5th Edition

Pregnancy at Risk

A Practical Approach to High Risk Pregnancy and Delivery

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2 Cytogenetics of Early Pregnancy Wastage

SV Kotwaliwale, Mangala Ketkar

Repeated pregnancy wastage is a very commonly observed entity in the obstetric practice. Early pregnancy wastage is related to maternal, paternal and fetal factors. Maternal factors include congenital abnormalities of the uterus, transplacental and intrauterine infections and endocrine factors. The paternal factors include abnormal semen and chromosomes. Fetal malformations are due to single gene defect, chromosomal aberrations or due to multifactorial reasons. Additionally, immunological factors also play an important role. In this chapter we shall consider the correlation between the gestational age and pregnancy wastage, the pathology of the specific chromosomal abnormalities, the subsequent need for counseling and practical aspects of successful cytogenetic results. Early pregnancy wastage can be divided into two categories: Preclinical loss and clinical loss.

Preclinical Loss

This includes pregnancy wastage occurring before 5-6 weeks of gestation. Highly sensitive β-hCG assays are nowadays available to diagnose the pregnancy as early as 5–6 weeks. However, this is not widely available. Studies dealing with preclinical as well as clinical losses by various authors (Miller et al, 1980; Edmond et al, 1982; Whittker et al, 1983) using positive hCG levels have indicated the preclinical loss to vary between 8% and 58% and clinical losses between 12% and 14%.[1-3] However, it is difficult to obtain adequate fetal tissue from such an early pregnancy. Therefore, very few studies are available. Cytogenetic findings in early embryos are available from IVF studies. Many researchers (Angell et al, 1983; Rudek et al, 1984 and Michelmann and Meltler 1984) have studied laparoscopically recovered oocytes and early human embryos.[4-6] They have demonstrated the presence of cytogenetic abnormalities in some of these specimens. These studies were conducted basically to reason out the cause for failure of implantation. They indicated the frequent occurrence of triploidy, monosomy, and occasionally trisomy. In our study we have found triploidy (69 chromosome complement) as a frequent cause for early pregnancy wastage. Triploidy is usually due to dispermy. Such conceptus, if retained will form an abnormal fetus or can lead to formation of vesicular mole. Assuming that IVF embryos represent *in vivo* conception, these pregnancy losses could be due to chromosomal etiology.

Clinical Loss

This category includes pregnancy wastage between 7 and 14 weeks of gestation, i.e. the first and early second trimester. Fetal loss is clinically recognized by passage of tissue, vaginal bleeding and opening of the cervical os. However, on sonography fetal demise can be recognized much earlier and is referred to as missed abortion. Carr in 1967 first reported that the chromosomal abnormalities are responsible for fetal wastage. Data published by Boue et al indicates that 50% of the clinically recognized pregnancy losses are chromosomally abnormal.[7] However, there is no data which indicates the correlation between specific type of abnormality and the period of gestation. The following data shows the frequency of chromosome complements detected in first trimester spontaneous abortions. **Table 2.1** and **Figure 2.1** describes the frequency of chromosomal complement in first trimester abortions studied in 1541 samples studied in this centre. The frequency of normal chromosomes was 57.8% by culture and the frequency of abnormal chromosomes was 23.14% which included structural and numerical abnormalities of autosomes and sex chromosomes. 23 (1.5% of total) samples were studied by FISH for

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Table 2.1: Frequency of chromosomal complements in 1st trimester abortions study of 1541 samples

Abnormality	*Chromosomal Complement*		*Percentage*	*Total Frequency (%)*
Normal	(46, XX or 46, XY)			57.8
Polyploidy	All Type			4.47
Monosomy	45, XO			3.8
Structural abnormalities	All Type			3.17
Total Double Cell line	All Type			3.6
Autosomy Trisomy	No.	1	0	8.1
		2	0.19	
		3	0.06	
		4	0.06	
		5	0.19	
		6	0.13	
		7	0.06	
		8	0.06	
		9	0.06	
		10	0.13	
		11	0	
		12	0.06	
		13	1.10	
		14	0.13	
		15	0.26	
		16	1.36	
		17	0.06	
		18	1.69	
		19	0	
		20	0.26	
		21	2.01	
		22	0.19	
Report by FISH (Normal)	1.0			
Abnormal by FISH	0.5			
Result Could Obtained	17.6			

