Air travel and pregnancy - with reference to obstetric and perinatal aeromedical retrieval

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Introduction

There are a number of well accepted risks for the air traveller[1,2,3,4]. Although the risks are generally low for the healthy traveller, there are subgroups in the population that are at higher risk for developing complications as a result of the flight environment. Amongst these groups are the pregnant traveller and the neonate. Air travel during pregnancy is generally considered to be safe with little risk to the healthy pregnant women or her foetus[1,3]. In line with current guidelines[5] most airlines accept carriage of pregnant women up to 36 weeks gestation. There have been several studies showing that flight during pregnancy is safe[6,7]. Although it is generally accepted that the foetus is more safely transported in utero than as a neonate in an air-transportable incubator, there is at least one study that shows no significant difference in neonatal morbidity and mortality rates[8]. With the increasing use of aeromedical perinatal retrieval services it would be intuitive to assume there would be a corresponding decrease in perinatal and maternal mortality rates. However, it is difficult to conduct appropriate studies to investigate this area, and those studies that have been conducted have provided some surprising results. This article will appraise the safety of air travel during pregnancy. In addition, aeromedical retrieval during the perinatal interval is examined.

The safety of air travel during pregnancy

Anatomy and physiology of pregnancy

Pregnancy brings about significant changes in anatomy and physiology. The anatomical changes are due to the enlarging vascular uterus which steadily increases in size, displacing other organs as it rises from the pelvic bowl into the abdominal cavity. The mass effect of the uterus causes partial occlusion of the inferior vena cava, leading to diminished venous return to the heart. The lowered venous return causes a decrease in cardiac output and blood pressure (systolic and diastolic). There is often an accompanying minor rise in heart rate. The mass effect is positional and is most pronounced when the woman is supine. Manoeuvres such as rolling the supine patient fifteen degrees to the left will decrease some of the occlusive pressure from the uterus and facilitate venous return. The venous stasis in the lower limbs leads to oedema and predisposes to thrombosis. The enlarged uterus is also much more prone to trauma with potentially significant haemorrhage. Tidal volumes are decreased and the rate of respiration increases. Physiologically, there is also an increase in intravascular volume and anaemia secondary to hypervolaemic dilution. As a result of this the signs of shock in the pregnant woman appear later than usual – after the loss of 2 to 2.5 litres of blood[2,9,10].

Anatomical or Physiological change	Effect
Enlarged uterus	Vulnerable to trauma Aorto-caval obstruction Decreased venous return Lowered cardiac output Lowered systolic and diastolic BP Reflex tachycardia Lower limb oedema Predisposal to thrombosis Decreased diaphragm movement Decreased tidal volume Increased respiratory rate Increased frequency of micturition
Increased intravascular volume	Hypervolaemic dilutional anaemia Late appearance of shock
Increased renal excretion	May require increased doses of medication
Hyperemesis gravidarum & delayed gastric emptying	Prone to in-flight motion sickness Fluid and electrolyte disturbance
Raised white cell count	May confuse interpretation of investigations.

Table 1: Anatomical and physiological changes of pregnancy, as related to aeromedical transfer.

Possible air travel hazards for pregnant women

Physical confinement for prolonged intervals is commonly encountered during air travel. Thromboembolism is a common cause of morbidity and mortality amongst pregnant women. Prolonged immobility is associated with an increased risk for the development of deep venous thrombosis (DVT)[7] and dehydration is another commonly accepted risk factor. The hypobaric hypoxia encountered in flight is not thought to be prothrombotic[11,12]. The risk of DVT is thus not increased by the unique environment of flight, but rather it is due to the prolonged immobility that usually accompanies flight.

