MEDICAL CONSIDERATIONS WHILE FLYING PREGNANT: STARTING A CONVERSATION WITH YOUR OB-GYN

Every woman, and every pregnancy, is unique. Age, health, medical history, flight duties, and scheduling are a few factors to consider when deciding how far into a pregnancy a pilot should continue to fly. Some women are medically grounded upon discovering a pregnancy; others fly comfortably into the third trimester. In speaking to many women who have had children while employed as airline pilots, it is apparent that there is a dearth of guidance (and conflicting information) about when to stop flying. Put simply, in the United States, there is no agreement among the medical community, military, FAA, and airlines regarding the matter; foreign countries, on the whole, are far more restrictive. [1]

Unfortunately, because there are relatively few female pilots, few ob-gyns have worked with a pregnant pilot; many are simply unaware of what the day-to-day of the job really entails. If they had a better idea, they might alter their guidance accordingly. Piloting an airplane at 36,000 feet is different than working in an office and should be treated as such. Providing the female pilot and her physician medically-backed literature about issues specific to pregnant pilots (while leaving the ultimate decision about when to stop flying to her and her doctor) is a good first step in assisting both in making an informed decision.

The following information is meant to educate, not dictate. Advice for the long-haul international pilot should differ from advice for the senior, domestic line-holder. Whether you stop flying immediately or continue flying until the end of your pregnancy, the decision is up to you and should be made with the support of an educated physician. Please refer to your union's Aeromedical Committee for additional information.

[1] In line with the Pregnancy Discrimination Act, many US airlines (most recently Delta and American) have eliminated the requirement to stop flying by a certain point in the pregnancy, leaving the decision to opt out to the pilot and her doctors.

1. ***Nausea/Morning sickness***

   Nausea and vomiting are common in pregnancy (especially during the first trimester) and are often exacerbated by motion and triggered by odors. It is very difficult to focus on the task at hand while feeling nauseous (or while making multiple trips to the lavatory to vomit). A pregnant pilot is unable to control or escape the in-flight environment (from a passenger or crewmember wearing cologne, perfume, or deodorant or from the smell of oil or jet fuel) to feel better. Medications to treat the symptoms are not FAA-approved. While some women are sick at specific times during the day, others experience morning sickness without warning or throughout the day, making it difficult to bid a schedule to avoid times one might be affected.

2. ***Dehydration***

   As a normal pregnancy progresses, a woman has to urinate more frequently. Depending upon various factors (segment of flight, weather, delays, cabin service, etc.) it is not always practical to use the lavatory. A pregnant pilot may try to limit her fluid intake to minimize bathroom trips.[2] This natural tendency can lead to dehydration (or to the pilot "making up" for not drinking during flight by drinking more at night, negatively impacting quality of sleep).

   Dehydration during pregnancy can lead to serious complications: neural tube defects, low amniotic fluid, inadequate breast milk production, and even premature labor.[3]

3. ***Size of Abdomen***

   As the pregnancy progresses and the uterus expands, the size of the abdomen may interfere with emergency egress and flight control manipulation. Although women carry differently and size may not interfere in normal flight for many, pilots must always consider worst-case scenarios. Abnormal flight (windshear, upset recoveries, engine loss, rapid de-pressurization, wake turbulence, and other emergencies) may require full deflection of flight controls and impose G-loads. In the third trimester, even relatively mild trauma to the abdomen (from turbulence or inadvertent yoke impact) can cause placental abruption. (*Aviation, Space, and Environmental Medicine,* A10).

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[2] The adequate daily intake (AI) for water during pregnancy is 3 liters. (US Institute of Medicine)

[3] In addition to staying hydrated, maintaining a nutritious diet is key to fetal development. Maternal and infant nutrition "may modulate the immunologic development of the fetus and young infant and permanently alter immunologic and regulatory mechanisms, which may affect the risk for later disease." (Horvath Marques, et al., 8).

4. ***Cosmic radiation***

Cosmic radiation varies with latitude and altitude, increasing in altitude and over the poles and with solar flare activity. Aircrews are among those with highest exposure; long-haul crews especially are at risk. Cosmic radiation has been associated with increased risk of cancer, genetic defects that can be passed to offspring, mental retardation, congenital malformations, growth restrictions, Down syndrome, and miscarriage.[4] According to Dr. Robert Barish, infertility in female crewmembers may really be a repeated loss of embryos as a result of many early-stage exposures (1327).

