ELSEVIER
SAUNDERS

CLINICS IN PERINATOLOGY

Clin Perinatol 35 (2008) 325–341

Late Preterm Infants, Early Term Infants, and Timing of Elective Deliveries

William A. Engle, MD[a,*],
Michelle A. Kominiarek, MD[b]

[a]*Section of Neonatal-Perinatal Pediatrics, Indiana University School of Medicine, 699 West Drive, RR-208, Indianapolis, IN 46202–5119, USA*
[b]*Division of Maternal Fetal Medicine, Indiana University School of Medicine, 550 North University Boulevard, Room 2440, Indianapolis, IN 46202, USA*

Delivery of infants who are physiologically mature and capable of successful transition to the extrauterine environment is an important priority for obstetric practitioners [1]. A corollary of this goal is to avoid iatrogenic complications of prematurity and maternal complications from delivery. It is generally accepted that births should occur at a minimum of 39 weeks' gestation unless earlier delivery occurs spontaneously or because of maternal or fetal medical indications. During the past 15 years in the United States, however, the percentage of infants born before 40 weeks' gestation has dramatically increased and the percentage of infants born after 40 weeks' gestation has decreased [2,3]. The shift in gestational age at birth raises the risk for the birth of physiologically immature infants and associated complications. The purpose of this review is to describe the consequences of birth before physiologic maturity in late preterm and term infants, to identify factors contributing to the decline in gestational age of deliveries in the United States, and to describe strategies to reduce premature delivery of late preterm (34 0/7–36 6/7 weeks' gestation) and early term infants (37 0/7–38 6/7 weeks' gestation) (Fig. 1).

Consequences after birth for late preterm infants and early term infants

During the past decade in the United States, delivery of late preterm infants and infants aged 37 0/7 to 39 6/7 weeks' gestation has increased by 14% and 21%, respectively, whereas births of infants after 40 weeks'

* Corresponding author.
E-mail address: wengle@iupui.edu (W.A. Engle).

doi:10.1016/j.clp.2008.03.003 ***perinatology.theclinics.com***

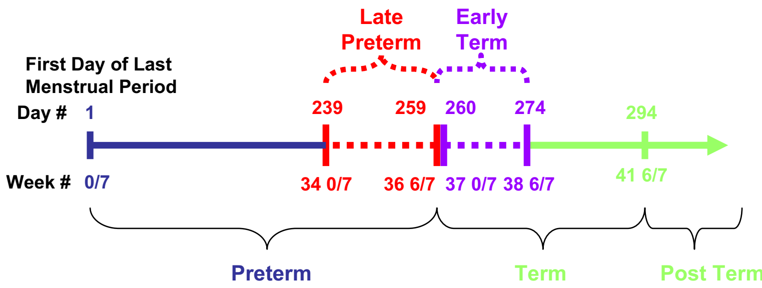

Fig. 1. "Late preterm" and "early term" definitions.

gestation have declined [2]. There are approximately 500,000 preterm births (births before 37 completed weeks of gestation), which account for 12.5% of live births in the United States annually. Of these preterm births, greater than 70% (approximately 350,000 live births) are late preterm. Another 700,000 births (17.5% of live births) occur at 37 and 38 weeks' gestation each year (early term infants) [4]. Both of these groups of infants may experience short-term and long-term consequences associated with premature delivery, whether indicated or elective.

Complications of prematurity in late preterm infants

Late preterm infants are at greater risk than term infants for complications of prematurity [5–9]. During the birth hospitalization, infants born at 34 0/7 to 36 6/7 weeks' gestation compared with term infants experience more difficulties with feeding (32% versus 7%), hypoglycemia (16% versus 5%), jaundice (54% versus 38%), temperature instability (10% versus 0%), apnea ($\sim$6% versus $<$ 0.1%), and respiratory distress (29% versus 4%) [7]. Late preterm infants also receive intravenous fluids (27% versus 5%), evaluations for sepsis (37% versus 13%), and mechanical ventilation (3.4% versus 0.9%) more often than their term counterparts. Late preterm infants are 3.5 times more likely to have two or more of these problems than term infants [5]. Because of these medical illnesses and management requirements, many of these infants need specialty care and hospitalizations beyond 5 nights in neonatal intensive care units [8]. Admission for intensive care is inversely proportional to gestational age [10]. In a large health care system, 88% of infants born at 34 weeks' gestation, 12% born at 37 weeks' gestation, and 2.6% born at 38 to 40 weeks' gestation were admitted to an intensive care unit [10]. Duration of hospital stay is also inversely proportional to gestational age [7,10–12].

Hospital readmission and late preterm infants

Late preterm infants who are discharged within the first days after birth are readmitted 1.5 to 3 times more often than term infants [5,10,13]. Rates of readmission to the hospital or an observational stay in late preterm and term infants were 4.3% and 2.7%, respectively, in a large population-based study of singleton infants [14]. The primary reasons for readmission of late preterm infants are hyperbilirubinemia (71%), suspected infection (20%), and feeding difficulty (16%), problems that reflect developing physiologic and metabolic organ functions [5,15]. Several risk factors for readmission of late preterm infants have been identified; these include firstborn or breastfed, maternal labor and delivery complications, recipients of public insurance, and Asian-Pacific Island descent [16]. Because readmission rates are increased in late preterm infants, it is important to focus care and support before discharge on the problems that may present during the first days and weeks at home, such as feeding issues and jaundice. Oral feeding dysfunction may only become apparent after the mother's breast milk supply increases and the infant's oromotor skills are challenged. Furthermore, concentrations of bilirubin, a neural toxin, may peak after discharge from the initial hospitalization in late preterm infants.