* The samples were studied in Genetic Diagnostic Center, Tardeo, Mumbai-34

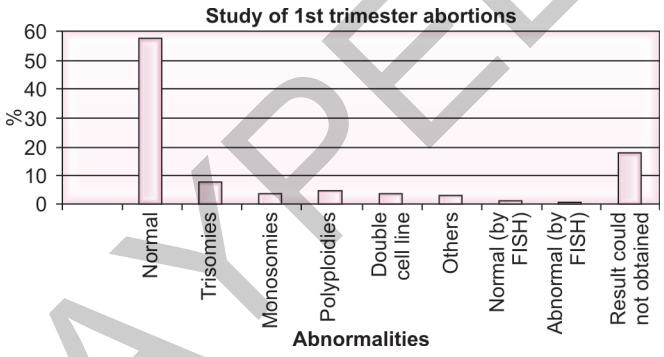

Fig. 2.1: Graph for frequency of chromosomal complements in 1st trimester abortions study of 1541 samples

chromosome 13, 18, 21 and sex chromosomes, 15 samples (1% of total) were normal and 8 samples (0.5% of total) were found abnormal. The results could not be obtained in 17.6% of the total samples. This could be because of various factors like non-viability of the tissue and infected samples, delay in transportation, etc. Sometimes it is difficult to separate maternal and fetal tissue especially in cases of very early pregnancy wastage. Extra embryonic tissue in the form of chorion villi sac or cord is known to be discordant for fetal tissue (Simoni).[8] Many times cytogenetic analysis from villous tissue shows 45, XO chromosome complement, but the fetal tissue shows 46, XX.

Pathology of Specific Chromosomal Abnormality

Recent advances in the form of FISH (Fluorescence In-Situ Hybridization) technique can identify the numerical aberrations of the chromosomes even in the interphase stage of the cell using chromosome specific DNA probes. This can also be used for metaphase chromosomes. In addition, DNA probes can also identify the deletions in metaphase. Chromosome painting can identify translocation. However, these techniques are laborious and expensive. We have used FISH technique occasionally for products of conception studies where cultures were not growing and on some occasions we could identify triploidy showing three signals **(Fig. 2.2)**, which was subsequently confirmed on karyotype **(Fig. 2.3)**. Normal human karyotype consists of 46 chromosome complement, 23 pairs of autosome and 1 pair of sex chromosomes XX / XY. Chromosomes are classified into different categories: Metacentric, submetacentric and acrocentric. According to the length of the chromosome and position of centromere, these are arranged into six groups A – G. Chromosomes in each pair are known as homologous chromosomes. The banding pattern of each chromosome is specific. Banding of the chromosome is

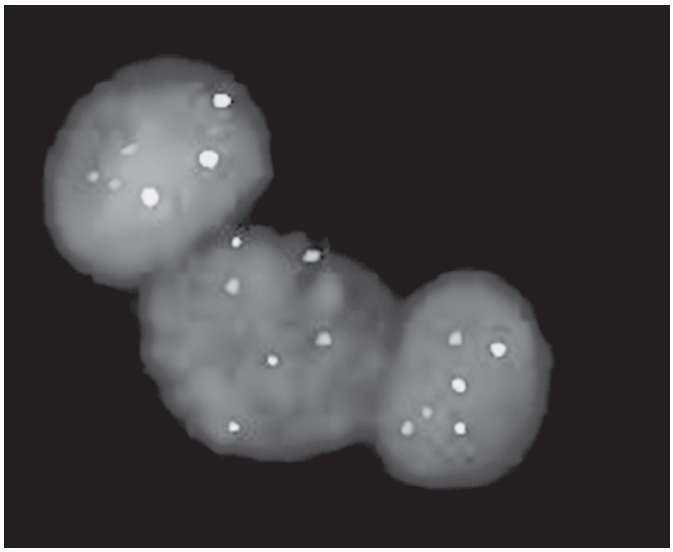

Fig. 2.2: FISH studies for products of conception, three signals for chromosome 13 and 21

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Fig. 2.3: 69,XXY (Triploidy) observed in 1st trimester products of conception

essential to identify the different segments of chromosomes. The chromosomal abnormalities are classified into numerical and structural.

Numerical

Numerical abnormalities include either presence of an extra chromosome or a chromosome less than normal, e.g. trisomy or monosomy. This could be either autosomal trisomy or trisomy for sex chromosomes. It also includes polyploidy where chromosome complement is a multiple of haploid number 23.