Both the National Council on Radiation Protection and Measurements (United States) and the International Commission on Radiological Protection (Europe) recommend maximum annual exposure limit of 1 mSv for the general public and pregnant crewmembers.[5] The FAA agrees with the ICRP's assessment that a significant modification to work schedule (i.e. working short, low-altitude flights or grounding herself) would be required to keep a pregnant crewmember's exposure within established occupational limits.[6] In the EU this is law, whereas in the US it is merely advisory, not regulatory. (Barish 1328).

Radiation exposure from solar flares should also be considered. Every 11 years, the sun goes through a cycle, defined by an increasing and then decreasing number of sunspots. Cycle 24 peaked in April 2014; thus the immediate potential for a significant solar flare event is relatively low. NASA is currently developing an early warning system for solar flares. For real-time solar flare forecast data, see http://www.swpc.noaa.gov/products/3-day-forecast.

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[4] Studies suggest a statistically significant correlation between the number of hours a pregnant flight attendant works per month and the incidence of miscarriage. As compared with their peers who flew fewer than 64 hours per month, those who flew more than 74 hours per month were twice as likely to miscarry. The authors note flight attendants are exposed to circadian rhythm disruptions, fatigue, radiation, chemicals and viral infections. (Cone, par.1)

[5] The FAA has developed a computer program, CARI-6, to calculate the effective dose of galactic cosmic radiation to which flight crew members are exposed. To calculate your risk, refer to https://www.faa.gov/data_research/research/med_humanfacs/aeromedical/radiobiology/cari6/

[6] A 2015 study (Grajewski et al.) examined two million individual flights actually flown by flight attendants. During one of the solar particle events studied, the radiation dose reached 0.45 mGy *on a single flight.* (2% of the flight attendants had been exposed to a solar flare event.) Because of the inability to accurately predict solar flare activity, a crew member (without ever knowing it) could potentially exceed the recommended radiation dose for an entire pregnancy on a single flight-even while flying a modified schedule. NOTE: Because milligray (mGy) measures absorbed radiation and millisievert (mSv) measures equivalent radiation, they cannot be directly converted. Analyses suggested that cosmic radiation exposure of 0.1 mGy or more may be associated with increased risk of miscarriage in weeks 9-13.

5. ***Sleep***

Due to hormonal and physical changes, a woman needs more sleep when she is pregnant. Particularly during the third trimester, pregnancy-related hormones (progesterone, estrogen, cortisol, and oxytocin) markedly affect sleep quality. Studies show two-thirds of pregnant women suffer from sleep disorders; insomnia, restless legs syndrome, sleep apnea, noctural gastroesophageal reflux, and nighttime urination are common. (National Sleep Foundation 1 & 3). **Sleep deprivation** during pregnancy is associated with longer labor, higher cesarean rates, and higher levels of pro-inflammatory serum cytokines (linked to preterm labor and post-partum depression). (Chang 1). It may also cause long-term behavioral changes in children.[7]

Irregular airline schedules (long duty days, short layovers, sleep disturbances at hotels, international travel, "red eye" flights, etc.) negatively impact circadian rhythms and contribute to chronic sleep deprivation (which leads to errors eroding safety of flight). Moreover, according to several independent studies among flight attendants, sleep deprivation attributed to shift work[8] has been linked to a higher incidence of miscarriage[9], menstrual disorders, and cervical erosion. (Radowicka et al., 1).

6. ***Fatigue***

Especially during early pregnancy, hormonal changes (most notably increased progesterone) cause fatigue. Studies show an increase in sleep time and daytime sleepiness in the first trimester and a decrease in sleep time and increase in the number of nocturnal awakenings in the third trimester. (Chang et al. 3). The body produces more blood to carry nutrients to the fetus; blood sugar levels and blood pressure levels are lower.

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[7] Multiple studies found that maternal sleep deprivation affects the long-term health of the child. In rats, it has been linked to behavioral alterations in offspring (to include significant deficit in spatial memory and an increase in risk-taking, depressive, and anxiety-like behaviors). (Peng et al. 4-5)

[8] According to the International Agency for Research on Cancer, shift work (which disrupts normal sleep patterns and changes hormone levels) may cause cancer. (National Institute for Occupational Safety and Health, "Health," par. 4).