Mortality, long-term morbidity, and late preterm infants

Mortality rates beyond the first month after birth are higher in late preterm infants than in term infants [5,17]. Neonatal mortality (deaths among infants 0–27 days' chronologic age) is 4.6 times higher than in term infants (4.1 versus 0.9 per 1000 live births in 2002, respectively) [17,18]. Infant mortality (deaths among infants 0–364 days' chronologic age) has been consistently higher in late preterm infants than in term infants for the past 15 years. In 2002, the infant mortality rate was 7.7 versus 2.5 per 1000 live births in late preterm and term infants, respectively [5,19]. Interestingly, infant mortality is greater in late preterm infants for each of the leading 10 causes of death (Table 1). In addition to an increased risk for mortality, late preterm infants have higher relative rates of developmental handicaps than term infants. Specifically, school performance difficulties and behavioral disabilities, especially attention deficit hyperactivity disorder, are

Table 1
Cause-specific infant mortality rates of late preterm and term infants (per 100,000 live births)

	Late preterm (rank)	Term (rank)
Congenital anomalies	333 (1)	77 (1)
Sudden infant death syndrome	99 (2)	49 (2)
Accidents (unintentional)	38 (3)	21 (3)
Disease of the circulatory system	25 (4)	10 (4)
Intrauterine hypoxia and birth asphyxia	17 (5)	7 (5)
Influenza and pneumonia	12 (6)	5 (7)
Assault (homicide)	12 (7)	6 (6)
Bacterial sepsis of the newborn	11 (8)	3 (9)
Newborn affected by complications of the placenta, cord, or membranes	11 (9)	2 (10)
Atelectasis	10 (10)	0.7 (24)

Table 2
Attention deficit hyperactivity disorder and gestational age

Gestational age (weeks)	Controls n = 20,100	ADHD cases n = 834 (%)	Adjusted relative risk (95% confidence interval)
<34	298	34 (11.4)	2.7 (1.8–4.1)
34–36	544	37 (6.8)	1.7 (1.2–2.5)
37–39	6629	298 (4.5)	1.1 (0.9–1.3)
40–42	12,365	456 (3.7)	Reference
43–44	264	9 (3.4)	1.0 (0.5–2.0)

Data from Linnet KM, Wisborg K, Agerbo E, et al. Gestational age, birth weight, and the risk of hyperkinetic disorder. Arch Dis Child 2006;9:655–60.

more prevalent in late preterm infants (Tables 2 and 3) [20–22]. Such impairments may relate to incomplete brain development after birth in late preterm infants [21]. At birth, the brain mass of late preterm infants is only approximately 70% that of term infants and myelinization is markedly underdeveloped.

Most late preterm infants thrive after birth and have no complications or long-term impairments. Because of the risks for mortality and morbidity associated with birth at 34 0/7 to 36 6/7 weeks' gestation, however, such infants need close monitoring and follow-up. Additional investigations to understand the causes for late preterm births better and efforts to prevent them, if possible, are warranted.

Respiratory morbidities, possible long-term morbidities, and early term infants

In a large retrospective review of the incidence of respiratory distress in term and late preterm infants, 1.9% experienced respiratory distress because of transient tachypnea, respiratory distress syndrome, or persistent pulmonary hypertension of the newborn (Table 4) [23]. A review of studies of term infants found that the incidence of transient tachypnea of the newborn, respiratory distress syndrome, and persistent pulmonary hypertension of the newborn were approximately 3.1%, 0.25%, and 0.17%, respectively

Table 3
School age outcome of healthy late preterm (n = 22,552) versus healthy term (n = 164,628) infants in Florida

Outcome	Age (years)	Relative risk (95% confidence interval)
Developmental delay or disability	0–3	1.46 (1.42–1.50)
Special education	5	1.13 (1.11–1.15)
Grade retention	5	1.11 (1.08–1.14)

Data from Adams-Chapman I. Neurodevelopmental outcome of the late preterm infant. Clin Perinatol 2006;30:947–64; with permission, and Morse SB, Tang Y, Roth J. School-age outcomes of healthy near-term infants (34–37 weeks) versus healthy term infants (38–42 weeks). Pediatr Res 2006;1(Suppl):158.

Table 4
Incidence of respiratory morbidity in late preterm and term infants

	Cesarean section n = 4301 (%)	Vaginal birth n = 21,017 (%)	Combined n = 25,318 (%)	Odds ratio (95% confidence interval) for cesarean section versus vaginal birth
Transient tachypnea of the newborn	151 (3.5)	238 (1.1)	389 (1.5)	3.3 (2.6–3.9)
Respiratory distress syndrome	20 (0.47)	33 (0.16)	53 (0.21)	3.0 (1.6–5.3)
Persistent pulmonary hypertension	17 (0.4)	17 (0.08)	34 (0.13)	4.9 (2.2–8.8)
Total	188 (4.4)	288 (1.4)	476 (1.9)	3.3 (2.7–4.0)

Data from Levine EM, Ghai V, Barton JJ, et al. Mode of delivery and risk of respiratory disease in newborn. Obstet Gynecol 2001;97:440.

(weighted calculation based on one third of infants being born by cesarean delivery) (Table 5) [24]. Considering that 87.5% of the 4 million deliveries annually in the United States occur at term and more than 3% neonates have respiratory disorders after birth, approximately 105,000 newborns are affected, require additional medical interventions, are exposed to complications of intensive care, and, although infrequent, die from their illnesses. Importantly, infants with respiratory distress are temporarily separated from their mothers and families.