Structural

Structural abnormalities are of different varieties, e.g. translocation, inversion, insertion, ring chromosome, etc. All these abnormalities when present in an individual are likely to produce an abnormal gamete which is responsible many times for repeated fetal loss or birth of an abnormal child.

The different cytogenetic abnormalities observed in the abortus material are discussed below:

Autosomal Trisomy

Autosomal trisomy is one most commonly observed aberration in the abortus material. Trisomy 21, 22, 18, 16 and 13 are frequently observed. All trisomies except trisomy 16 may be observed in the live born baby. Clinical manifestations of these trisomies usually manifest in form of hypoplastic or avascular chorionic villi with enlarged cytotrophoblastic cells. Blighted ova are reported in trisomy 2, 3, 4, 5 (Boue et al). Trisomy for 'C' group of chromosome (6-12) is also observed and shows presence of little amount of fetal tissue as compared to the blighted ovum. Facial abnormalities are seen in trisomy for 13, 14 and 15 chromosomes. Most of the trisomies are due to non-disjunction at meiosis. In our study we have more often observed trisomy for 13, 16, 18 and 21 **(Fig. 2.4)**.



Fig. 2.4: Trisomy 13 observed in products of conception

Monosomy

Monosomy of any chromosome is reported in 20 to 25% of abnormal specimens. Out of these, 8% are due to

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monosomy 'X'. The placental morphology in such specimens includes hypoplastic and small avascular villi along with the areas of thrombosis. In a slightly advanced pregnancy, Turner stigmata in the fetus will be observed.

Polyploidy

Polyploidy includes triploidy and tetraploidy. Triploidy (69, XXY and 69, XXX) is frequently observed in IVF conceptuses. However, 69, XXY is rarely observed. Triploid fetus if retained may result in the formation of an abnormal fetus or a vesicular mole.

Placental tissue in such pregnancy is voluminous and shows evidence of cystic changes. Tetraploid (92 chromosomes) fetuses are uncommon and rarely progress beyond 2–3 weeks.

Structural Aberrations

Structural aberrations account for 3% of abnormal specimens. The structural rearrangements could be *de novo* occurring during gametogenesis or could be inherited from one of the parents who is a balanced translocation carrier or has inversion.

Translocation

Translocation carriers are usually detected from the investigation in a family with repeated miscarriages.

There are two types of translocation observed: Robertsonian and reciprocal balanced translocation. Robertsonian translocations are due to whole arm translocation between two different chromosomes (heterozygote carrier). However, translocation between the two same chromosomes (homologous translocation carrier) is also known to exist. **Figure 2.5** explains the recurrence risk for heterozygote translocation carrier (Simpson and Bombard).

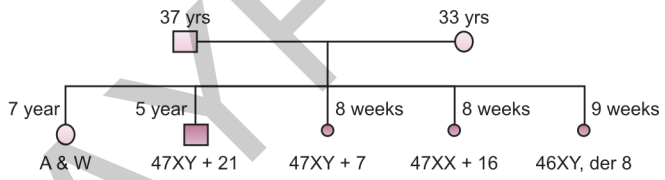

Fig. 2.5: Family with different chromosomal patterns in each abortus indicating the tendency for non-dysjunction during gametogenesis

From **Figure 2.6** it is evident that three combinations in the zygote are not compatible with life, and therefore, are not observed in the live born. Probably these conceptuses are aborted early. One combination will form a normal child, one will be normal but a carrier and one