Another possible risk to the mother and her foetus is the hypobaric hypoxia encountered during flight. Typically, short haul flights will maintain a cabin pressure of 6,000 feet, whilst long haul flights maintain pressures of 8,000 feet. These cabin pressures reduce the alveolar partial pressure of oxygen to 73mmHg and 64mmHg respectively (compared to 103mmHg at sea level). At 8,000 feet, maternal haemoglobin remains 90 per cent saturated, even though the maternal PaO_2 is 64mmHg. The foetal PaO_2 remains virtually unchanged due to the increased oxygen carrying properties of foetal haemoglobin and the Bohr effect[1]. One study examining the oxygen saturation levels of healthy airline passengers showed that slightly over half (54%) had SpO_2 values less than 95% at cruising altitude, with a range of values between 85-98%[13]. The human foetus is thought to develop normally under low-oxygen conditions such as those encountered when pregnant women live at high altitude, maternal hyperventilation helping to maintain arterial oxygenation[7]. A study conducted amongst women living at high altitude for a prolonged interval demonstrated lower neonatal birth weights[14]. There is a significant difference in the length of exposure to hypobaric hypoxia between the pregnant women living at altitude for months and the pregnant passenger, in the air for several hours.

Radiation exposure is also known to be increased with air travel[1]. In general, the higher the latitude or the flight level, the greater the exposure. The mother and her foetus are both exposed during air travel; however the radiation dose is usually 0.005 to 0.01 mSv per hour and the cumulative dose is thus negligible when compared to the annual maximum permissible dose for pregnant flight crew (US) of 1mSv. The pregnant air traveller would have to complete 100 to 200 hours of flying to even approach the permissible safe dose.

Does air travel affect pregnancy outcome?

Despite the significant changes in anatomy and physiology in the gravid female there are multiple studies that find few, if any, harmful effects. Air travel during pregnancy does not seem to pose a significant risk to the pregnancy[6,7]. These studies show minor variations in findings, which were usually not reproducible in another study.

One study involved a sample group of 222 pregnant women and concluded that there was no correlation between adverse outcomes, hours spent travelling by air or the gestational age at the time of travel[6]. Importantly, this study showed no correlation between gestational age at delivery, neonatal birth weight, rates of vaginal bleeding, preterm delivery (less than 37 weeks), preeclampsia, neonatal intensive care admission or cumulative adverse obstetric outcome.

No effect[6,7]	Possible effect[7,15]
Gestational age at delivery[6] Neonatal birth weight[6] Incidence of vaginal bleeding[6,7] Preterm delivery[6] Preeclampsia[6,7] Neonatal intensive care admission[6] Caesarean section rate[7] Neonatal death[7] DVT[7]	Increased risk of preterm (34 to 37 week) delivery in primiparas only[7] Slight increase in spontaneous abortion rates when exposed to flight in early pregnancy[15]

Table 2: The effects of air travel on pregnant women.

Another larger study group involved 546 healthy women who flew during pregnancy[7]. There were 447 women in a separate control group. The study group women flew for the first time in the pregnancy at a gestational age of 11.2±2.2 weeks, with average flights lasting 7.8±1.2 hours. The women had a median of seven flights. This study showed differences between outcomes for primigravid and multigravid women. Air flight amongst primigravidae was associated with an increased risk of preterm births at 34-37 weeks gestation. Gestational age at delivery was 36.1±0.8 weeks, with lower birth weights (2684±481 g) compared with the controls (39.2±2.1 weeks; 3481±703 g). (The lower birth weights were commensurate with gestational age.) Among the primigravidae, a relationship was found between gestational age at delivery and gestational age at first air travel and total hours airborne. No such relationship was shown among the multigravidae who travelled by air. Overall, the groups did not differ in the incidence of more serious complications, including risk of vaginal bleeding, preeclampsia, caesarean birth, or birth asphyxia/neonatal death. Further, no individual variable was significantly or independently associated with adverse neonatal outcome when results were corrected for maternal age, race, parity and the trimester at the time of air travel[7]. In addition there were no cases of DVT in this study. This suggests that DVT is no more common in pregnant women who have flown than those who have not. However it may also reflect increased awareness of the risk of DVT, and that pregnant air travellers are taking heed of the standard advice to remain active in flight, avoid alcohol and remain well hydrated.

Figure 1: In flight advice on DVT prevention is now routinely given by commercial carriers, often preceding the in-flight entertainment. Photo J. Stephenson (QANTAS B747 flight – with permission)

Whilst these studies have shown only minor or nil effects, attention should be drawn to a retrospective cohort study conducted amongst Finnish flight attendants who had worked during early pregnancy. There were 1751 eligible pregnancies eligible for analysis. Flight attendants who worked during early pregnancy had a slightly elevated risk of spontaneous abortion, as compared with attendants who were pregnant outside a time span of active flying[15]. Whether this single study reflects a definitive finding will only be determined by further studies, each correctly designed using appropriate cohorts, with longitudinal follow-up to minimise bias.