According to a retrospective geographically based analysis of 179,701 births, the incidence of severe respiratory distress syndrome in infants aged 34 to 41 weeks' gestation declines with increasing gestational age (Table 6) [25]. Infants born at 37 weeks' gestation have a 3-fold greater rate of respiratory distress syndrome that those born at 38 weeks' gestation, who, in turn, have a 7.5-fold greater rate than infants born at 39 to 41 weeks' gestation. Infants born at 37 to 38 weeks' gestation also have a significantly

Table 5
Incidence of respiratory morbidity in term infants and effect of cesarean section

	Cesarean section	Vaginal birth	Range of odds ratios for cesarean section versus vaginal birth (range)
Transient tachypnea of the newborn	0.9%–12%	0.3%–3%	1.2–2.8
Respiratory distress syndrome	0.2–0.7%	0.1–0.2%	0–7.1
Persistent pulmonary hypertension of the newborn	0.37%	0.08%	4.6

Data from Kirkeby Hansen A, Wisborg K, Uldbjerg N, et al. Elective caesarean section and respiratory morbidity in the term and near-term neonate. Acta Obstet Gynecol Scand 2007;86:392.

Table 6
Respiratory distress syndrome in late preterm and term infants

Gestational age (weeks)	Incidence of respiratory distress syndrome (per 1000 infants)	Relative rate compared with following gestation
34	30	2.1
35	14	2.0
36	7.1	3.9
37	1.8	3.0
38	0.6	7.5
39–41	0.08	Reference

Data from Madar J, Richmond S, Hey E. Surfactant-deficient respiratory distress after elective delivery at 'term.' Acta Paediatr 1999;88:1245.

higher risk for transient tachypnea of the newborn, persistent pulmonary hypertension, hospital stays beyond 5 nights, and diagnoses associated with severe morbidities or death than infants born at 39 weeks' gestation [3,8,9,24–27].

Delivery by cesarean section is an important independent risk factor for respiratory morbidity in term infants. Studies of infants delivered by elective cesarean section have consistently shown that the risk for respiratory distress syndrome and transient tachypnea of the newborn is inversely proportional to gestational age [7,9,24,25,27–30]. Respiratory distress syndrome and transient tachypnea of the newborn is 1.7 times more frequent at 37 weeks' gestation compared with 38 weeks' gestation and 2.4 times as frequent at 38 weeks' gestation compared with 39 weeks' gestation in infants delivered by elective cesarean section [31]. Long-term morbidities in term infants have been inconsistently correlated with birth by cesarean section. Such morbidities include asthma, hay fever, respiratory and food allergies, and diarrhea [32–35].

Factors contributing to increased birth rate of late preterm and early term infants

Birth before fetal maturity contributes to short-term and long-term morbidity and mortality in late preterm and early term infants. Most babies born between 34 and 38 weeks' gestation are delivered prematurely because of maternal or fetal medical indications [2,36]. All categories of live births (spontaneous, associated with premature rupture of membranes, and associated with medical intervention) of infants born at 34 to 36 weeks' gestation and 37 to 39 weeks' gestation increased as a percent of live births between 1992 and 2002. During this same interval, the percent of live births attributed to infants with gestational ages of 40 to 44 weeks declined considerably, whereas births of infants aged less than 32 weeks' gestation remained stable or decreased.

The reasons for the increase in rates of late preterm and early term births are unclear because of a paucity of information [28]. Several disparate factors have been implicated as important influences on these rates [36–40]:

- Increased medical surveillance and interventions
- Inaccurate gestational age assessment during elective deliveries
- Presumption of fetal maturity at 34 weeks' gestation
- Increase in multifetal pregnancies
- Changes in maternal demographics and health
  - Delayed childbearing and increased risk for prematurity
  - Use of assisted reproductive technologies (multifetal pregnancies)
  - Maternal obesity and increased risk for complications associated with premature delivery (eg, preeclampsia, diabetes)
- Maternal autonomy and route and timing of delivery
  - Cesarean or planned induction of labor
    - Indicated: abnormal presentation, abnormal placentation, maternal or fetal conditions (eg, premature rupture of membranes without labor, fetal hydrocephalus)
    - Repeat
    - Without medical indication (induction of labor or cesarean section on maternal request)
  - Fear of fetal and neonatal risks with vaginal delivery
    - Increased rate of stillbirths beginning at 39 weeks' gestation
    - Hypoxic ischemic encephalopathy, brachial plexus, and other birth trauma, especially with breech or other abnormal presentation
  - Fear of fetal and neonatal risks with cesarean delivery
    - Higher rates of mortality, respiratory and other acute morbidity, neonatal intensive care, separation from family, longer hospital stay
  - Fear of maternal risks with vaginal delivery
    - Risk for genital tract, anus, and perineal injury and sexual dysfunction
    - Perception that cesarean delivery is "easier" and "less stressful" than vaginal delivery
    - Fear of the second stage and having to "push the baby out"
  - Fear of maternal risks with cesarean delivery
    - Bladder injury, hemorrhage, death, hysterectomy, intensive care, repeat cesarean section, abnormal placentation in future pregnancies, future fetal loss, poor perception of birth experience, financial costs, repeat hospitalization
  - Maternal willingness to accept risk on behalf of the infant
    - Convenience for mother and family
  - Physician practice patterns and risk/benefit determination
    - Convenience
    - Liability

Accuracy of obstetric estimates of gestational age

Estimating the delivery date and gestational age prenatally is inexact because the commonly used methods, Naegle's rule (calculated from the first date of the last menstrual period) and the second trimester sonogram, are both accurate to only within 1 to 2 weeks [41,42]. Naegle's rule depends on the assumptions that a woman's menstrual cycles are regular and occur every 28 days, recall is accurate, and ovulation occurs 14 days after the first day of the last menstrual period. Only approximately 30% of women are in their fertile window 10 to 17 days after the first day of the last menstrual period [43]. Maternal recall is frequently not dependable, menstrual cycles may vary considerably, vaginal bleeding or spotting may occur during the first few cycles after fertilization, and use of oral contraceptives often alters menstrual periodicity. Combined with inherent biologic variability in fetal maturation at any one gestational age, the accuracy of the commonly used prenatal methods to determine fetal gestational age and the estimated date of delivery is limited. If dates associated with artificial reproductive technologies or first trimester ultrasonogram assessments of the gestational sac (appears at ~5 weeks' gestation), appearance of fetal heart rate (appears at ~6 weeks' gestation), or crown-rump length at 6 to 11 weeks' gestation are performed, accuracy of dating may be within 3 to 5 days of the actual gestational age.

