The developing fetus is affected by social and environmental influences, including maternal nutritional status; substance use (both legal and illicit); and psychologic trauma. Correspondingly, the psychologic alterations experienced by the parents during the gestation profoundly impact the lives of all members of the family. Growing evidence implicates the importance of these and other maternal and paternal experiences that occur during and prior to the pregnancy (and even among members of earlier generations) on the subsequent development of the individual (epigenetic effects). The complex interplay between these forces and the somatic and neurologic transformations occurring in the fetus influence growth and behavior at birth, through infancy, and potentially throughout the individual's life.

**SOMATIC DEVELOPMENT**

**Embryonic Period**

Table 8-1 lists milestones of prenatal development. By 6 days postconception age, as implantation begins, the embryo consists of a spherical mass of cells with a central cavity (the blastocyst). By 2 wk, implantation is complete and the uteroplacental circulation has begun; the embryo has 2 distinct layers, endoderm and ectoderm, and the amnion has begun to form. By 3 wk, the 3rd primary germ layer (mesoderm) has appeared, along with a primitive neural tube and blood vessels. Paired heart tubes have begun to pump.

During wk 4-8, lateral folding of the embryologic plate, followed by growth at the cranial and caudal ends and the budding of arms and legs, produces a human-like shape. Precursors of skeletal muscle and vertebrae (somites) appear, along with the branchial arches that will form the mandible, maxilla, palate, external ear, and other head and neck structures. Lens placodes appear, marking the site of future eyes; the brain grows rapidly. By the end of wk 8, as the embryonic period closes, the rudiments of all major organ systems have developed; the crown-rump length is 3 cm.

**Fetal Period**

From the 9th wk on (fetal period), somatic changes consist of rapid body growth as well as differentiation of tissues, organs, and organ systems. Figure 8-1 depicts changes in body proportion. By wk 10, the face is recognizably human. The midgut returns to the abdomen from the umbilical cord, rotating counterclockwise to bring the stomach, small intestine, and large intestine into their normal positions. By wk 12, the gender of the external genitals becomes clearly distinguishable. Lung development proceeds, with the budding of bronchi, bronchioni, and successively smaller divisions. By wk 20-24, primitive alveoli have formed and surfactant production has begun; before that time, the absence of alveoli renders the lungs useless as organs of gas exchange.

During the 3rd trimester, weight triples and length doubles as body stores of protein, fat, iron, and calcium increase.

**NEUROLOGIC DEVELOPMENT**

During the 3rd wk, a neural plate appears on the ectodermal surface of the trilaminar embryo. Infolding produces a neural tube that will become the central nervous system and a neural crest that will become the peripheral nervous system. Neuroectodermal cells differentiate into neurons, astrocytes, oligodendrocytes, and ependymal cells, whereas microglial cells are derived from mesoderm. By the 5th wk, the 3 main subdivisions of brain, midbrain, and hindbrain are evident. The dorsal and ventral horns of the spinal cord have begun to form, along with the peripheral motor and sensory nerves. Myelination begins at midgestation and continues for years.

By the end of the embryonic period (wk 8), the gross structure of the nervous system has been established. On a cellular level, neurons migrate outward to form the 6 cortical layers. Migration is complete by the 6th mo, but differentiation continues. Axons and dendrites form synaptic connections at a rapid pace, making the central nervous system vulnerable to teratogenic or hypoxic influences throughout gestation. Figure 8-2 shows rates of increase in DNA (a marker of cell number), overall brain weight, and cholesterol (a marker of myelination). The prenatal and postnatal peaks of DNA probably represent rapid growth of neurons and glia, respectively. By the time of birth, the structure of the brain is complete. Synapses are pruned back substantially and new connections will be made, largely as a result of experience. Many psychiatric and developmental disorders are thought to result at least in part from disruptions in the functional connectivity of brain networks. Disorders of connectivity may begin during fetal life; MRI studies provide a developmental timetable for such connections that lend support to the possible role of disruptions in the establishment of such connections during fetal life.

**BEHAVIORAL DEVELOPMENT**

No behavioral evidence of neural function is detectable until the 3rd mo. Reflexive responses to tactile stimulation develop in a craniocaudal sequence. By wk 13-14, breathing and swallowing motions appear. The grasp reflex appears at 17 wk and is well developed by 27 wk. Eye...
Bibliography


A basic form of learning in which repeated stimulation results in a response decrement. If the tone changes in pitch, the movement increases again, which is evidence that the fetus distinguishes between a familiar, repeated tone and a novel tone. Habituation improves in older fetuses, and decreases in neurologically impaired or physically stressed fetuses. Similar responses to visual and tactile stimuli have been observed.

