Chapter

Introductory Chapter: Chromosomal Abnormalities

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1. Introduction

DNA molecules are tightly wrapped around proteins called histones, non-histone proteins that make structures called **chromosomes,** and are present in the cell nucleus as unconcentrated during the cell cycle. Chromosomes are structures inside cells that contain an individual's genes. The human genomes have 46 chromosomes, composed of 22 pairs of autosomes and a pair of sex chromosomes (X and/or Y). All of the somatic cells in females carry two X chromosomes, and all of the somatic cells in males carry one X and one Y chromosome. One half of each pair of chromosomes comes from through the egg cells; one half of each pair comes from through the sperm cells. As a result, females carry two copies of each X-linked gene, while males carry only one copy of X-linked and Y-linked genes. They vary in size and appearance, the X being much somewhat bigger than the Y and contain entirely separate genes, but they do have small areas of resemblance. Both individuals of a species contain the same number of chromosomes specific for that species. Nonetheless, there are individuals that exhibit differences in this standard complement. Such differences may be changes in number of chromosomes or structural changes inside and within chromosomes, collectively such changes are called chromosomal aberrations or chromosomal anomalies.

Over the past few decades, genetic and genomic advancements have changed our understanding about health. Genetic anomalies are also related to pregnancy and birth defects. Any disease is partly caused by the individual's genetic characteristics. These genetic abnormalities cause genetic defects that arise as a result of changes (mutations) in a person's DNA. Such variations in DNA occur on nucleotide sequences called genes. In this case, the function of the affected gene(s) may be impaired. The disturbance in the structure of the gene will disturb the normal structure and function of proteins. Mutations change the protein coding sequence of the genome in some way. Nonetheless, there are potentially several different pathways that can impair natural gene expression which can lead to genetic defects. Many genes are dominantly transmitted down the family, in which, the individual bears a regular copy and a modified copy of the gene. The altered gene is therefore prevalent or superior to the regular gene. This occurrence triggers a genetic disorder effect to the child. This case is a spontaneous phenomenon. In all boys and girls, this possibility is the same throughout each birth, and the altered gene cannot be reversed and remain constant in one's life. Many dominant or recessive genetic disorders affect the child from birth, while others have an adult effect on the person only. An organism's genetic component regulates its development and its interplay with its environment. Consequently, any change in this genetic material results in variation in phenotypic characters. These effects can vary, depending on the extent of the aberrations, from being lethal to being harmless. Normally, the cell divisions in daughter cells should have an equal number of chromosomes. The duplicated

chromosomes must be specifically separated into daughter cells during the cell division. However, too few or too many copies of a chromosome will transfer through daughter cells as a result of cell division errors.

Chromosome abnormalities are mostly the result of a cell division malfunction. A chromosomal abnormality happens when fetus has wrong amount of DNA in a cell; the chromosomes are structurally deficient, or the number of chromosomes is wrong. Additionally, errors can occur in the cell cycle when coping chromosomes. During meiosis division and fertilization, a wide range of chromosomal abnormalities exist; they can be classified into two classes, namely numerical and structural abnormalities. For the gain or loss of a whole chromosome, numerical variations or aneuploidies arise. The resulting phenotypes in a single chromosome or chromosomal fragment are triggered by the mismatch in one or more dosage-sensitive genes. These imbalances in the number of chromosomes also interact with the dose-sensitive and developmentally essential genes and ultimately induce the emergence of unique and complex phenotypes [1, 2]. As a consequence, numerical chromosomal aberrations may be symptomatic of tension on DNA replication without actual chromosome segregation defects. Although most human chromosomal DNA dose not encode proteins, even rather small pieces of chromosomes that contain hundreds of genes [3, 4].

A mutation in a chromosome is an unpredictable change. Quite commonly such modifications are caused by complications that arise during meiosis, or by mutagens such as toxins, radiation, viruses, etc. Chromosome mutations may result in changes in cell count or changes in chromosome structure. Mutations in the composition of chromosomes are variations that affect whole chromosomes and whole genomes rather than just individual nucleotides. Chromosome mutations can cause a large variety of genetic disorders. Chromosome abnormalities are also the cause of early pregnancy loss, fetal malformations, stillbirth, and male infertility associated with it. Addition or deletion of entire chromosomes (aneuploidy) will also have fatal consequences. Aneuploid cells exhibits particular defects in the cell cycle kinetics, growth rate, metabolism, and response to specific stresses [3, 5]. Chromosomal disorders may lead to mental retardation or other developmental problems. For more than one system, phenotypic results of a certain gene typically provide details on the biological roles of the particular gene. Furthermore, a deletion or replication of a single gene that may cause other genes affecting several phenotypes are considered pleiotropic genes [2, 6]. Pleiotropy indicates that certain proteins have more than one role in various types of cells, and any genetic alteration that change the gene expression or function of different tissues will theoretically have far-reaching consequences [6, 7].

Contrary to numeric abnormalities, structural chromosomal abnormalities result from a break or breaks that disrupt the continuity of a chromosome. Sometimes a spontaneous break or breaks occur in a chromosome or chromosomes in a different cell which may lead to deletion, inversion, translocation, isochromosome, and ring chromosome [8]. During the cell division, a part of chromosome content is destroyed; the intrinsic rearrangement becomes unbalanced [9]. A disease may arise as a result of a balanced rearrangement if the breaks in the chromosomes occur in a gene, resulting in a missing or nonfunctional protein, or if the fusion of chromosomal segments results in a two gene combination, creating a new protein product whose work damages the cell. Some of the developmental abnormalities found in embryos are closely linked to chromosomal defects that occur, such as mosaism, haploidy, and polyploidy [10–13].

The classical and molecular cytogenetic techniques provide significant potential applications, especially in clinical trials and biomedical diagnosis, rendering them a strong to other molecular and genomic methods and chromosomal abnormalities.

Genetic knowledge can influence not just the entire populations, but the generations come too. Medical genetics' primary aim is to help individuals with a genetic disorder, their families to lead a life as normal as possible, and to provide adequate care or social support systems.

Biochemical genetics and cytogenetics work in numerous research fields, such as induce genes defects, chromosome-specific zone recognition, and molecular mechanism of chromosomal abnormalities. The advances in genetic testing using molecular biotechnology and mass screening systems for newborn infants help to understand the role of genes, their behavior, the interaction between genetic diseases and environment, the causes of their appearance, and the development of successful therapies and technologies.

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