In summary, air travel for the pregnant traveller is safe, and this is summarised in two recommendations by the American College of Obstetrics and Gynaecology (ACOG) Committee on Obstetric Practice. The first ACOG recommendation states that pregnant women at significant risk for preterm labour or with placental abnormalities should avoid air travel1[6]. The second ACOG recommendation states that pregnant women can safely fly up until 36 weeks of gestation[5]. Most commercial airlines have guidelines which are similar to the ACOG recommendations, with some permitting domestic travel until 36 weeks and international travel until 35 weeks gestation.

Aeromedical transfer – unborn foetus or neonate

Background

Acute antenatal aeromedical transfer is an accepted means for providing specialist perinatal and obstetric care[17]. The alternative is local delivery and postnatal transfer of the neonate and the mother. In countries such as the USA, aeromedical transport services were often commenced with the intention of bringing neonates to tertiary level centres. Over time it was realised that the early transport incubators were less than ideal, and that the mother was the ideal "incubator". The end result was the commencement of aeromedical transfers whereby the gravid woman was brought to specialised neonatal and obstetric centres[2]. There have been numerous studies examining and comparing each mode of transportation, with the majority of studies showing that transport of the foetus in-utero produced better outcomes. This practice has now been accepted as the preferred transport option, and is recommended by various bodies including the British Association of Perinatal Medicine and Clinical Standards Advisory Group on neonatal transfers[18,19]. In September 2004, the British Thoracic Society recommended that when possible, healthy term babies should not fly in the first week of life. In addition, they recommended that premature babies, who have had complications, probably should not fly on commercial flights until 6 months after their due dates, due to the increased risk of apnoeic episodes[20]. (Fact box A contains a list of those maternal groups most commonly transported. Fact box B contains a specific list of conditions.)

Fact Box A - Which maternal patient groups do we transport

- The goal is to transport only one patient-the mother-prior to delivery.
- Studies on fixed wing and rotary wing aeroretrieval patients revealed that the two commonest reasons for transfer were:
  1. Premature labour or Preterm labour (PTL); and,
  2. Third trimester vaginal bleeding.
- To this should be added a third group (from Royal Flying Doctor Service experience),
  3. The elective transfer of "high-risk" patients to tertiary centres.

Fact Box B - Specific obstetric disorders commonly transported

Vaginal bleeding

- Causes include infection, miscarriage and hormonal. All are common in early pregnancy.

PTL (Pre-Term Labour)

- Can be the primary reason for the flight and may occur during flight.

PROM (Premature Rupture of Membranes)

- PTL +/-precipitous delivery.
- Predisposes to infection.

Precipitous delivery

- Not always predictable.

Pre-eclampsia and eclampsia

- Pregnancy Induced Hypertension (PIH) can then lead on to eclampsia.

Amniotic fluid emboil

- Cause Pulmonary emboli (PE) and Cerebrovascular accidents (CVA).
- Major cause of Disseminated Intravascular Coagulation (DIC).

Malpresentation

Infection

- Amnionitis

Flight issues

Aeromedical transportation of the gravid female is usually safe for both mother and foetus[1,2]. The single most feared complication when transporting the gravid female is in-flight delivery and subsequent resuscitation of a distressed, and often premature neonate[21]. Fortunately this is a rare event with very few in-flight births occurring[22,23]. At standard cabin pressures, the maternal inspired concentration of oxygen (FIO2) is adequate to meet the demands of both mother and the foetus. In cases where the mother or the foetus is distressed, the mother should be given supplemental oxygen during the flight[2]. Aeromedical evacuation staff should err on the side of providing oxygen if any doubt exists.

The most commonly encountered in-flight complications during in-utero transfer, were nausea and vomiting. The frequency of contractions was also significantly increased. Other complications such as hypertension, hypotension and decreased maternal respiratory drive were relatively uncommon[24].