Another important factor in accurate determination of fetal gestational age is obesity, which is an epidemic in the United States [40]. Obesity during pregnancy may be associated with fetal macrosomia and inaccurate ultrasonographic estimation of gestational age. Excess weight gain during pregnancy is protective for preterm delivery (adjusted odds ratio = 0.54, 95% confidence interval: 0.52–0.57), although complications of obesity are associated with preterm delivery (gestational diabetes: adjusted odds ratio = 1.28, 95% confidence interval: 1.20–1.36; pregnancy-associated hypertension: odds ratio = 1.82, 95% confidence interval: 1.67–1.98). Oligohydramnios also interferes with the accuracy of ultrasonographic measurements for gestational age, especially in the setting of premature rupture of membranes. Inaccurate estimations of fetal gestational age pose a degree of uncertainty when counseling patients about the optimal route and timing of delivery, especially if elective induction of labor or cesarean delivery is considered.

Obstetric surveillance

Medical surveillance has intensified with advances in obstetric practices. The primary purpose of antenatal testing and intrapartum monitoring is to identify maternal or fetal complications early in the pathophysiologic process when they may be amenable to interventions to prevent progression of maternal illness or fetal compromise. Electronic fetal monitoring and prenatal ultrasonography were used in 85% and 67% of pregnancies, respectively, in 2003 [5]. In contrast, in 1989, electronic fetal monitoring was used in only 68% of pregnancies and prenatal ultrasonography was used in only 48% of pregnancies. Deliveries after interventions, such as labor induction and elective cesarean section, have also increased during the past 10 years [2,44–47]. Increased use of these and other obstetrics tools has resulted in a reduction in stillbirths and perinatal mortality [4]. Conversely, some antenatal tests (eg, nonstress tests, biophysical profile) have low positive predictive values. As such, an abnormal test result may not reflect the true fetal status. Thus, more intensive testing and monitoring may lead to more delivery interventions and, subsequently, contribute to a higher rate of late preterm and early term births.

Multifetal pregnancies

The percent of live births that accompany multifetal pregnancies increased from 2.4% to 3.2% of live births between 1992 and 2002 [44]. This increase in multifetal gestations is partly explained by artificial reproductive technologies and delayed childbearing. The average gestational age of twin births is 35 weeks [38]. The increase in percent of late preterm and early term births is, at least in part, associated with late preterm delivery of multifetal pregnancies. Recurrent preterm delivery is not prevented in multifetal pregnancies by maternal administration of 17 α-hydroxyprogesterone caproate as it is in singleton births [48,49]. Efforts to understand and discover strategies that safely prolong the duration of gestation in multifetal pregnancies are warranted.

Race and ethnicity

Race and ethnicity have an impact on rates of late preterm and early term deliveries [2]. Non-Hispanic white births accounted for the largest percent increase in births between 1992 and 2002 at 35 weeks' gestation (1.7%–2.0% of live births) and at 36 weeks' gestation (3.1%–3.9% of live births) compared with Hispanic and black births. During this same interval, Hispanic births at 34 and 35 weeks' gestation were stable but increased from 3.7% to 4.1% of live births at 36 weeks' gestation. In contrast, the percentage of births of black infants declined at 34 and 35 weeks' gestation but increased slightly at 36 weeks' gestation. Common among non-Hispanic white, Hispanic, and black births was an increase in the percentage of births at 36 weeks' gestation. The reason why the largest percent change occurred in non-Hispanic white births has not been determined. In a separate study, risk factors frequently associated with preterm birth, such as tobacco use and vaginal infections, were not significantly more common in late preterm infants than in term infants [50]. Factors speculated to account for these differences in perinatal outcomes include socioeconomic status, access to health care, and maternal demand for elective delivery.

Fetal maturity and 34 weeks' gestation

In the past, research protocols and practice guidelines implied that 34 weeks' gestation was a surrogate for fetal maturity; therefore, infants born at or later than 34 weeks' gestation were considered to be at low risk for morbidity and mortality [1,39,51]. When such protocols and guidelines were developed, infant mortality in late preterm infants was within 1% of that of term infants. Since the publication of these guidelines, a growing body of literature indicates that late preterm and early term infants are at risk for respiratory, developmental, and behavioral morbidity in addition to mortality. It is anticipated that future research and guideline revisions are likely to consider this rapidly growing body of literature about the morbidities that accompany late preterm and early term birth.

Route and timing of delivery

Patients and physicians must weigh the risks and benefits for each delivery option when deciding about route and timing of delivery. Spontaneous vaginal deliveries account for approximately 60% of all deliveries, and medical interventions to effect deliveries account for the remaining 40% [2]. Cesarean delivery is elective for several reasons (eg, repeat, abnormal presentation, multifetal pregnancy, maternal request without a medical indication) or necessitated by intrapartum conditions (eg, cephalopelvic disproportion, nonreassuring fetal heart rate, failed operative forceps or vacuum delivery).

The rates of cesarean deliveries and inductions of labor have increased dramatically during the past 10 years. Cesarean sections account for approximately one third of deliveries. Although estimates vary considerably because of insufficient documentation and lack of prospective investigations [52,53], Menacker and colleagues [52] estimated that 3% to 7% of cesarean deliveries were performed without a clear medical indication. Other investigators have reported that elective cesarean deliveries account for as many as 18% of cesarean deliveries in the United States [36]. Inductions of labor occur in approximately 10% to 20% of deliveries, and roughly half are performed electively [4,36,44–47,54,55]. Because inductions of labor are so common, small shifts in clinical thresholds to convert to cesarean delivery may greatly increase the number of cesarean deliveries [46].