[9] A recent study indicated that flight attendants who flew more than 15 hours during normal sleep hours (for example, three domestic redeye flights or a single transatlantic trip) in the first trimester were at an increased risk for miscarriage. (Cone, et al.)

Cumulative and insidious, **fatigue** has been cited as a causal factor in many fatal airline accidents. Sleep deprivation due to airline schedules exacerbates the problem. [10]

7. ***Stress***

For the health of the mother and fetus, experts recommend avoiding stress while pregnant, but this is not always practical. Challenging weather conditions, diversions, pressure to be on-time, scheduling issues, mechanical irregularities, passenger concerns, recency of experience, and in-flight emergencies are a few of the stressors a pilot deals with on any given day (in addition to the challenges of working with unfamiliar crewmembers of differing experience levels and personalities every trip). A pregnant pilot must manage daily work-related stressors in addition to those pertaining specifically to pregnancy: managing bathroom breaks, fatigue, nausea, mental fog, and heightened emotional response due to surging hormones.

Stress during pregnancy has been linked to premature birth, miscarriage[11], and increased risk of birth defects and disorders (from schizophrenia, autism, asthma, and anencephaly to orofacial defects such as cleft lip or cleft palate).[12] There is strong evidence (human and animal data) that prenatal stress compromises the immune response of the child and can cause disease. (Horvath Marques, 1-7).

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[10] According to a US Air Force research team, a pilot awake for 17-18 hours can "expect performance at a level similar to 0.05 blood alcohol content." (315th Wing Safety and 437th MDG Human Performance Training Team). For an airline pilot at the end of an extended duty day (12 hours plus 2 hour extension plus time from wake up to arriving at airport to report for duty), this degradation in performance could coincide with the critical landing phase of flight.

[11] In response to stress, the body produces hormones (corticotropin-CRH- and urocortin among others) which target mast cells in the uterus. The local release of these hormones cause the mast cells to secrete substances that can cause miscarriages. The fetuses of women who had miscarried multiple times had significantly higher levels of CRH than those of women who had a single miscarriage or abortion. Previous studies found high levels of CRH in the bloodstream of women who delivered prematurely or who had low-birth-weight babies. (Madhappan et al.)

[12] Evidence suggests stress has long-term effects on the vaginal mucosal environment and may cause neurodevelopmental disorders in offspring.

> The neonate is exposed to the maternal vaginal microbiota during birth, providing the primary source for normal gut colonization, host immune maturation, and metabolism. These early interactions between the host and microbiota occur during a critical window of neurodevelopment, suggesting early life as an important period of cross talk between the developing gut and brain. Changes in the vaginal microbiome are associated with effects on offspring gut microbiota and on the developing brain. (*Endocrinology* 156: 3265).

8. ***Hypoxia***

During a commercial flight, an aircraft is pressurized from a given field elevation to 8,000 feet cabin altitude and back down to another field elevation upon landing. Pilots can fly upwards of 15-20 flights over a given four-day trip and typically operate 4-5 trips per month. The lower air pressure in the cabin causes heart rate and blood pressure to rise in order to accommodate the need for oxygen. Significantly for the pregnant pilot, physiological changes lead to an increased oxygen demand and greater stress on the heart and lungs.[13]

Maternal exposure to a persistently hypoxic environment may lead to preterm birth, fetal organ failure or death, or long-term disabilities (including cerebral palsy, hearing loss, and chronic lung disease). The main causes of pre-placental hypoxia are a hypoxic environment (high-altitude, hypobaric hypoxia) and pre-existing maternal cardiovascular disease. While a pregnant pilot cannot control genetics, she can limit hypoxic exposure by flying fewer trips or trips with fewer legs.

9. ***Circulation, Edema, Deep Vein Thrombosis, and Pulmonary Embolism***

The incidence of varicose veins is three times higher in women than men. Due to the expanding uterus compressing the venus cava, the risk of edema and blood clot formation increases substantially during pregnancy. For the pregnant pilot, the risk is compounded both by restricted mobility and increased estrogen levels (which adversely affect the body's ability to prevent blood clots). (ICAO III-7-2). Deep vein thrombosis and pulmonary embolism are among the most common serious vascular diseases occurring during pregnancy and account for the greatest number of maternal deaths.

