Anencephaly [1]

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Anencephaly is an open neural tube [5] defect, meaning that part of the neural tube [5] does not properly close or that it has reopened during early embryogenesis [6]. An embryo with anencephaly develops without the top of the skull, but retains a partial skull, including the face. Anencephaly is one of the most common birth defects [7] of the neural tube [5], occurring at a rate of approximately one in one thousand human pregnancies. The condition can be caused by environmental exposure to chemicals, dietary deficiencies, or genetic mutations.

For animals with brains and spinal cords, those parts form in the embryo from the neural tube [5]. In humans [8], the neural tube [5] forms during the third week of human pregnancy [9] from a flattened layer of ectoderm [10] on the dorsal side of the embryo called the neural plate [11]. In normal embryogenesis [6], the outside edges of the neural plate [11] fold and fuse along the middle of the plate. The fusing of the neural plate [11] extends in both proximal and distal directions, forming a cavity called the neural tube [5]. In normal human embryogenesis [6] the formation of the neural tube [5] is complete within the first month of pregnancy [9]. When the proximal neural tube [5] does not fuse, the ectoderm [10] that forms the brain is exposed to the amniotic fluid. The bony tissue covering the brain does not develop, and the unprotected neural tissue is destroyed. Due to the lack of brain development, anencephalic fetuses cannot survive. Approximately sixty-seven percent of anencephalic newborns die within twenty-four hours of birth, and the remaining anencephalic newborns typically survive no longer than two to five days.

There are many genetic and environmental factors that cause anencephaly, including folic acid [12] deficiency, genetic mutations, and chemical exposure. While anencephaly results from an open neural tube [5], the molecular mechanisms behind why the neural tube [5] does not close properly are not entirely understood. In the 1960's researchers linked insufficient folic acid [12] intake by pregnant women with neural tube [5] defects in their fetuses. In 1989 Aubrey Milunsky at the Boston University [13] School of Medicine in Boston, Massachusetts, and colleagues determined that fetuses of pregnant women who took folic acid [12] supplements had a significant reduction [14] in neural tube [5] defects. The benefits of supplements were especially pronounced when folic acid [12] was taken during the first six weeks of pregnancy [9].

In addition to nutritional causes, certain genetic abnormalities potentially cause anencephaly. Mutations in genes [15] such as MacMARCKS, which is active during neural tube [5] development, and FOXN1, a gene that is important for the proper development of the central nervous system [16], have been suggested to cause anencephaly. A 1996 study suggested that the protein coded by the MacMARCKS gene may play a role in closing the neural tube [5]. The MacMARCKS protein embeds in the cellular membrane that regulates binding of actin filaments between cells. Jianmin Chen and colleagues at The Rockefeller University [17] in New York, New York, examined mouse [18] embryos with normal *MacMARCKS* gene expression patterns and noted that the brain developed normally with no cases of anencephaly or other identifiable neural tube [5] defects. They then created mutants which expressed a nonfunctional MacMARCKS protein, and they found that all mutant embryos were anencephalic. Upon further analysis, researchers found the wild type MacMARCKS protein in the area of neural tube [5] closure, concluding that MacMARCKS plays an important role in the proper closure of the neural tube [5].

In 2007 Stefania Amorosi and colleagues, at the University of Naples in Naples, Italy, examined anencephalic mouse [18] embryos and an anencephalic human embryo. The embryos were homozygous for a mutation in the *FOXN1* gene. Amorosi found that the *FOXN1* gene was expressed in the choroid plexus of mice, a structure in the ventricles of the mammalian brain responsible for secreting cerebrospinal fluid (CSF). CSF is a tissue that transports signaling molecules and directs brain development. The *FOXN1* gene codes for a transcription factor protein that controls the expression of genes [15] that contribute to development of the central nervous system [16]. Amorosi and colleagues concluded that mutations in *FOXN1* resulted in improper neural tube [5] formation, leading to anencephaly.