The reasons for the increasing trends in elective cesarean deliveries and labor inductions are complex. Concern about stillbirth, birth trauma, shoulder dystocia, and neonatal encephalopathy with vaginal birth beyond 39 weeks' gestation and willingness of mothers to incur risk on behalf of their child are important influences when deciding about timing and route of delivery [4]. Patient fear of vaginal delivery because of perceived discomfort and complications (eg, pelvic floor dysfunction with incontinence and loss of sexual functioning), complications associated with vaginal breech delivery, subtle changes in medical thresholds for abandoning vaginal delivery and proceeding to intrapartum cesarean delivery, convenience for families and physicians, the decline in the rate of vaginal birth after cesarean delivery because of the risk for uterine rupture, and liability concerns of physicians are also likely influences [4,28].

Neonatal and maternal complications after cesarean and vaginal delivery were prospectively evaluated and reported in 97,095 deliveries [28]. Investigators analyzed data from the 2005 World Health Organization survey on maternal and perinatal health. In this large cohort of deliveries, a significantly increased risk for a neonatal intensive care stay of 7 days or more occurred for cesarean delivery, including elective cesarean delivery (odds ratio = 2.11, 95% confidence interval: 1.75–2.55) and intrapartum cesarean delivery (odds ratio = 1.93, 95% confidence interval: 1.63–2.29). Mortality in infants with a cephalic presentation delivered by elective cesarean section was also increased 1.7-fold. Similarly, mortality in infants with a cephalic presentation delivered by intrapartum cesarean section was increased 2-fold. Cesarean delivery also significantly reduced mortality associated with breech presentation. Although cesarean delivery reduced vaginal injuries (third and fourth degree lacerations and fistula formation), severe maternal morbidity (eg, death, hysterectomy, blood transfusion, intensive care stay) and antibiotic use were increased 2-fold and 5-fold, respectively. The maternal and neonatal outcomes reported in this large population study support findings from other investigators that cesarean delivery is associated with relatively higher rates of neonatal mortality and prolonged neonatal intensive care stay, severe maternal morbidities, and maternal antibiotic use [36,56,57]. In contrast, cesarean delivery has advantages for breech presentations and maternal perineal injury. In 2007, the American College of Obstetricians and Gynecologists described several benefits of planned cesarean delivery compared with intrapartum cesarean or vaginal delivery that included lower rates of postpartum hemorrhage, transfusion, surgical complications, and urinary incontinence in the first year after delivery [57].

Cesarean delivery is associated with a large list of potential complications, most with weak correlations, that favor vaginal delivery [36,53,56]. Examples of complications associated with cesarean delivery include separation from the mother and delayed breastfeeding; higher rates of postpartum fever, infection, pneumonia, and thromboembolic events; organ injury (eg, bladder, ureter, bowel); lower postpartum health status scores; reduced satisfaction with the birth experience; low self-esteem, depression, and psychologic trauma; longer length of hospital stay; additional laboratory and imaging assessment; additional procedural interventions; and higher cost than vaginal deliveries [36,56–59]. Cesarean delivery also has implications for future deliveries [36,53,56]. Uterine rupture during labor occurs at a higher rate in patients who have had a previous cesarean delivery. Abnormal placentation, such as placenta previa and placenta accreta, increased risk for intrapartum hemorrhage and hysterectomy, and more complicated repeat abdominal surgery because of adhesions may further complicate future deliveries. Counseling about these additional risks related to cesarean delivery is important for patients, especially primigravid women who intend to have more children.

Advances in cervical ripening and induction agents, careful selection of patients with a favorable cervix, and labor induction protocols are believed to have reduced the risks related to labor induction. Despite these improvements, debate about the use of elective induction of labor continues [45,46]. It has been argued that the induction process and higher risk for cesarean delivery, exposure to complications of the procedure, longer hospital stays, and higher costs, especially in primigravid patients or patients with an unfavorable cervix, outweigh the psychosocial and convenience benefits in most cases [46].

Reducing iatrogenic late preterm and early term births

If elective cesarean or labor induction is considered before 39 weeks' gestation, the American College of Obstetricians and Gynecologists has recommended fetal pulmonary maturity confirmation, a surrogate for physiologic maturation [1]. If fetal pulmonary maturity is not proved, however, it may be inferred from any of the following criteria:

- Fetal heart tones have been documented for 20 weeks by nonelectronic fetoscope or for 30 weeks by Doppler.
- It has been 36 weeks since a positive serum or urine human chorionic gonadotropin pregnancy test result by a reliable laboratory.
- Ultrasound measurement of the crown-rump length at 6 to 11 weeks of gestation supports a gestational age equal to or greater than 39 weeks.
- Ultrasound measurements at 12 to 20 weeks of gestation support a clinically determined gestational age of 39 weeks or greater.

Adherence to these recommendations is not uniform [60]. Confidence in current methods of fetal gestational age assessment and complications of amniocentesis may deter obstetricians from confirming fetal pulmonary maturity before elective delivery [60]. Accurate gestational age assessment is essential when determining timing of elective delivery. If gestational age estimates vary by even 1 or 2 weeks, elective induction of labor or elective cesarean section may be associated with premature delivery of a late preterm or early term infant. New methods to determine fetal gestational age more accurately, especially during the end of the second trimester and during the third trimester, are needed.

