Reproductive Problems of the Work Force

G D Premalatha, MPH*, J Ravindran, FRCOG, *Jelebu District Health Office, 71600 Kuala Klawang, **Department of O & G, Seremban Hospital, 70300 Seremban, Negeri Sembilan**

Summary

The number of women in the workforce is increasing. A substantial proportion are in the reproductive age which brings to attention the problem of work exposures that adversely affect reproductive outcome. These exposures include chemicals, radiation, strenuous physical activity and infections. They affect reproduction by effect on the germ cells, through hormonal distribution which in turn affects transport of germ cells or zygote, implantation and development. Some of these exposures are teratogenic. At present, some regulations and policies seem to be directed at women workers while there is evidence to show that women are not the only victims. Paternal exposures have also been reported to be associated with infertility, spontaneous abortions and other adverse outcomes. There is insufficient information about reproductive effects of work exposures and hence further research is required in this area.

Key Words: Reproductive hazards

Introduction

Couples may experience anxiety at conception or when deciding to start a family. So doctors treating workers, whether occupational physicians, obstetricians or primary care physicians may be called upon to clarify the doubts couples experience. Despite the immense addition to knowledge regarding health and disease, there is still considerable ignorance about reproduction. We have known for centuries that some substances are hazardous to the reproductive system.

Over a hundred years ago, lead-exposed women in the pottery industry were found to be at increased risk of sterility, miscarriage, stillbirth and death in the neonatal period[1]. In the 1950s, children whose mothers consumed fish contaminated with organic mercury in Japan during their pregnancy developed mental retardation, cerebral palsy and developmental delay[1]. These were examples that exposure to certain substances in the environment during pregnancy could cause harm to the developing fetus. Worldwide, the number of women in the workforce has increased[2]. A large number of them are in the reproductive age group[3]. These women may be exposed to the hazardous substances found in the workplace.

Fertility and Infertility

To achieve a pregnancy several processes are involved. These would be:-

1. The production of the egg (ovum) and the sperm
2. The transport of the ovum and the sperm
3. Fertilisation of the ovum by the sperm
4. Transport of the embryo or zygote to the uterus
5. Implantation of the embryo in the uterus
6. The subsequent development of the foetus[4]

One in seven married couples are involuntarily infertile and 15 - 20% of pregnancies result in a clinically recognisable spontaneous abortion[5]. About 10 - 15% of the fertilised ova degenerate before implantation and 30% after, but before the pregnancy is recognised[6]. Hormonal disturbances can upset production and transport of the sperm and ova, implantation of the

embryo or its further development. These hormones can be disturbed in many ways, such as exposures that are directly toxic to the organs producing the hormones or through chemicals like DDT that have oestrogen-like properties[4]. Direct cell damage to the sperm or ova can cause infertility or congenital malformations[6]. Therefore an adverse exposure at any one of these stages can affect the conception, the continuation of pregnancy or the development of the fetus, thus affecting fertility.

In females, oogenesis occurs in-utero. The first mitotic division and the first meiotic division begin at the 5th month of gestation. Then it remains dormant until puberty when the development of the ovum continues. The first meiotic division is completed just before ovulation. It is believed that genetic damage can occur during the replication and division of the genetic material. Relatively little is known about ovarian toxicity as the female germ cell is inaccessible but theoretically an insult to the mother at this stage of pregnancy can produce effects on the fetal reproductive system[6]. It can also occur just before ovulation. Chromosomal damage that results can be one which is compatible with survival or can cause embryolethal conceptions which will spontaneously abort. The former will include defects which can be transmitted to future generations or it may be teratogenic which would then cause birth defects or functional defects[6].

The embryogenic period i.e. the 17 - 56th day post conception, is the period of organogenesis and at this stage the fetus is extremely sensitive to teratogenic insult. Exposure in the second and third trimesters result in growth retardation, central nervous system defects or neurobehavioral problems[7].

What may go wrong?

Over 60,000 chemicals are used commercially today[1]. Only 10,000 have been tested for toxicity in animals[8]. Of the 5,000 chemicals in commercial usage for which toxicity data is available, only 500 have been evaluated for reproductive toxicity[9].