There is also evidence that environmental exposure to certain chemicals early in pregnancy [9] can cause anencephaly. A 2001 study by Julia Blanco Muñoz, at the University of Granada in Granada, Spain, surveyed the families of 157 Mexican children born with anencephaly and 151 families whose children developed normally. The study showed that mothers exposed to pesticides such as methyl parathion during their first month of pregnancy [9] were five times more likely to give birth to a child with anencephaly than were women not exposed to pesticides. The study also showed that families were twice as likely to have an anencephalic child when the father was exposed to methyl parathion at any time prior to conception [19]. As of 2002 Mexico had the world's highest rate of anencephaly, with 8.05 cases per 10,000 live births.

Anencephaly can be diagnosed using a sonogram, an imaging method using ultrasound [20] technology to visualize the fetus [21] inside the mother. An anencephalic fetus [21] has a triangular-shaped face and lacks the anterior region of the skull, both of which can be seen on the sonogram. Using a sonogram, anencephaly can be diagnosed as early as eleven weeks into the pregnancy [9]. An older method for diagnosing anencephaly is using karyotyping, a method of staining chromosomes with dye, and investigating chromosome structure with a microscope [22]. Researchers have found evidence of a connection between anencephaly and chromosome 13, when the latter has the shape of a ring. In these cases, genes [15] which are responsible for proper brain development are deleted, and the remaining sections of the chromosome bind at the ends, forming a ring.

Some controversy accompanies the idea of using anencephalic fetuses as organ donors. Anencephalic fetuses are unable to survive outside of the womb [23], but they develop many functional organs, and anencephalic fetuses are candidates for organ donation. Proponents of embryonic organ donation state that because large sections of the brain are missing, anencephalic fetuses cannot feel pain and are never conscious. Ethicists, scientists, and doctors grapple with questions about the morality of distributing organs from anencephalic fetuses.

Sources

1. Amorosi, Stefania, Massimo D'Armiento, Giuseppe Calcagno, Vincenzo Russo, Marsilio Adriani, Andrea Christiano, Louis Weiner, and Claudio Pignata. "FOXN1 Homozygous Mutation Associated with Anencephaly and Severe Neural Tube Defect in Athymic Human Nude/SCID Fetus." *Clinical Genetics* 73 (2008): 380–4.
2. Chen, Chih Ping, Schu-Rern Chern, Chen-Chi Lee, Wen-Lin Chen, and Wayseen Wang. "Prenatal Diagnosis of Mosaic Ring Chromosome 13 with Anencephaly." *Prenatal Diagnosis* 21 (2001): 102–5.
3. Chen, Jianmin, Sandy Chang, Stephen A. Duncan, Hirotaka J. Okano, Gord Fishell, and Alan Adarem. "Disruption of the MacMARCKS Gene Prevents Cranial Neural Tube Closure and Results in Anencephaly." *Proceedings of the National Academy of Sciences [24] of the United States of America.* 93 (1996): 6275–9.
4. Milunsky, Aubrey, Hershel Jick, Susan Jick, Carol L. Bruell, Dean S. MacLaughlin, Kenneth J. Rothman, and Walter Willett. "Multivitamin/Folic Acid Supplementation in Early Pregnancy Reduces the Prevalence of Neural Tube Defects." *The Journal of the American Medical Association [25]* 262 (1989): 2847–52.
5. Moore, Lisa. "Anencephaly." *Journal of Diagnostic Medical Sonography* 26 (2010) 286–9.
6. Morlock-Stemp, Graeme. "Pesticides and Anencephaly." *Environmental Health Perspective* 115 (2007): 78.
7. Muñoz, Julia Blanco, Marina Lacasaña, Victor Hugo Borja Aburto, Luisa Elvira Torres Sánchez, Ana María García García, and Lizbeth López Carrillo. "Socioeconomic Factors and the Risk of Anencephaly in a Mexican Population: A Case-Control Study."*Public Health Reports* 120 (2005): 39–46.
8. Reagan, James E. "Ethics Consultation: Anencephaly and Organ Donation." *Journal of Law, Medicine and Ethics* 23 (1995): 398–400.

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Subject

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