Abstract
Management of hyperglycaemia is crucial during labour to improve outcomes both in the newborn and in the mother. This is particularly crucial in mothers with pregestational type 1 diabetes and in all mothers requiring insulin treatment during pregnancy.

The use of antenatal steroids in mothers at risk of preterm delivery complicates management of hyperglycaemia in the immediate antepartum period and requires appropriate dosing adjustments of insulin therapy.

Mothers are generally asked to be nil per orum during active labour. This requires appropriate fluid, glucose and insulin management in the hours leading on to the delivery of the baby. If the woman undergoes an operative delivery then patients continues to require glucose insulin infusion till patient is able to eat and drink normally.

This review focuses on the management of hyperglycaemia during labour and in the immediate postpartum period. A dosing schedule for women who receive steroids in the antepartum period is also discussed. The review suggests a practical glucose insulin regimen that can be followed during active labour in women who are nil orally. Lastly the review discusses immediate postpartum management in these women as well.

Keywords: Diabetes Mellitus, Pregnancy, Labour, Antenatal Steroids, Intra-partum.

Introduction
The requirement of insulin in the intrapartum or the postpartum period is very rare in women with gestational diabetes. The need for insulin is resolved due to the decreased insulin resistance with the delivery of the placenta. In women with pregestational type 1 or type 2 diabetes the insulin requirement during active labour decreases to some extent compared to previously. Following delivery of the placenta the insulin requirements drop to over 50% in type 1 diabetes and even further in type 2 diabetes mellitus.

The most important aspect of managing diabetes in the mother during labour is to avoid hyperglycaemia as this leads to an increased risk of acidaemia and complications in the newborn in addition to the risk of hypoglycaemia in the newborn after delivery. This review focuses on the management of hyperglycaemia during labour and the immediate postpartum period.

Intra-partum Care
Timing and Mode of Delivery
Pregnant women who are diagnosed of diabetes are typically delivered earlier than term to decrease the danger regarding intrauterine death. However with better obstetric care or foetal monitoring, obstetricians do wait to term in some pregnant women with diabetes. Pregnant women together with infants who are in the normal growth curve (documented with serial ultrasounds) should be offered to be sent into labour or if a caesarean section is required then to time it at 38 weeks of gestation. There should be no reason why the presence of diabetes should contraindicate an attempt at vaginal birth in women who have had a preceding normal delivery. Even if there is a presence of macrosomia as detected on ultrasound findings, the women should be encouraged to undergo vaginal delivery as it has its added benefits as compared to an operative intervention. A pre-anaesthetic assessment prior to elective or emergency operative delivery is mandatory in all women who are diagnosed to have diabetes.

Antenatal Steroid Use
Antenatal steroids reduce the risk of hyaline membrane disease and associated respiratory distress in mothers at risk for preterm delivery. This is due to the improving lung maturation in the preterm offspring. Glucocorticoids increase lung surfactant production in foetal lungs and hence further improve outcomes. Insulin and hyperglycaemia decrease the surfactant production in the foetal lung. The lung maturation lags of about 2 weeks in preterm babies born to mothers with diabetes. Antenatal steroid use reduces the risk of foetal respiratory distress but use of steroids results in further deterioration of hyperglycaemia and insulin resistance taking the increase of insulin by 20-40%. A protocol developed by Prof
Donald Pearson at the Aberdeen Maternity Hospital, which we have been following in our patients, is being shared.1

Dexamethasone dosing; Day 1: 2 doses of 6 mg 12 hours apart and Day 2: 2 doses of 6 mg 12 hours apart

Betamethasone dosing; Day 1: 12 mg and Day 2: 12 mg

In patients with gestational diabetes mellitus treated by diet ± Metformin

- Women should continue with their normal diet and omit Metformin.
- Monitor meter glucose BB (Before breakfast), B2 (2 hours after Breakfast), BL (Before Lunch), L2 (After Lunch), BD (Before Dinner), D2 (After Dinner), Bbed (Before Bed), and at 2am, 4am.
- If glucose is over 140 mg/dl repeat after one hour. If still over 140 mg/dl inform obstetric medical staff who can prescribe subcutaneous (SC) insulin
- Initial SC insulin regime: Injection Aspart (or other quick acting insulin) 4 units BB, BL and BD, NPH Insulin (intermediate acting insulin), 4 units at bedtime. Warn the patient about the potential for hypoglycaemia. Stop SC insulin if glucose < 70 mg/dl.
- Contact the Diabetes Team to review the patient (that day up till 9pm or first thing the following morning).
- If pre or postprandial glucose >180mg/dl, and/or persistent ketonuria, and/or blood ketones > 0.6 mmol/l, despite correction doses of SC insulin, switch to the intravenous dextrose /insulin protocol described later.