Antenatal corticosteroids have been proved to reduce the severity of respiratory distress syndrome and survival of infants born before 34 weeks' gestation. Investigators have recently reported benefits from fetal corticosteroid exposure in late preterm and early term infants [61,62]. Antenatal betamethasone administration to effect pulmonary maturation before elective delivery reduced the incidence of respiratory morbidity (transient tachypnea and respiratory distress syndrome) by half (relative risk = 0.46, 95% confidence interval: 0.23–0.93) [61]. Patients receiving betamethasone reported more minor complications (flushing, nausea, pain at the injection site, and increased energy) than patients receiving the placebo in this study. In a large retrospective cohort of 1044 infants, antenatal steroids administered to mothers before 34 weeks' gestation who delivered at 34 to 36 weeks' gestation effected significant reductions in respiratory disorders (24.4% versus 81.6%; $P < .0001$) and respiratory distress syndrome (7.5% versus 35.5%; $P < .0001$). In contrast, a meta-analysis of corticosteroids given after 33 weeks' gestation did not show decreased neonatal morbidity; however, the analysis was limited because of small numbers of infants [63]. Confirmation of the efficacy and safety of antenatal corticosteroids before elective deliveries and at 34 to 38 weeks' gestation is needed.

A recently published study of 21,771 late preterm births (34–36 weeks) occurring over an 18-year period at a single university-based hospital confirmed the increased neonatal morbidity at these gestational ages compared with term births [9]. Eighty percent of these births were attributed to idiopathic preterm labor or premature rupture of membranes. The remaining deliveries were associated with hypertension, placental accidents, fetal problems, and maternal medical problems. It is unknown whether elective deliveries without a medical indication contributed to any of the deliveries in this study because such information was not reported [9]. Details about strategies that may be altered to prolong a pregnancy, such as expectant management of premature rupture of membranes, were also not reported. Furthermore, in non–university-based hospitals, the reasons for elective labor inductions and cesarean deliveries in late preterm infants have not been reported. Thus, additional information is necessary to determine whether there are specific medical interventions or strategies that may reduce the incidence of late preterm and early term births.

Few studies have addressed the benefits of expectant management of premature rupture of membranes at greater than 34 weeks, and two older studies have not shown a benefit [64,65]. A meta-analysis of planned early birth (using oxytocin or prostaglandin) versus expectant management for prelabor premature rupture of membranes in patients at 37 weeks' gestation or greater found no difference in the need for cesarean or operative delivery or neonatal infection [66]. Maternal infection and the proportion of infants admitted to neonatal intensive care units were significantly reduced in the planned early delivery group. These results were unexpected and suggest that planned early birth has advantages over expectant management, at least in infants greater than or equal to 37 weeks' gestation. Better understanding of the outcomes of mothers and infants born at each gestation between 34 and 38 weeks after prelabor premature rupture of membranes is needed to focus efforts to prevent premature delivery.

Iatrogenic late preterm and early term births can be reduced by adherence to guidelines for determining gestational age and elective deliveries (inductions and cesarean sections). Early prenatal care, which should be encouraged, optimizes the opportunities to assess gestational age most accurately, and thus to plan timing and route of delivery. Women requesting cesarean delivery are likely to benefit from a thorough discussion of the advantages and disadvantages of cesarean and vaginal births for the fetus, newborn infant, and woman. If maternal fears of pain, fetal complications, or maternal morbidities with vaginal delivery are the primary reasons to request cesarean delivery, education and counseling about such fears are recommended [56]. Furthermore, the safety and efficacy of alternative management strategies to increase pulmonary maturity or prolong pregnancy, such as maternal corticosteroid administration beyond 34 weeks' gestation and expectant management for premature rupture of membranes without labor, merit additional study.

Summary

1. Late preterm and early term infants are at greater risk than term infants for acute and long-term complications of premature birth.
2. The rates of late preterm and early term births are increasing.
3. Causes for the increase in rates of late preterm and early term infants are unclear. Factors that are hypothesized to be associated with the increase in rates include the following:
   - Increased surveillance and medical interventions
   - Inaccurate gestational age estimates
   - Presumption of fetal maturity at 34 weeks' gestation
   - Changes in maternal demographics and health
   - Increased rates of elective cesarean sections and inductions of labor
   - Maternal and physician concerns about complications of vaginal delivery and subtle changes in medical thresholds for cesarean birth
   - Willingness of mothers to incur risk on behalf of their child
4. The route and timing of delivery of late preterm and early term newborn infants have important implications for short-term and long-term neonatal outcomes.
5. The risks and benefits for spontaneous vaginal delivery, planned induction of labor, or elective cesarean section for mother and infant should be carefully considered by mothers, families, and physicians when determining the optimal timing and route of delivery.
6. Our understanding of the maternal, fetal, neonatal, and long-term outcomes and causes of late preterm and early term births is incomplete.
7. Research is needed to increase our understanding of maternal and infant outcomes of infants born at 34 to 38 weeks' gestation, to determine the efficacy and safety of strategies to optimize these outcomes, and to develop interventions that effect physiologic maturation of the fetus when premature delivery is necessary or elective.

References

[1] Assessment of fetal lung maturity. Practice bulletin number 230. American College of Obstetricians and Gynecologists November 1996.