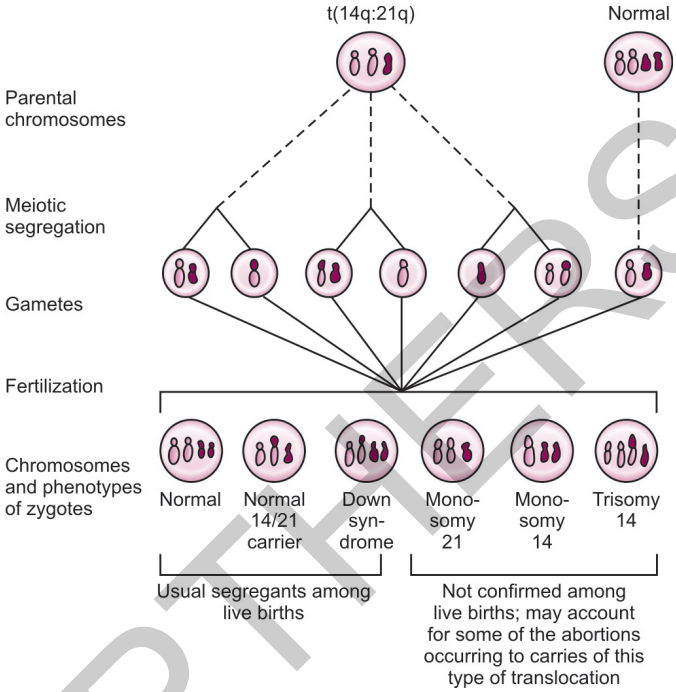

Fig 2.6: Possible gamete and progeny in 14/21 translocation carrier

will be affected with Down syndrome. Therefore, the risk for having a Down syndrome child in such a translocation carrier is 33%. These couples can be offered prenatal diagnosis and assured regarding the outcome. The outcome of pregnancy in homologous translocation carrier state in parent is hopeless. It will always produce either a trisomic infant or monosomy which not being compatible with life, and will naturally abort. Such couples can be offered donor insemination if the male is a carrier or donor egg IVF if the female is a carrier. It is therefore, valuable to perform cytogenetic analysis on the products of conception which is useful for further treatment.

In reciprocal balanced translocations, there is translocation of chromosome segment between two different chromosomes. Parent will be always normal. However, as per 3:1 segregation, the gamete will be trisomy or monosomy for the segment involved in the translocation in 50% cases, the other 50% will be normal out of which 25% will be translocation carriers like the parents and 25% will be without any chromosomal abnormality.

Sampson and Bombard (1987) have suggested that if balanced translocation is detected in one of the parents in the family investigations, the risk of having an abnormal child is low.[9] If the same is detected through an abnormal child, the risk of having the same abnormality in the next pregnancy is more and if it is detected in a couple investigated because of repeated abortions the risk

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may or may not be the same as detected through a live born infant. In our data, in cases with balanced translocation prenatal diagnosis did not reveal any abnormal chromosome and fetuses were normal. These couples were mainly investigated because of repeated early miscarriages. The couples with these types of translocations can be offered prenatal diagnosis either by CVS, amniocentesis or by fetal blood sampling. Whenever the segment of the chromosome involved is small, we do not advise CVS, but offer them either amniocentesis or fetal blood sampling, because the chromosomes obtained in this tissue are of good quality for banding.

Inversions

In the inversion type of aberration, the segment of chromosome gets the reverse of the original. If the segment involves the centromere, it is pericentric inversion. Pericentric inversion leads to duplication or deficiency of the segments outside the inverted segment. This is because of formation of a loop in homologous pairs during cell division. If the inverted segment is small, the duplication or the deficiency of segment will be large leading to an abnormality. If the inversion is detected because of a live born abnormal infant, the recurrence risk is higher. However, if it is detected because the family is being investigated for repeated miscarriages, the risk for an abnormal child is low. Since the recombinant (new chromosome) is lethal, it therefore, leads to abortion.

Paracentric inversion will form acentric and dicentric segments of a chromosome during cell division—leading to duplication and deficiency. However, acentric segments are lost and the dicentric segments can form an abnormal gamete which could be lethal or produce an abnormal child. In these cases, prenatal diagnosis is possible. It seems logical from the above description that cytogenetic analysis of the products of conception is worthwhile for further counseling and prenatal diagnosis.

Genetic Counseling, Recurrence Risk and Prenatal Diagnosis

Genetic counseling is a process by which a patient who is at a risk of having a disorder is advised regarding the consequences, the probability of developing and transmitting it to the next generation and the methods by which it can be prevented (Harper). For effective genetic counseling one has to know the exact diagnosis of the disorder. We shall restrict ourselves to the chromosomal disorders. For prevention, the exact diagnosis of the previous abortus material or an affected abnormal child or cytogenetic analysis of the couple concerned is necessary. Based on this data, prenatal diagnosis by proper methods is possible. Let us consider the recurrence risk for different types of aberrations.

Recurrent Numerical Aberration

It is observed that recurrent risk of numerical aberration is more if the first conceptus was diagnosed as monosomy or trisomy. However, if the first conceptus is normal, the chances of the second one being normal are more. The most common type of aneuploidy is trisomy, but it also could be monosomy and polyploidy as well. It is suggested that certain couples are predisposed to the formation of an abnormal gamete. Males and females could be equally responsible for such a phenomenon. The important question is whether the previously trisomic conceptus increases the risk of another trisomic pregnancy. In fact, the birth of a live born trisomic child increases the risk of a similar child during the next pregnancy. In this situation prenatal diagnosis is possible.