Gestational diabetes mellitus already on insulin or type 2 DM on insulin

- Monitor blood glucose as above
- Insulin dose adjustment to address insulin resistance (Table-1)
- If pre-prandial glucose >140 mg/dl give 2 units additional to the calculated dose
- Diabetes team to review that day up till 9pm or first thing next morning. Diabetes team will visit daily.
- If pre or postprandial glucose >180 mg/dl, and/or persistent ketonuria, and/or blood ketones > 0.6 mmol/l despite correction doses of SC insulin switch to the intravenous dextrose /insulin protocol.

Type 1 diabetes mellitus

- Monitor meter blood glucose BB, B2, BL, L2, BD, D2, Bbed, 2am, 4am*
- Insulin dose adjustment to address insulin resistance (Table-1)
- If pre or postprandial glucose >180 mg/dl take 4 units in addition to the calculated dose or as advised by the diabetes team.
- If pre or postprandial glucose >140 mg/dl, and/or persistent ketonuria, and/or blood ketones > 0.6 mmol/l despite correction doses, switch to the intravenous dextrose /insulin protocol.

Management of Blood Glucose During Labour

Studies of normal pregnant women during active labour suggest that glucose turnover increases fourfold with little or no change in circulating insulin levels.9 This strongly suggests that muscle contraction related glucose uptake in both uterine and skeletal muscles, independent of insulin, is the predominant determinant of glucose utilization during labour.10

The goal of intra-partum treatment of women with diabetes is firstly to maintain normoglycaemia to prevent neonatal hypoglycaemia.11 Secondly in type 1 diabetes insulin and glucose infusions are required to prevent metabolic de-compensation and ketogenesis during active labour or surgery when the patient is fasting.12 Target glucose values during labour to prevent neonatal hypoglycaemia, between 4-7 mmol/L (70-120mg/dl).13

Table-1: Insulin dosing in patient administered steroids that are already treated with insulin.

<table>
<thead>
<tr>
<th></th>
<th>BB</th>
<th>BL</th>
<th>BD</th>
<th>Bed</th>
</tr>
</thead>
<tbody>
<tr>
<td>First day of steroids</td>
<td>Usual dose</td>
<td>Usual dose</td>
<td>Usual dose</td>
<td>Increase by 25%</td>
</tr>
<tr>
<td>Day 2</td>
<td>Increase by 40%</td>
<td>Increase by 40%</td>
<td>Increase by 40%</td>
<td>Increase by 40%</td>
</tr>
<tr>
<td>Day 3</td>
<td>Increase by 40%</td>
<td>Increase by 40%</td>
<td>Increase by 40%</td>
<td>Increase by 40%</td>
</tr>
<tr>
<td>Day 4</td>
<td>Increase by 20%</td>
<td>Increase by 20%</td>
<td>Increase by 20%</td>
<td>Increase by &gt;20%</td>
</tr>
<tr>
<td>Day 5</td>
<td>Increase by 10%</td>
<td>Increase by 10%</td>
<td>Increase by 10%</td>
<td>Increase by 10%</td>
</tr>
</tbody>
</table>

* BB - before breakfast, B2 - 2 hours post breakfast, BL - before lunch, L2 - 2 hours post lunch, BD - before dinner, BD - 2-2 hours post dinner, Bbed - before bed, 2am and 4am early morning.
Starting dextrose infusion
Commence dextrose infusion via intravenous access at 50ml/hour of 10% dextrose solution using an infusion pump. Potassium Chloride (KCL) supplementation is generally not required but can be added onto the 10% Dextrose solution based on the treating physicians discretion. Baseline serum potassium should be measured and if the infusion continues for more than twelve hours it should be rechecked.

Starting insulin infusion
Start insulin infusion with soluble human insulin by diluting 50 units of insulin in 49 ml of 0.9% saline (i.e. 1 Unit = 1 ml) in a 50ml syringe pump. Starting insulin doses are based on capillary plasma glucose (CPG) at onset of infusion

<table>
<thead>
<tr>
<th>CPG levels</th>
<th>Rate of start of Insulin infusion</th>
<th>Measure CPG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 120 mg/dl (7 mmol/l)</td>
<td>Withhold insulin Continue Dextrose</td>
<td>2 hours</td>
</tr>
<tr>
<td>120-140 mg/dl (7-8 mmol/l)</td>
<td>Start at 1 unit/ hour i.e. 1 ml/hour.</td>
<td>2 hours</td>
</tr>
<tr>
<td>Higher than 140 mg/dl (8 mmol/l)</td>
<td>Start at 2 units/hour i.e. 2 ml/hour.</td>
<td>1 hour</td>
</tr>
</tbody>
</table>