One should not forget the physiological changes that occur during pregnancy, such as increased tidal volume and respiratory rate which might increase the absorption of airborne chemicals. Plasma proteins are increased during pregnancy. These factors affect the binding of various chemicals and will result in increased bioavailability and enhanced toxic responses to the chemicals. In pregnancy, the uptake of benzene is increased thus increasing the toxicity to the mother. A number of other substances can also present with toxicity particularly in pregnancy like beryllium, mercury, formaldehyde and organochlorine[10].

In South East Asia, it is estimated that about 90% of the electronic assembly workforce are women[11]. Studies of pregnancy outcome in women who had been drinking water contaminated with substances used in the electronic industry suggested that there was an association between substances used in the electronic industry and birth defects as well as spontaneous abortions. Following a report of a cluster of untoward pregnancy outcomes, the California Department of Health Services found a significant increased risk of spontaneous abortion (twice the rate for the remainder of the county) and congenital cardiac birth defects (2.6 times the rate in the rest of the county) in the geographic area where the water was contaminated with trichloroethane and other solvents from an industrial storage tank leak compared to the rate for the rest of the country[11]. Animal experiments seem to implicate that some substances used in the electronic industry are teratogens or embryo-fetal toxins[12].

In various industries, workers are exposed to heavy metals. Arsenic, which can cross the placenta, has been shown to cause higher rates of chromosomal aberrations in smelter workers. A series of studies in Finnish metal workers and in a Swedish community with exposure to higher levels of arsenic (from smelter emissions) suggested that it might increase the risk of spontaneous abortions and low birth weight babies[12]. Cadmium is another metal that workers are exposed to. Animal studies indicated that it is embryolethal, fetotoxic and teratogenic. It led to stillbirths, miscarriages and caused abnormal neurodevelopment[13,14].

Many organic solvents are used in various industries. Benzene and toluene are fetotoxic in animals, causing reduction in birth weight. Benzene has mutagenic properties and can produce chromosomal aberrations[9]. Chromosomal aberrations were also seen in animal studies with rats and mice. There are reports of toluene

being reported to increase the frequency of renal-urinary and other congenital defects[15]. Xylene has been associated with minor skeletal abnormalities and possible preimplantation losses after exposure in early pregnancy[16]. Menstrual irregularities have been identified in women exposed to toluene and benzene[17]. Similar findings were also seen in the California semiconductor manufacturing industry.

Between 1977 and 1990, 6 independent surveys were carried out on plantation workers and farmers in Malaysia and it was reported that a considerable percentage experienced poisoning symptoms[18]. It was reported that between 34% of these workers never read labels, 74% would spray on windy days, a range of 55.6% did not wear protective clothing and 9% did not bathe after spraying[19]. In one survey of rice farmers, it was reported that their spray equipment were faulty and leaked[20]. In this study 80.4% (of the 467 farmers surveyed) wore "masks" but these were face towels, cloth and sponge masks which were obviously inadequate; only 25% wore boots or shoes. Of these 467 rice farmers, 80% experienced spillage of pesticides[20].

Women of reproductive age do work in the agricultural industry and continue to do so in early and middle pregnancy. Endrin is one pesticide reported to be associated with congenital anomalies and intrauterine growth retardation in rats[21]. Heptachlor is a pesticide that is reported to be associated with reduction in pregnancy rates, a decreased survival of offspring and cataracts in such children. TCDD (tetrachlorodibenzopara -dioxin), a herbicide, interferes with the establishment of pregnancy due to its anti-estrogenic effect[22]. Ethylene glycol is used extensively in paints, lacquers, printer ink, resins, dyes, industrial cleaners and antifreeze. It has been reported to be teratogenic in experimental animals. It can cause congenital malformations and increased resorption, and decreased fetal body weight in rats and rabbits[23].