Supporting and conflicting studies - in-utero transportation versus neonatal transportation

Many studies have concluded that neonatal morbidity and mortality in infants delivered after in-utero transfer is less than in infants transferred after delivery[25-31]. Some authors have reported no significant improvement in outcomes[8]. Others have ascribed the differences to confounding variables, such as birth weight and gestation at delivery[32], or different work practices[33,34] as likely factors to explain the findings. The absence of an appropriate control group may also offer an explanation[17].

Some benefits of transferring a high risk foetus in-utero rather than delivering locally include: increased infant survival rates, higher five minute APGAR scores (which reflect an infant in better condition and probably lower morbidity), shorter hospital stays, and enhanced mother-child bonding[23]. In addition, there has been a claim that the transfer of the high risk foetus in-utero (by rotary wing transfer) is cost effective[23].

Whilst some studies have concluded that there are benefits to transferring the foetus in-utero, other studies have reached equivocal or negative conclusions. One study concluded that neonatal survival following local delivery with or without postnatal transfer is the same as for antenatal transfer[17].

Figure 2: An older style foetal incubator. This model could operate utilising 120V AC, 12 or 24 V DC power and was certified for aeromedical transfer use.

In-utero	Neonate	No difference
Pre-term rupture of membranes. Preterm labour. Pre-eclampsia. Lower mean birth weight. Lower gestational age.	Placental abruption more common in mother. Decreased administration of corticosteroids.	Neonatal mortality. Respiratory distress syndrome. Intraventricular haemorrhage. Necrotising enterocolitis. Persisting ductus arteriosus. Septicaemia.

Table 3: In-utero and neonatal transportation are associated with different patterns of infant and maternal morbidity. A summary of the more likely patterns of morbidity found in the in-utero group and the neonatal transfer group. The third column is a list of complications that could occur regardless of whether the infant had arrived in-utero or as a neonate. (Based on Hauspy et al)[35].

A 12 month study conducted in the Northern Region of the UK, involving 129 transfers, revealed some remarkable results[17]. The study highlighted that a large number of infants transported in-utero *remained* undelivered at the receiving hospital with 24% of mothers either being discharged home or transferred back to the referring unit. Further, many of those infants who had been transferred in-utero, and whose mother was in active preterm labour, did not actually require intensive care admission (only 31% of women in preterm labour). Possible explanations for these facts would include: that the transfer was performed as a logistic exercise (bed capacity issue), that the initial assessment at the requesting facility was inadequate or incorrect, or that there simply was good obstetric care at the receiving institution. All of these possibilities certainly make valid (and statistically significant) analysis all the more difficult.

In Australia there are vast distances between rural and outback communities and tertiary-level neonatal and obstetric centres. This contrasts with the aeromedical transfer experience in many other parts of the world, including the UK and Europe, where most intrauterine and neonatal transport occurs over a relatively short distance[35]. Due to these vast distances in Australia, there is often elective transfer of pregnant women from remote areas to urban areas at 36 weeks of gestation. Pregnant women who are thought to be at risk for developing obstetric complications, and those identified as high-risk for social reasons are amongst those electively transferred. (Fact box C contains a list of those patients who may be electively transferred at 36 weeks gestation.)

Fact Box C - Elective Fixed Wing transfer of "high risk" patients

These patients are moved electively to tertiary centres at 36 weeks gestation for a variety of reasons - the patient is not so much high risk in some cases, but is an unknown quantity. Subgroups would include:

- Previous poor outcome - foetal death or significant maternal complications.
- Scant or absent antenatal care (ANC).
- No local birthing service.
- Significant intercurrent disease - diabetes mellitus, infections, poor nutrition, alcoholism.
- Social reasons - risk of child/mother abuse by partner, possibility of abandonment of newborn.
- Patient is markedly remote from any medical care.

In summary, it would appear that the consensus opinion is for the transfer of the foetus in-utero, and this is reflected in the conclusions of the majority of studies. There are a significant number of transfers that result in the gravid women not delivering, and even being returned to the referring institution. In addition, the majority of neonates delivered at the tertiary institution do not require neonatal intensive care. Whether this is due to the timely transfer in-utero or poor patient selection is not clear. Whilst the studies would seem to support in-utero transport as the preferred option, the limitations of the studies to date need to be borne in mind – most of the studies involve short distance aeromedical transfer, and there is ongoing difficulty in most of the studies with providing appropriate control groups for comparison. (Fact box D lists contra-indications for obstetric aeromedical transportation.)