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[13] According to International Civil Aviation Organization (ICAO), a medical examiner and pilot should consider the following the physiological changes associated with pregnancy on the safe operation of an aircraft:

> Cardiac output rises in early pregnancy, accompanied by an increase in stroke volumes, heart rate, and plasma. Haemoglobin and haematocrit begin to fall between the third and fifth month and is lowest by the eighth month. Progressive growth of the fetus, placenta, uterus and breasts, and the vasculature of these organs, leads to in increased oxygen demand. Increased blood volume and oxygen demands produce a progressive increase in workload on both the heart and lungs. Hormonal changes affect pulmonary function by lowering the threshold of respiratory center to carbon dioxide, thereby influencing the respiratory rate. In order to overcome pressure on the diaphragm, the increased effort of breathing leads to greater consciousness of breathing and possibly greater cost in oxygen consumption. The effect of hypoxia at increased altitude further increases the ventilatory effort required to provide for increasing demands for oxygen in all tissues." (ICAO III-7-3).

Sitting for prolonged periods increases the risk for lower extremity edema, thrombophlebitis, and deep vein thrombosis. Pilots, and especially pregnant pilots, should ambulate every hour or two.

10. ***Exposure to Viral Infections, Chemicals, and Illnesses***

The air conditioning system in most commercial aircraft (the Boeing 787 is the exception) works by tapping unfiltered bleed air from the engines. In some cases, the air may become contaminated by engine oil, resulting in a toxic fume event. Pilot and flight attendant unions in the US and abroad are aware of crewmembers and passengers suffering from long-term health issues (termed "aerotoxic syndrome") associated with these events. Multiple lawsuits by passengers and crewmembers have been brought against airlines and airplane manufacturers. No test currently exists to definitively prove inhalation exposure, but a research team at the University of Washington (with funding from US pilot unions) is working to develop such a test.[14]

Although fume events are rare, passengers and crew are routinely exposed to airborne pathogens and viruses present in recycled cabin air. Unfortunately, many passengers (and crewmembers) choose to fly while sick and may be contagious.

11. ***Limited Medical Response or Availability (in Flight and at Destinations)***

Pregnancy-related emergencies are most likely to occur in the first and third trimesters. If an emergency occurs in flight, obviously medical facilities and response are limited by the environment, location, and phase of flight. (For this reason, most airlines do not allow a pregnant woman to fly beyond 36 weeks, or 32 weeks if carrying twins.)

Pregnant crewmembers (especially those working long-haul, over-water flights) should be mindful of access to medical care during flight and also at destination cities. The pilot and her physician should also be aware of outbreaks (such as zika virus) which may be prevalent at international destinations. Access to clean drinking water on layovers should also be considered.

[14] For more information or to donate to the project, see the following: https://www.generosity.com/medical-fundraising/air-crew-passenger-health-research-toxic-oil.

12. ***Changes in Brain Structure***

During pregnancy progesterone and estrogen levels increase dramatically, affecting neurons in the brain. Hormones may affect spatial memory and the result is what is commonly referred to as "pregnancy brain."

Indeed, a recent study published in *Nature Neuroscience* showed pregnancy alters the structure of the brain in first-time mothers. MRIs revealed a reduction in gray matter in areas serving social cognition and also in the hippocampus (the region associated with memory). Two years later the gray matter loss remained (although the volume in the hippocampus was fully restored). Mothers with stronger attachment had more gray matter loss. A computer algorithm predicted with 100% accuracy whether a woman had been pregnant from her MRI scan. (Hoekzema et al.)

13. ***High-Risk Factors***

Pregnancies are considered high-risk for many reasons: history of multiple pregnancies, advanced maternal age, previous pre-term deliveries, cervical incompetence, bleeding, increased uterine activity, anemia, reduced placental respiratory reserve such as intrauterine growth retardation, post maturity, pre-eclampsia, chronic hypertension, placental infarction, placenta previa, ovarian cysts, gestational diabetes, etc. (Pilot Medical Solutions).

Your doctor may refer you to a perinatologist (a specialist in maternal-fetal medicine) to monitor your pregnancy.