Compared to the numerical aberration, the risk for miscarriage because of structural aberration in the form of translocation or inversion in one of the parents is more, because abnormal conceptuses are usually not viable and end up in early pregnancy wastage. In case the pregnancy reaches beyond the usual gestational age of miscarriage, prenatal diagnosis should be offered either by amniocentesis or by fetal blood sampling in order to confirm the normality of the fetus.

Prenatal Diagnosis

Prenatal diagnosis of cytogenetic disorders is possible either by chorion villous sampling between 6 and 8 weeks, amniocentesis by 16-20 weeks or by fetal blood sampling at 20 weeks. Each procedure has its own advantages and disadvantages. An individual case needs its own consideration and a suitable method is chosen. It will be worthwhile mentioning that aseptic precautions are necessary while collecting samples at source and at the laboratory. Similarly, adequate amount of tissue is required for suitable analysis, so that a repeat test can be avoided. The results are usually available within 15 days.

Practical Aspects for Successful Cytogenetic Results

Products of conception usually contain the fetal tissue in the form of chorionic villi, amniotic sac, fetal parts and maternal deciduas. These products should be collected

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under aseptic precautions in the tissue culture medium which can be obtained from the genetic laboratory or IVF laboratories. The tissue should be transported to the laboratory immediately. In case of emergency, the tissue can be stored in the refrigerator for 24 hours. Upon receipt, the tissue is dissected under an inverted microscope and 2–3 cultures are set up. As far as possible, fetal tissue is selected for setting up a culture. Tissue usually requires a very long period to yield sufficient metaphases for analysis.

In spite of the above precautions, the success rate for culture is low because of nonviability of the infected tissue samples and delay in transporting the sample to the laboratory. The cultures will also fail if very superior quality culture media are not used. Missed abortion samples which are of more than one week duration diagnosed on ultrasonography are difficult to grow. However, placental tissue in such specimens can yield chromosomes. The only disadvantage is that placental tissue karyotype may not reflect the true fetal karyotype since it known to be discordant with fetal tissue. In such a case, the couple is investigated at a later stage. In case of a birth of an abnormal child cytogenetic analysis should be requested immediately because such an infant is prone to infection and is usually given a lot of medication. The response for culture is poor in such a situation. In addition, prolonged hypoxia to the child can produce similar effects and valuable analysis will be lost. It is difficult to convince the parents regarding the investigations because of the psychological trauma of having an abnormal child or having lost the pregnancy in addition to the heavy cost to be incurred by them.

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Pregnancy at Risk

A Practical Approach to High Risk Pregnancy and Delivery

Pregnancy and childbearing have been associated with certain complications to the mother as well as the fetus. The aim of this book is to improve the management of high-risk situations, thereby optimizing the pregnancy outcomes. The overwhelming response of previous editions has prompted FOGSI to come up with the fifth edition which has been thoroughly revised and updated. This is a multi-contributor book comprising of 100- plus chapters contributed by eminent specialists and experts in various subjects pertaining to high-risk pregnancy management. With the tremendous progress made in the field of Perinatology, there are now better diagnostic methods, excellent interventional possibilities and management of various problems by new drugs and techniques. Understanding of genetics, placental insufficiency and medical and obstetric problems have changed significantly and the chapters have been updated to keep obstetricians and postgraduates abreast with the latest. The book covers pathophysiology, infections during pregnancy, labor and delivery, management of medical problems, application of bio-physical and interventional methods and even high-risk obstetrics in low resources settings.



Usha Krishna has been a professor of obstetrics and gynecology at GS Medical College and KEM Hospital. She is past president of FOGSI, MOGS and chairperson of scientific committee AOFOG. She is chairperson of ICMR "Reproductive Health and Nutrition Division" and president, Family Planning Association of India, consultant, Obstetrician and Gynecologist, Bhatia General Hospital, Director, Clinic for Women Laburnum Road Gamdevi, Mumbai, Maharashtra, India. She has received FIGO award for 'Outstanding Work for Women' and FOGSI award for 'Lifetime Achievement'. She has contributed to innumerable publications and is interested in academics and teaching programs.



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