Fact Box D - Contradictions for aeromedical transfer od obstetric patients

(Note there are no absolute contra-indications to aeromedical transfer.)

- First trimester
  1. Uterine bleeding (with cramping).
  2. Suspected ruptured ectopic.
- Second and third trimester
  1. Active labour.
  2. Uterine bleeding.
  3. Cervix>4 cm dilated.
  4. Incompetent cervix, untreated.
  5. Severe pre-eclampsia.
- Postpartum
  1. Heavy vaginal bleeding.

The impact of aeromedical retrieval on perinatal mortality.

Background

The perinatal interval is defined by the World Health Organisation as the interval from 24 weeks gestation (or 500g) to 28 days neonatal life. In other countries, such as South Africa, the perinatal interval commences with foetal viability (28 weeks or 1000 g) and ends at the end of the seventh day after delivery. Perinatal deaths are the sum of stillbirths plus early neonatal deaths occurring within this interval. The perinatal mortality rate (PNMR) is expressed as the number of deaths per 1000 births. The PNMR is the most sensitive indicator of obstetric care[36]. For developed countries the rate for babies over 1000g is usually less than 6/1000 births, whereas for developing countries PNMR ranges from 30-20036. The first generation of rotary wing aeromedical retrieval services commenced in the 1970's. The second generation was developed and refined in the 1980's. Many of these services originally commenced with the intention of transferring critically ill neonates. The aeromedical transfer of the in-utero foetus and neonate (in an incubator), remains commonplace. Aeromedical transfers are resource intensive and require considerable organisation - consuming the time of nursing and medical staff[37]. It would be intuitive to hypothesise that these transfers should lower mortality rates.

Studies on perinatal mortality following aeromedical retrieval

Acute antenatal transfer to specialist centres is relatively commonplace; however there is a paucity of data on the pregnancy outcome[17]. Several studies have claimed that infants of high risk patients born after the mother has been transported via aeromedical services (to a tertiary neonatal centre) have lower mortality rates[26,28,38]. A large study over a one year interval in the UK, involving 120 transfers, concluded that neonatal survival (and hence mortality) following local delivery with or without postnatal transfer was the same as that following antenatal transfer (to a specialist centre)[37]. Another very large study involving 800 transfers highlighted that many neonatal transfers were being performed from one area to another as there were bed shortages at the originating medical facility. In a significant number of cases, neonates were transported from similar secondary and tertiary level centres to another – so called "capacity transfers"[37]. This study highlighted the lack of capacity within the region's neonatal service. The performance of multiple elective perinatal aeromedical retrievals for capacity reasons alone will dilute any data that may support the notion that perinatal retrieval *actually* lowers mortality rates.

There is a paucity of studies that precisely analyse whether aeromedical retrieval services influence perinatal mortality rates. A confounding factor in any study of regional perinatal mortality rates was highlighted in one study from northern Australia which correctly pointed out that local perinatal mortality rates were probably improved as the result of aeromedical transfer of the high risk mothers and premature or sick neonates[39]. The corollary of this statement is that perinatal mortality is likely to be increased in the tertiary centre receiving the aeromedical transfer. Again it would be correct to state that it is difficult, if not impossible to design studies that have appropriate controls for these circumstances.

Conclusion

Air travel during pregnancy is accepted as being safe. There are caveats which apply to the acceptance of pregnant women for regular air services, and these are summarised in position statements from several sources. There appears to be a consensus that in-utero aeromedical transfer is preferred to transfer of the newborn neonate in an incubator. This policy has probably resulted in increased maternal and neonatal survival with an accompanying decrease in morbidity. Whilst this policy would appear to be sound, it is correct to point out that there are studies which conflict with this assertion. In addition, the aeromedical transportation comes at a considerable financial cost and is labour intensive. Some studies have highlighted that many aeromedical transfers are being performed for reasons of bed capacity, rather than for clinical reasons. The success of in-utero transport is difficult to assess due to problems in designing appropriately controlled studies. This same problem with study design is further highlighted when evidence for the lowering of perinatal mortality via aeromedical transfer is sought. With time further studies will help to clarify this situation.

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