[2] Davidoff MJ, Dias T, Damus K, et al. Changes in the gestational age distribution among US singleton births; impact on rates of late preterm birth, 1992 to 2002. Semin Perinatol 2006;30: 8–15.
[3] Miesnik SR, Reale BJ. A review of issues surrounding medically elective cesarean delivery. J Obstet Gynecol Neonatal Nurs 2007;36(6):605–15.
[4] Hankins GDV, Clark S, Munn MB. Cesarean section on request at 39 weeks: impact on shoulder dystocia, fetal trauma, neonatal encephalopathy, and intrauterine fetal demise. Semin Perinatol 2006;30:276–87.
[5] Engle WA, Tomashek KM, Wallman C, and the Committee on Fetus and Newborn. "Late-preterm" infants: a population at risk. A clinical report. Pediatrics 2007;120(6): 1390–401.
[6] Engle WA. A recommendation for the definition of "late-preterm" (near-term) and the birth weight-gestational age classification system. Semin Perinatol 2006;30(1):2–7.
[7] Wang ML, Dorer DJ, Fleming M, et al. Clinical outcomes of near-term infants. Pediatrics 2004;114:372–6.
[8] Shapiro-Mendoza CK, Tomashek KM, Kotelchuck M, et al. Effect of late preterm birth and maternal medical conditions on newborn morbidity risk. Pediatrics 2008;121:e223–32. 10.1542/peds.2006-3629.
[9] McIntire DD, Leveno KJ. Neonatal mortality and morbidity rates in late preterm births compared with births at term. Obstet Gynecol 2008;111:35–41.
[10] Escobar GJ, Greene JD, Hulac P, et al. Rehospitalization after birth hospitalization: patterns among infants of all gestations. Arch Dis Child 2005;90:125–31.
[11] Rubaltelli FF, Bonafe L, Tangucci M, et al. Epidemiology of neonatal acute respiratory disorders. Biol Neonate 1998;74:7–15.
[12] Gilbert WM, Nesbitt TS, Danielsen B. The cost of prematurity: quantification by gestational age and birth weight. Obstet Gynecol 2003;102:488–92.
[13] Oddie SJ, Hammal D, Richmond S, et al. Early discharge and readmission to hospital in the first month of life in the Northern Region of the UK during 1998: a case cohort study. Arch Dis Child 2005;90:119–24.
[14] Tomashek KM, Shapiro-Mendoza CK, Weiss J, et al. Early discharge among late preterm and term newborns and risk of neonatal mortality. Semin Perinatol 2006;30:61–8.
[15] Escobar GJ, Joffe S, Gardner MN, et al. Rehospitalization in the first two weeks after discharge from the neonatal intensive care unit. Pediatrics 1999;104(1). Available at: www.pediatrics.org/cgi/content/full/104/1/e2. Accessed April 9, 2008.
[16] Shapiro-Mendoza CK, Tomashek KM, Kotelchuck M, et al. Risk factors for neonatal morbidity and mortality among "healthy" late preterm newborns. Semin Perinatol 2006; 30:54–60.
[17] Kramer MS, Demissie K, Yand H, et al. The contribution of mild and moderate preterm birth to infant mortality. Fetal and Infant Health Study Group of the Canadian Perinatal Surveillance System. JAMA 2000;284:843–9.
[18] Martin JA, Hamilton BE, Sutton PD, et al. Births: final data for 2002. Natl Vital Stat Rep 2003;52:1–114.
[19] Tomashek KM, Shapiro-Mendoza CK, Davidoff MJ, et al. Differences in mortality between late-preterm and term singleton infants in the United States; 1995–2002. J Pediatr 2007;151: 450–6.
[20] Linnet KM, Wisborg K, Agerbo E, et al. Gestational age, birth weight, and the risk of hyperkinetic disorder. Arch Dis Child 2006;9:655–60.
[21] Adams-Chapman I. Neurodevelopmental outcome of the late preterm infant. Clin Perinatol 2006;30:947–64.
[22] Morse SB, Tang Y, Roth J. School-age outcomes of healthy near-term infants (34–37 weeks) versus healthy term infants (38–42 weeks). Pediatr Res 2006;1(Suppl):158.
[23] Levine EM, Ghai V, Barton JJ, et al. Mode of delivery and risk of respiratory disease in newborn. Obstet Gynecol 2001;97:439–42.

[24] Kirkeby Hansen A, Wisborg K, Uldbjerg N, et al. Elective caesarean section and respiratory morbidity in the term and near-term neonate. Acta Obstet Gynecol 2007;86:389–94.
[25] Madar J, Richmond S, Hey E. Surfactant-deficient respiratory distress after elective delivery at 'term.' Acta Paediatr 1999;88:1244–8.
[26] Jain L, Golde G. Respiratory transition in infants delivered by cesarean section. Semin Perinatol 2006;30:296–304.
[27] Sutton L, Sayer GP, Bajuk B, et al. Do very sick neonates born at term have antenatal risks? 2. Infants ventilated primarily for lung disease. Acta Obstet Gynecol Scand 2001; 80:917–25.
[28] Villar J, Carroli C, Zavaleta N, et al. Maternal and neonatal individual risks and benefits associated with caesarean delivery: multicenter prospective study. BMJ 2007;335:1025–36. 10.1136/bmj.39363.706956.55.
[29] Zanardo V, Simbi A, Franzoi M, et al. Neonatal respiratory morbidity risk and mode of delivery at term: influence of timing of elective caesarean delivery. Acta Paediatr 2004;93: 643–7.
[30] Yamazaki H, Torigoe K, Numata O, et al. Neonatal clinical outcome after elective cesarean section before the onset of labor at the 37th and 38th week of gestation. Pediatr Int 2003;4: 379–82.
[31] Morrison JJ, Rennie JM, Milton PJ. Neonatal respiratory morbidity and mode of delivery after term: influence of timing of elective caesarean section. J Obstet Gynaecol 1995; 102(2):101–6.
[32] Salam MT, Margolis HG, McConnell R, et al. Mode of delivery is associated with asthma and allergy occurrences in children. Ann Epidemiol 2006;16:341–6.
[33] Werner A, Ramlau-Hansen CH, Jeppesen SK, et al. Caesarean delivery and risk of developing asthma in the offspring. Acta Paediatr 2006;96:595–9.
[34] Renz-Polseer H, David MR, Buist AS, et al. Caesarean section delivery and the risk of allergic disorders in childhood. Clin Exp Allergy 2005;35:1466–72.
[35] Ribley JS, Smith JM, Redding GJ, et al. Childhood asthma hospitalization risk after cesarean delivery in former term and premature infants. Ann Allergy Asthma Immunol 2005;94(2):228–33.
[36] Fuchs K, Wagner R. Elective cesarean section and induction and their impact on late preterm births. Clin Perinatol 2006;33(4):793–801.
[37] Raju TNK. Epidemiology of late preterm (near-term) births. Clin Perinatol 2006;33:751–63.
[38] Lee YM, Cleary-Goldman J, D'Alton ME. The impact of multiple gestations on late preterm (near-term) births. Clin Perinatol 2006;33(4):777–92.
[39] Antenatal corticosteroid therapy for fetal maturation. ACOG Committee opinion number 273. American College of Obstetricians and Gynecologists May 2002.
[40] Rosenberg TJ, Garber S, Lipkind H, et al. Maternal obesity and diabetes as risk factors for adverse pregnancy outcomes: differences among 4 racial/ethnic groups. Am J Public Health 2005;95:1545–51.
[41] Filley RA, Hadlock FP. Sonographic determination of gestational age. In: Callen PW, editor. Ultrasonography in obstetrics and gynecology. 4th edition. Philadelphia: WB Saunders; 2000. p. 146–70.
[42] Laing FC, Frates MC. Ultrasound evaluation during the first trimester of pregnancy. In: Callen PW, editor. Ultrasonography in obstetrics and gynecology. 4th edition. Philadelphia: WB Saunders; 2000. p. 105–44.
[43] Wilcox AJ, Dunson D, Baird DD. The timing of the "fertile window" in the menstrual cycle: day specific estimates from a prospective study. BMJ 2000;321:1259–62.
[44] Martin JA, Hamilton BE, Sutton PD, et al. Births: final data for 2003. Natl Vital Stat Rep 2005;54(2):1–116.
[45] Grobman WA. Elective induction: when? Ever? Clin Obstet Gynecol 2007;50(2):537–46.
[46] Moore LE, Rayburn WF. Elective induction of labor. Clin Obstet Gynecol 2006;49(3): 698–704.