**PSYCHOLOGIC CHANGES IN PARENTS**

Many psychologic changes occur during pregnancy. An unplanned pregnancy may be met with anger, denial, or depression. Ambivalent feelings are the norm, whether or not the pregnancy was planned. Elation at the thought of producing a baby and the wish to be the perfect parent compete with fears of inadequacy and of the lifestyle changes that mothering will impose. Parents of an existing child feel protective for the existing child, worried that the existing child may feel less valued. Old conflicts may resurface as a woman psychologically identifies with her own mother and with herself as a child. The father-to-be faces similar mixed feelings, and problems in the parental relationship may intensify.

Tangible evidence that a fetus exists as a separate being, whether as a result of ultrasonic visualization or awareness of fetal movements (at approximately 20 wk), often heightens a woman’s feelings. Parents worry about the fetus’s healthy development and mentally rehearse what they will do if the child is malformed, including their response to evidence of abnormality through ultrasound, amniocentesis or other fetal laboratory tests. Toward the end of pregnancy, a woman becomes aware of patterns of fetal activity and reactivity and begins to ascribe to her fetus an individual personality and an ability to survive independently. Appreciation of the psychologic vulnerability of the expectant parents and of the powerful contribution of fetal behavior facilitates supportive clinical intervention.

**THREATS TO FETAL DEVELOPMENT**

Mortality and morbidity are highest during the prenatal period (see Chapter 93). An estimated 50% of all pregnancies end in spontaneous abortion, including 10-20% of all clinically recognized pregnancies. The vast majority occur in the 1st trimester. Some occur as a result of chromosomal or other abnormalities.
Growth, Development, and Behavior

Teratogens associated with gross physical and mental abnormalities include various infectious agents (toxoplasmosis, rubella, syphilis); chemical agents (mercury, thalidomide, antiepileptic medications, and ethanol), high temperature, and radiation (see Chapters 96 and 718).

Teratogenic effects may also result in decreased growth and cognitive or behavioral deficits that only become apparent later in life. Nicotine has vasoconstrictor properties and may disrupt dopaminergic and serotonergic pathways. Early exposure to cigarette smoke is associated with lower birthweight, shorter length, and smaller head circumference, as well as changes in neonatal neurodevelopmental assessments. Later, these children are at increased risk for learning problems, externalizing behavior disorders, and long-term health effects. The effects of prenatal exposure to cocaine, also occurring through alternations in placental blood flow and in direct toxic effects to the developing brain, have been followed in several cohorts and are less dramatic than previously believed. Exposed adolescents show small but significant effects in behavior and functioning, but may not show cognitive impairment. The associated risk factors including other prenatal exposures (alcohol and cigarette co-use) as well as “toxic” postnatal environments frequently characterized by instability, multiple caregivers, and violence exposure remain significant (see Chapters 39 and 40).

The association between an inadequate nutrient supply to the fetus and low birthweight has been recognized for decades; this adaptation on the part of the fetus presumably increases the likelihood that the fetus will survive until birth. For any potential fetal insult, the extent and nature of its effects are determined by characteristics of the host as well as the dose and timing of the exposure. Inherited differences in the metabolism of ethanol, timing of exposure, and the mother’s diet may explain the variability in fetal alcohol effects. Organ systems are most vulnerable during periods of maximum growth and differentiation, generally during the 1st trimester (organogenesis). http://www2.epa.gov/children/children-are-not-little-adults

Fetal adaptations or responses to an adverse situation in utero (referred to as fetal programming or developmental plasticity) have lifelong implications for the individual. Fetal programming may prepare the fetus for an environment that matches that experienced in utero. Fetal programming in response to some environmental and nutritional signals in utero increase the risk of cardiovascular disease, diabetes, and obesity in later life. These adverse long-term effects appear to represent a mismatch between fetal and neonatal environmental conditions and the conditions that the individual will confront later in life; a fetus deprived of adequate calories may or may not as a child or teenager face famine. One proposed mechanism for fetal programming is epigenetic imprinting, in which two genes are inherited but one is turned off through environmentally induced epigenetic modification (see Chapters 80 and 81.1). Imprinted genes play a critical role in fetal growth and thus may be responsible for the subsequent lifelong effects on growth and related disorders.

