of placental position and fetal lie and presentation to inform decisions about safe methods of delivery. It has brought unprecedented opportunities to examine the fetus in utero and to treat the fetus as a patient in its own right,[17] complete with a whole new set of diagnostic and moral dilemmas.[18]

The past 25 years have brought a wave of progress in medical genetics. There have been steps forward from the molecular genetic diagnosis of single-gene disorders in relatively small numbers of phenotypically abnormal persons[19] to routine screening of large numbers of phenotypically normal persons to inform them about their risk of conceiving abnormal offspring.[20] Correlations between genotype and phenotype remained challenging.[21]

A LECTURE IN 2012

On a March morning in 2012, Dr. Katherine J. Reagan, professor of reproductive medicine at the University of California, San Diego, School of Medicine steps to the podium to address second-year medical students and brings her PowerPoint presentation onto the screen.

"Good morning. As you prepare to see patients in your Ob/Gyn rotations, let me introduce you briefly to the scope of care that you will see provided to patients who wish to have healthy families.

"First, despite a variety of available contraceptive methods, approximately half of all pregnancies in the United States are unintended, with no appreciable change in that rate in several decades. Approximately 43% of those pregnancies end in induced abortions. In 1972, the last calendar year before the Roe v. Wade U.S. Supreme Court decision, which paved the way for legalized abortion, there were 39 maternal deaths due to illegal abortions in the United States. In the most recent decade for which we have data (1998–2007), there were 2 maternal deaths due to illegal abortions — a 99.5% reduction.[22]

"Approximately 10% of couples will not conceive after having unprotected intercourse on a regular basis for 1 year. Those couples will increasingly turn to in vitro fertilization, or IVF. The technique of microinjection of a single sperm pronucleus into an ovum, which is known as intracytoplasmic sperm injection, or ICSI, will also be used in patients with male-factor infertility as part of their IVF [Fig. 3]. Collectively known as assisted reproductive technology, or ART, these techniques are associated with the highest per-cycle success rates among subfertile couples.[23] Per-cycle live birth rates decrease with increasing maternal age. Among younger women, the rate is 50% and increases cumulatively to 70% after several cycles.[24] Collectively, infertility treatments are responsible for more than 1% of all babies born in the United States today[25] and more than 2% of those born in Sweden.[26] Associated with the success of all types of treatments for subfertility has been a 74% increase in the rate of multiple births in the United States, from 1.9% in 1980 to 3.3% in 2008.[27]

"As women get older, their risks of conceiving and delivering aneuploid fetuses increase progressively.[28] In 1980, women 30 years of age or older delivered 20% of the babies in the United States; between 2000 and 2008, that proportion was 35%.[29] In the 1980s, the only options available to women who wished to avoid delivering an aneuploid fetus were invasive diagnostic procedures: amniocentesis or chorionic villus sampling followed by pregnancy termination of affected fetuses.[30] Because of the invasive nature of the testing and the risk of procedure-related complications,[31-33] testing was offered only to women at highest risk — those 35 years of age or older. The past three decades have seen several developments in noninvasive, and therefore risk-free, prenatal screening based on fetal ultrasonographic imaging [Fig. 4] and maternal serum biochemical markers.[34-36] As compared with a population-based maternal age–specific risk, these techniques derive an estimate of risk of fetal aneuploidy that is specific to a pregnancy in an individual woman. Women at high risk for single-gene disorders or aneuploidies who want to avoid these births but find pregnancy termination unacceptable may choose preimplantation genetic diagnosis. In this process, a single blastomere is removed from each of the embryos created by means of IVF and ICSI and studied with the appropriate molecular genetic techniques to enable transfer into the uterus of only genetically normal embryos.[37] Recognition that measurable quantities of cell-free fetal DNA appear in the maternal circulation very early in gestation[38] has resulted in successful noninvasive prenatal diagnosis of single-gene disorders in fetuses of women known to be at risk.[39,40]

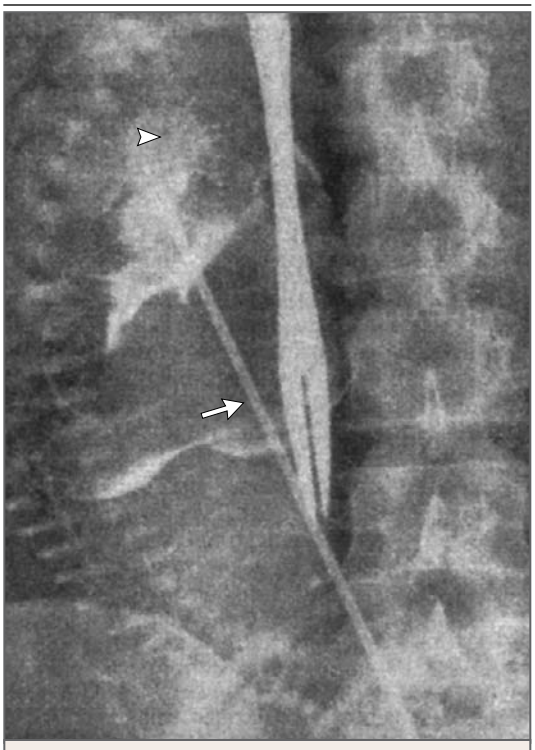

Figure 5. Radiographic Image of the First Successful Intrauterine Fetal Transfusion Performed under Fluoroscopic Guidance by Liley, in 1963.