[47] DeFrances CJ, Hall MJ. 2005 National Hospital Discharge Survey. Advanced data from vital and health statistics; number 385. Hyattsville (MD): National Center for Health Statistics; 2007.
[48] Meis PJ, Klebanoff M, Thom E, et al. Prevention of recurrent preterm delivery by 17 alpha-hydroxyprogesterone caproate. N Engl J Med 2003;348(24):2379–85.
[49] Rouse DJ, Caritis SN, Peaceman AM, et al. A trial of 17 alpha-hydroxyprogesterone caproate to prevent prematurity in twins. N Engl J Med 2007;354:454–61.
[50] Selo-Ojeme DO, Tewari R. Late preterm (32–36 weeks) birth in a North London hospital. J Obstet Gynaecol 2006;26(7):624–6.
[51] Management of preterm labor. Practice bulletin number 43. American College of Obstetricians and Gynecologists May 2003.
[52] Menacker F, Declercq E, Macdorman MF. Cesarean delivery: background, trends, and epidemiology. Semin Perinatol 2006;30(5):235–41.
[53] NIH State-of-the-Science Conference Statement on cesarean delivery on maternal request. NIH Consens State Sci Statements 2006;23(1):1–29.
[54] Rayburn WF, Zhang J. Rising rates of labor induction: present concerns and future strategies. Obstet Gynecol 2002;100:164–7.
[55] Hankins GD, Longo M. The role of stillbirth prevention and later preterm (near-term) births. Semin Perinatol 2006;30:20–3.
[56] American College of Obstetricians and Gynecologists. Cesarean delivery on maternal request. ACOG Committee opinion number 394. Obstet Gynecol 2007;110:1510–4.
[57] Wax JR, Cartin A, Pinette MG, et al. Patient choice cesarean: an evidence-based review. Obstet Gynecol Surv 2004;59:601–16.
[58] Rice Simpson K, Thorman KE. Obstetric "conveniences," elective induction of labor, cesarean birth on demand, and other potentially unnecessary interventions. J Perinat Neonatal Nurs 2005;19:134–44.
[59] Kaufman KE, Bailit JL, Grobman W. Elective induction: an analysis of economic and health consequences. Am J Obstet Gynecol 2002;18:858–63.
[60] Laye MR, Dellinger EH. Timing of scheduled cesarean delivery in patients on a teaching versus private service: adherence to American College of Obstetricians and Gynecologists guidelines and neonatal outcomes. Am J Obstet Gynecol 2006;195:577–84.
[61] Stutchfield P, Whitaker R, Russell I, Antenatal Steroids for Term Elective Caesarean Section (ASTECS) Research Team. Antenatal betamethasone and incidence of neonatal respiratory distress after elective caesarean section: pragmatic randomized trial. BMJ 2005;331(7518): 662.
[62] Ventolini G, Neiger R, Mathews L, et al. Incidence of respiratory disorders in neonates born between 34 and 36 weeks of gestation following exposure to antenatal corticosteroids between 24 and 34 weeks of gestation. Am J Perinatol 2007;10.1055/s-2007-1022470.
[63] Roberts D, Dalziel S. Antenatal corticosteroids for accelerating fetal lung maturation for women at risk of preterm birth. Cochrane Database Syst Rev 2006;(3):CD004454.
[64] Naef RW, Albert JR, Ross EL, et al. Premature rupture of membranes at 34 to 37 weeks' gestation: aggressive versus conservative management. Am J Obstet Gynecol 1998;178: 126–30.
[65] Mercer BM, Crocker LG, Boe NM, et al. Induction versus expectant management in premature rupture of the membranes with mature amniotic fluid at 32 to 36 weeks: a randomized trial. Am J Obstet Gynecol 1993;169:775–82.
[66] Dare MR, Middleton P, Crowther CA, et al. Planned early birth versus expectant management (waiting) for prelabour rupture of membranes at term (37 weeks or more). Cochrane Database Syst Rev 2006;(1):CD005302. 10.1002/14651858.CD005302.pub2.