It is not just those in the agricultural industry who are exposed to the effects of pesticides. Others exposed include those involved in the manufacture, transport, storage and sale of these products. With aerial spraying, others living nearby may also be at risk. Pet lovers are also exposed to pesticides such as carbaryl which is used on household pets. Some insect repellents are also hazardous, e.g. dibutyl phthalate which is found to be teratogenic when injected into the peritoneum of female rats.

Those involved in animal rearing are exposed to certain diseases like toxoplasmosis and brucellosis. Those

Table I
Some Chemicals Associated with Reproductive Hazards Following Occupational Exposure

Agent	Males	Females
Anaesthetic gases	Unknown	Abortion
? nitrous oxide ? halothane	? increased minor malformations	? Fetal growth retardation, stillbirth
Cytotoxic drugs	Unknown	Abortion, malformation
Stilboestrol	Loss of libido, impotence	Unknown
Lead	Oligospermia, abnormal sperm Morphology, decreased sperm Motility	Reduced fertility, abortion stillbirth
Manganese	Reduced libido, impotence	Unknown
Chlordecone	Oligospermia, reduced sperm Motility, abnormal sperm Morphology	Concentrates in milk
Carbaryl	Abnormal sperm morphology	Unknown

attending to the deliveries of the young or abortus of animals are at risk of brucellosis which itself can cause spontaneous abortions. One Irish study showed that 75% of farmers tested for antibodies to toxoplasmosis were found to have antibodies against this organism[24]. It can cause abortions, stillbirth, chorioretinitis or brain damage in the fetus.

Hazards to health care workers

In the course of their work doctors, nurses, laboratory technicians and those who remove hazardous wastes are exposed to a number of diseases. They may be transmitted through a needle prick, through the respiratory tract or by some other route like a break in the skin. Diseases like influenza, rubella and cytomegalovirus infections could result in abortion. Rubella carries the risk of congenital anomalies.

Doctors and nurses in the operation theatres are exposed to anaesthetic gases which are a reproductive hazard. A number of studies show that rates of spontaneous abortions in those exposed were higher than in those unexposed[13,14]. Some of the studies also show an association between exposure to anaesthetic gases and congenital malformations[15]. Pharoah *et al* showed an increased rate of only congenital heart diseases among anaesthetists whereas Corbett et al reported a raised incidence of minor congenital anomalies of skin and inguinal hernia[25].

Ionising radiation is used in industry and it is used in hospitals. The long-term effects of low dose exposure include sterility - temporary or permanent. An embryo is sensitive to injury from radiation in early pregnancy. Irradiation during major organogenesis (2nd to 6th weeks) may induce many types of malformations (seen in animal studies). After the 6th week, humans become less susceptible to malformations except that of CNS and the gonads. This was seen in the Japanese children whose mothers were exposed to the Hiroshima atomic blast. A peak in the incidence of microcephaly was seen in the Japanese children whose mothers had been exposed to the atomic explosion. However the dosages were probably higher than could be expected in occupational exposures.

Ionizing radiation is known to be mutagenic. It is associated with an increased risk of leukaemia in the offspring when the mother is exposed in pregnancy. There have also been reports of increased rates of certain childhood cancers seen in the children of mothers exposed to radiation during their pregnancies[17,18]. There have also been associated childhood cancers with paternal exposures.

Even in this day of mechanisation, some jobs involve strenuous physical activity, which is reported to produce menstrual disturbances. Dancers and athletes are known to suffer from amenorrhoea due to reduced hypothalamic function. Similarly strenuous activity has been associated with spontaneous abortions, preterm birth and low birth weight babies. Heavy lifting and long hours of work have also been associated with premature birth and dysmature babies. Prolonged standing while working has also been associated with intrauterine uterine growth restriction.

Those exposed to estrogenic substances or ones that have estrogenic properties can affect hormonal balance leading to adverse outcomes like infertility or abortions and altered sex ratios.