As described when the procedure was reported, the radiograph shows "contrast medium and the coiled catheter [arrowhead] in the [fetal] peritoneal cavity. The Tuohy needle [arrow] has been withdrawn and lies on the mother's abdominal skin."[44]

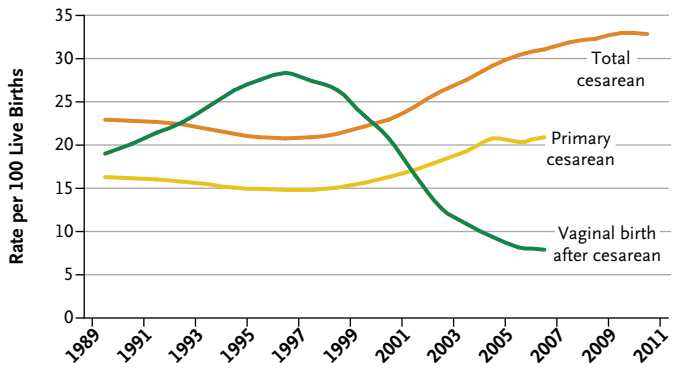

Figure 6. Rates of Cesarean Deliveries and of Vaginal Births after Cesarean Delivery in the United States.

The rate of total cesarean deliveries is shown for the period from 1989 through 2011. The rate of primary cesarean deliveries and the rate of vaginal births after cesarean delivery are shown for the period from 1989 through 2007. Data are from the National Center for Health Statistics.[50]

It also promises the potential that batched, or 'multiplexed' massively parallel sequencing could accomplish highly sensitive and specific mass population screening for aneuploidies at an affordable price.[41] New techniques identify new genetic differences that may or may not be responsible for phenotypic consequences but are most certainly responsible for difficult conversations between doctors and patients and agonizing decisions for patients.[42] Most recently, the entire genome of a human fetus has been sequenced noninvasively from cell-free fetal DNA in the maternal circulation.[43]

"Sir William Liley was the first person to treat a fetus in utero when he performed an intrauterine fetal transfusion into the peritoneal cavity under fluoroscopic guidance for severe isoimmune hemolytic disease in New Zealand in 1963 [Fig. 5].[44] Enthusiastic reports of noncontrolled case series of 'fetal surgery' in the 20th century ultimately resulted in randomized, controlled trials in the 21st century, with a more sober assessment of mixed results.[45,46]

"You will note careful attention to screening for and treatment of infections, especially human immunodeficiency virus (HIV) infection in pregnancy. Among women with untreated HIV infection in pregnancy, the probability of transmitting the infection vertically to their fetuses and neonates is 25%. Zidovudine treatment in the mother during pregnancy, labor, and delivery and in the newborn for several weeks after birth was first shown in 1994 to reduce the risk of vertical transmission of HIV to 8%.[47] Treatment of the mother with highly active antiretroviral therapy that is successful in reducing the maternal viral load to less than 50 copies per milliliter can reduce the risk of vertical transmission to less than 0.2%.[48]

"In the labor-and-delivery suite, you will encounter physicians and patients engaged in conversations about the most appropriate route of delivery for the individual patient. Such conversations are a relatively new phenomenon.[49] For the past 100 years, it has been the patient's assumption and the obstetrician's practice that women would labor and deliver vaginally, with cesarean delivery reserved for clinical circumstances that made vaginal delivery immediately dangerous for the mother or fetus. This change in the standard of practice has resulted in a progressive increase in the cesarean delivery rate in the United States from single-digit percentages in the first decade of the 20th century to 32.8% in 2011 [Fig. 6].[50] Currently, maternal mortality is one 1000th and newborn mortality one 100th of the corresponding rates at the start of the 20th century. Dramatic regional and other practice-based differences in cesarean delivery rates without similar differences in maternal or newborn outcomes make it clear that current high cesarean delivery rates are not absolutely necessary to achieve the observed benefits in maternal and newborn outcomes. Furthermore, as risks of all types of adverse outcomes decrease in modern obstetrical practice and care providers respect the autonomy and decisions made by prospective parents, many of our traditional perspectives and practices are changing. It would be the worst form of hubris for clinicians to think that we can anticipate the details of obstetrical practice 100 years from now, any more than an obstetrical care provider 100 years ago could have predicted where we stand today."

THE FUTURE

Future generations will judge the success of changes introduced into obstetrical care in the next 100 years by a more expansive, complex, and multidimensional set of criteria than have generally been used to date. They will expect that clinicians will continue to reduce morbidity and mortality while increasing the options and autonomy

of patients in their care. But they will also demand that, as those goals are achieved, clinicians will assume more responsibility and accountability for the financial burden that their decisions and practices place on society. While those of us who provide care assume a greater stewardship role over costs and value for patients who currently have access to care, we must negotiate for adequate societal resources to bring care to those who are currently without it. As necessary and important as these achievements will be, they will seem somewhat selfish and parochial if we do not also find ways to reduce the burden of perinatal morbidity and mortality in areas of the world that presently have outcomes that are similar to those in the United States a century ago. Science and technology will undoubtedly help extend and deliver care in new ways; however, more fundamentally, progress in global obstetrical health will depend on developing the infrastructure, political will, and culture that value the health of women and their pregnancies.

Disclosure forms provided by the author are available with the full text of this article at NEJM.org.

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