Maintaining insulin infusion
Adjust the insulin infusion rates based on periodic monitoring of capillary plasma glucose (CPG) levels

<table>
<thead>
<tr>
<th>CPG levels</th>
<th>Action</th>
<th>Next check of CPG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher than 260 mg/dl (15 mmol/l)</td>
<td>Give 4 ml (4 Units) bolus</td>
<td>In 1 hour</td>
</tr>
<tr>
<td>120-260 mg/dl (7-15 mmol/L)</td>
<td>Increase infusion rate by 1 unit/hour</td>
<td>In 1 hour</td>
</tr>
<tr>
<td>90-120 mg/dl (5-7 mmol/L)</td>
<td>Increase infusion rate by 1 unit/hour</td>
<td>Continue same rate</td>
</tr>
<tr>
<td>No increase in rate in last hour</td>
<td>Decrease insulin rate by 1ml/hour (1 unit/hour)</td>
<td>Recheck every 1 hour, if stable for 3 hours, recheck every 2 hours</td>
</tr>
<tr>
<td>Higher than 140 mg/dl (8 mmol/l)</td>
<td>Decrease insulin rate by 50%</td>
<td>In 1 hour</td>
</tr>
<tr>
<td>70-90 mg/dl (4-5 mmol/L)</td>
<td>Decrease insulin rate by 50%</td>
<td>Stop infusion</td>
</tr>
<tr>
<td>Blood glucose less than 70 mg/dl (4 mmol/dl)</td>
<td>Give 50ml bolus of 10% dextrose</td>
<td>In 15 minutes</td>
</tr>
</tbody>
</table>

On delivery of placenta
Reduce infusion rate by 50% on delivery of placenta and continue as per above till patient has first meal following birth. Subcutaneous insulin should be administered with the first meal and the infusion can be discontinued after 20 minutes of the subcutaneous injection.

Most published protocols of intra-partum management of hyperglycaemia recommend a low dose insulin infusion with dextrose.14-17 Most of the recommendations are based on case series and observational studies. A low dose insulin and dextrose infusion protocol is given in Table-2.

* Type 1 Diabetes Mellitus
Women with type 1 diabetes require insulin and dextrose for active labour and during caesarean section. The target is to keep the capillary glucose values between 4-7 mmol/l (70-120 mg/dl). In the event of elective induction of labour (IOL) or caesarean section continue regular glucose monitoring and insulin till the patient is asked to commence fasting. Reduce nighttime long acting insulin by 50% of the night prior to the planned fasting. Upon start of fasting commence on an insulin-dextrose infusion as per Table-2. In the event of an emergency caesarean section or spontaneous labour insulin-dextrose infusion (Table-2) should be started once the obstetrician/anaesthetist decides that the patient is to be kept on an empty stomach. On delivery of the placenta the insulin infusion rate should be reduced by 50% and the insulin-dextrose infusion continued until the first meal.
meal after birth.

- **Type 2 Diabetes Mellitus**
  Blood glucose targets are similar to patients with type 1 diabetes and should be kept between 4-7mmol/L (70-120 mg/dl). Some women with type 2 diabetes may require insulin during labour and surgery. On the evening prior to elective surgery or IOL, omit the oral agents including metformin. Basal insulin doses can be given at half the usual dose on the night before. With onset of fasting, blood glucose should be checked every 2 hours and if values are higher than 120 mg/dl on two occasions commence on insulin-dextrose infusion as per Table-2.

- **Gestational Diabetes Mellitus**
  Blood glucose targets are similar to that in women with type 1 and type 2 diabetes (i.e. 72-126 mg/dl) (4-7 mmol/L). Rarely is insulin required during delivery or surgery. However if blood glucose values stay above 126 mg/dl (7 mmol/L) the insulin-dextrose infusion can be commenced.

**Post-Partum Metabolic Management**

The insulin requirements fall dramatically at the time of delivery, and occasionally no insulin may be required for a few hours. In patients with type 1 diabetes reduce the insulin infusion by 50% soon after delivery of the placenta and the planned post-partum dose of subcutaneous insulin given with the first post-delivery meal. Insulin and dextrose infusions can be stopped 20 minutes after administration of subcutaneous insulin. In patients with type 2 diabetes and gestational diabetes requiring insulin dextrose infusion during labour the infusion can be stopped soon after the delivery of the placenta. It is highly unlikely that patients who did not require insulin during pregnancy, will do so after delivery.

**References**