Just as the fetal adaptations to the in utero environment may increase the likelihood of later metabolic conditions, the fetus adapts to the mother’s psychologic distress. In response to the stressful environment, physiologic changes involving the hypothalamic–pituitary–adrenal axis and the autonomic nervous system occur. Dysregulation of the hypothalamic–pituitary–adrenal axis and autonomic nervous system may explain the associations observed in some but not all studies between maternal distress and negative infant outcomes, including low birthweight, spontaneous abortion, prematurity, and decreased head circumference. In addition, children born to mothers experiencing high stress levels have been found to have higher rates of inattention, impulsivity, conduct disorders, and cognitive changes. Although these changes may have been adaptive in primitive cultures, they are maladaptive in modern societies, leading to psychopathology. Genetic variability, timing of stress during sensitive periods, and the quality of postnatal parenting can attenuate or exacerbate these associations.

Bibliography is available at Expert Consult.

Chapter 9

The Newborn

John M. Olsson

(See also Chapter 94.)

Regardless of gestational age, the newborn (neonatal) period begins at birth and includes the 1st mo of life. During this time, marked physiologic transitions occur in all organ systems, and the infant learns to respond to many forms of external stimuli. Because infants thrive physically and psychologically only in the context of their social relationships, any description of the newborn’s developmental status has to include consideration of the parents’ role as well.

PARENTAL ROLE IN MOTHER–INFANT ATTACHMENT

Parenting a newborn infant requires dedication because a newborn’s needs are urgent, continuous, and often unclear. Parents must attend to an infant’s signals and respond empathically. Many factors influence parents’ ability to assume this role.

Prenatal Factors

Pregnancy is a period of psychologic preparation for the profound demands of parenting. Women may experience ambivalence, particularly (but not exclusively) if the pregnancy was unplanned. If financial worries, physical illness, prior miscarriages or stillbirths, or other crises interfere with psychologic preparation, the neonate may not be welcomed. For adolescent mothers, the demand that they relinquish their own developmental agenda, such as an active social life, may be especially burdensome.

The early experience of being mothered may establish unconsciously held expectations about nurturing relationships that permit mothers to “tune in” to their infants. These expectations are linked with the quality of later infant–parent interactions. Mothers whose early childhoods were marked by traumatic separations, abuse, or neglect may find it especially difficult to provide consistent, responsive care. Instead, they may reenact their childhood experiences with their own infants, as if unable to conceive of the mother–child relationship in any other way. Bonding may be adversely affected by several risk factors during pregnancy and in the postpartum period that undermine the mother–child relationship and may threaten the infant’s cognitive and emotional development (Table 9-1).

Social support during pregnancy, particularly support from the father and close family members, is also important. Conversely, conflict with or abandonment by the father during pregnancy may diminish the mother’s ability to become absorbed with her infant. Anticipation

<table>
<thead>
<tr>
<th>Table 9-1 Prenatal Risk Factors for Attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recent death of a loved one</td>
</tr>
<tr>
<td>Previous loss of or serious illness in another child</td>
</tr>
<tr>
<td>Prior removal of a child</td>
</tr>
<tr>
<td>History of depression or serious mental illness</td>
</tr>
<tr>
<td>History of infertility or pregnancy loss</td>
</tr>
<tr>
<td>Troubled relationship with parents</td>
</tr>
<tr>
<td>Financial stress or job loss</td>
</tr>
<tr>
<td>Marital discord or poor relationship with the other parent</td>
</tr>
<tr>
<td>Recent move or no community ties</td>
</tr>
<tr>
<td>No friends or social network</td>
</tr>
<tr>
<td>Unwanted pregnancy</td>
</tr>
<tr>
<td>No good parenting model</td>
</tr>
<tr>
<td>Experience of poor parenting</td>
</tr>
<tr>
<td>Drug and/or alcohol abuse</td>
</tr>
<tr>
<td>Extreme immaturity</td>
</tr>
</tbody>
</table>

From Dixon SD, Stein MT: Encounters with children: pediatric behavior and development, ed 3, St. Louis, 2000, Mosby, p 74.
Bibliography