Male reproductive factors

Factors that cause male infertility or sterility affects a couple's ability to have children. Spermatogenesis takes place continuously which makes these germ cells susceptible to the effects of mutagenic agents. Carbon disulphide and organic lead has been reported to cause decreased libido and impotence. Male fertility is also dependent on the ability to maintain an erection and to ejaculate. Vinyl chloride has been shown to be associated with increased spontaneous abortions in wives of workers exposed to it[26]. DBCP (dibromochloropropane), a nematocide causes decreased sperm counts, testicular dysfunction and testicular atrophy. The prevalence was 20 - 25% of the male workers in a banana growing region in Costa Rica making a total of 1,500 workers affected[27].

Breast feeding problems

Breast feeding is another problem faced by working mothers. The milk supply varies as there are women who maintain adequate supply even with high pressure

jobs while others cannot. Fatigue and stress are two factors that affect milk supply. Certain fat soluble substances like organic solvents and organochlorine pesticides are secreted in breast milk. Polychlorinated biphenyls (PCB) have been known to be concentrated and secreted in breast milk[1]. There is one report of a baby that presented with jaundice whose mother regularly visited the dry cleaners at lunch time. The jaundice was attributed to carbon tetrachloride exposure[28].

Conclusion

When a women is affected by the workplace hazards, the child she is carrying or nursing is also affected in someway, temporarily of permanently, as she contributes largely to that child's environment. When mothers' health are affected, it can affect the health and quality of the next generation.

To want a child and not be able to have one can be quite distressing for the couple affected. Anything that could reduce this distress would definitely be worthwhile. Similarly to give birth after the long wait, to a child with deformities is also distressing. This does not take into account the difficulty in caring for the child or the pain of losing the child before he even becomes an adult. If working men and women were to talk freely about which potential workplace hazard worries them the most, disorders of reproduction would rank high if not the first on the list[29].

If these hazards were identified then preventive measures could be implemented. However attempting to specify the aetiology of poor pregnancy outcomes is not easy as many factors affect the developing fetus; namely the genetic factors and the environmental factors. Moreover a substance may not produce a uniform effect throughout pregnancy.

Sometimes pregnant women and women of childbearing age are excluded from certain jobs because of exposure to reproductive hazards. This may seem fair to protect the fetus but it is not an acceptable alternative to engineering control. By these exclusionary policies, women face loss of jobs, loss of pay, may have to settle for lower paid jobs, may suffer loss of seniority and other benefits. A women's income is important to her and her family. Losing this will affect the financial status and possibly the welfare of her family. It will also affect her self esteem. This is not justice for some of the hazards also affect men but they are not excluded from these jobs. Employers have a duty to their workers, be they male or female to protect them from the hazards of their work.

People should be made more aware of the true situation so that they can insist on the appropriate remedies to be implemented. What is needed is more research to improve our understanding regarding developmental biology.

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MCQs for Reproductive Problems of the Work Force

1. Regarding reproduction
   A. The harm that resulted from certain metals has only recently been realised.
   B. 90% of couples will conceive within 9 months of attempting a pregnancy.
   C. Fertilisation normally occurs in the fallopian tube.
   D. Infertility is mainly due to a female cause.
   E. Defective implantation may be helped by oestrogen therapy.

2. With regards to development in pregnancy
   A. The ovary is quiescent in the female fetus.
   B. The number of follicles in the ovary is determined in fetal life.
   C. Effects of teratogens usually occur by the 7th week of intrauterine life.
   D. Toxins have no effect during the 2nd and 3rd trimester.
   E. The fetal heart starts beating in the 8th week of intrauterine life.

3. The following have been implicated with toxicity in pregnancy
   A. Mercury
   B. Vitamin E
   C. Organochlorine
   D. Video Display Units
   E. Cadmium

4. With regards to workers and their reproductive health
   A. Doctors have a higher rate of abortions and congenital malformations.
   B. Anaesthetists have a higher risk of abortions compared to surgeons.
   C. X-rays must never be taken in early pregnancy.
   D. Children born to fathers exposed to high levels of radiation may develop malignancies in their childhood.
   E. Pregnancy itself poses an additional risk to some workers.

5. The following are associated with adverse effects on reproduction
   A. Driving
   B. Noise
   C. Vibration
   D. Physically tiring work
   E. Microwaves