Original Article

Adverse pregnancy outcomes with respect to treatment modalities in women with gestational diabetes mellitus at a rural tertiary care teaching hospital

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Abstract

Objectives: To estimate the prevalence of gestational diabetes mellitus (GDM) and compare adverse pregnancy outcomes with respect to treatment modalities in a peri-urban teaching hospital in Telangana. **Methods:** A prospective study was conducted on GDM cases delivered from January 2019 to March 2020. GDM was diagnosed using a two-step procedure of screening using IADPSG criteria. Women diagnosed with GDM were divided into four groups – diet group, metformin group, metformin plus insulin group and insulin group based on the treatment modalities. Adverse pregnancy outcomes of the women managed with different treatment modalities were recorded. **Results:** Good glycaemic control (FBS, $P = 0.04$, 2 hrs PLBS, $P = 0.01$) was achieved in diet and metformin groups. Incidence of Gestational hypertension ($P = 0.01$) and preeclampsia ($P = 0.01$) were found to be higher in the insulin group when compared to the metformin and insulin group, metformin group and diet group. No difference was noted with respect to polyhydramnios, preterm birth, premature rupture of membranes, induction labour and caesarean delivery rates between the treatment groups. Apgar score at 5 min of <7 ($P = 0.02$), neonatal intensive care unit admissions for >24 hrs ($P = 0.03$) and neonatal hypoglycaemia ($P = 0.01$) were found to be higher in insulin-required groups. Rates of shoulder dystocia, stillbirth, early neonatal death within 1 week and respiratory distress did not vary significantly between the treatment groups. **Conclusion:** Universal screening of women for GDM and multidisciplinary management of women once diagnosed tend to lessen maternal and fetal complications. Metformin can be an effective, cheaper and non-invasive alternative to insulin in the management of GDM.

Keywords: GDM, insulin, metformin, pregnancy

Introduction

Gestational diabetes mellitus (GDM), defined as a state of hyperglycaemia that is first recognised during pregnancy, is currently the most common medical complication in pregnancy.[1] It is estimated that 21.1 million, or 16.7% of live births to women in 2021, had some form of hyperglycaemia in pregnancy. Of these, 80.3% were due to GDM, while 10.6% were the result of diabetes detected before pregnancy, and 9.1% were due to diabetes (including type 1 and type 2) first detected in pregnancy.[2] In the South East region, prevalence rates of GDM are estimated to be 25.9%, which is much higher than in the West.[2]

GDM is associated with increased maternal and neonatal morbidity and mortality. Maternal morbidity is due to induction of labour, operative delivery and perineal trauma. High fasting blood glucose and insulin requirement during pregnancy are

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Table 1: Maternal sociodemographic variables

	Diet *n*=37	Diet + metformin *n*=48	Diet + metformin + insulin *n*=31	Diet + insulin *n*=12	Total (128)	*P*
Age in years (mean)	26.04±4.17	26.4±4.7	26.4±4.22	25.89±4.29		
Number of women with age >30 yrs (elderly)	4 (10.8%)	3 (6.25%)	5 (16.1%)	5 (41.6%)	17 (13.2%)	0.0001
Booked	36 (97.3%)	43 (89.6%)	26 (83.9%)	9 (75%)	114 (89%)	0.09
BMI ≥25 kg/m^2 (obese)	3 (8.1%)	16 (33.3%)	21 (67.7%)	8 (66.7%)	48 (37%)	0.0001
Weight gain in kgs (mean)	9.03±2.97	9.28±2.84	9.33±2.82	9.30±2.78		
Number of women with weight gain >11kgs	6 (16.2%)	6 (12.5%)	20 (64.5%)	10 (83.3%)	42 (32.8%)	0.0003
Primigravida	17 (45.9%)	14 (29.2%)	9 (29%)	4 (33.3%)	44 (34.3%)	0.3
Gestational age at diagnosis of GDM in weeks (mean)	27.8±1.8	28±1.8	28.05±1.96	27.85±1.9		0.73
Positive family history of diabetes mellitus	8 (21.6%)	13 (27.1%)	10 (32.3%)	4 (33.3%)	35 (27%)	0.75
Previous history of GDM	2 (14.3%)	6 (18.8%)	11 (42.3%)	5 (62.5%	24 (18.7%)	0.024
Previous history of intrauterine death	-	3 (9.4%)	3 (11.1%)	2 (25%)	8 (6.56%)	0.26
Previous history of stillbirth	-	3 (9.4%)	4 (14.8%)	1 (12.5%)	8 (6.5%)	0.5
Previous history of preeclampsia	3 (20%)	4 (12.5%)	4 (14.8%)	1 (12.5%)	12 (9.3%)	0.94
Previous birth weight (mean)	2.93±0.35	2.98±0.35	2.97±0.36	2.93±0.36		0.8

Table 2: Maternal complications

Maternal complications	Diet *n*=37	Diet + metformin *n*=48	Diet + metformin + insulin *n*=31	Diet + insulin *n*=12	Total (128)	*P*
Polyhydramnios	3 (8.1%)	5 (10.4%)	7 (22.5%)	2 (16.6%)	17 (13.2%)	0.3
Gestational HTN	4 (10.8%)	11 (22.9%)	13 (41.9%)	6 (50%)	34 (26.5%)	0.01
Preeclampsia	1 (2.7%)	3 (6.2%)	5 (16.1%)	4 (33.3%)	13 (10.1%)	0.01
Preterm birth	4 (10.8%)	6 (12.5%)	6 (19.3%)	3 (25%)	19 (14.8%)	0.85
Premature rupture of membranes	8 (21.6%)	8 (16.7%)	5 (16.1%)	-	21 (16.4%)	0.38
Induction of labor	14 (37.8%)	23 (47.9%)	16 (51.6%)	7 (58.3%)	60 (46.8%)	0.54
Normal vaginal delivery	18 (48.6%)	24 (50%)	10 (32.3%)	3 (25%)	55 (42.9%)	0.38
Assisted vaginal delivery	9 (24.3%)	5 (10.4%)	5 (16.1%)	2 (16.7%)	21 (16.4%)	0.3
Elective LSCS	5 (13.5%)	9 (18.7%)	13 (41.9%)	4 (33.3%)	31 (24.2%)	0.05
Emergency LSCS	4 (10.8%)	10 (20.8%)	4 (12.9%)	3 (25%)	21 (16.4%)	0.48
FBS ≤90mg/dl within 1 week of delivery	32 (86.4%)	36 (75%)	18 (58.06%)	6 (50%)	92 (71.8%)	0.04
2 hrs PLBS ≤120mg/dl within 1 week of delivery	29 (78.3%)	34 (70.8%)	14 (45.1%)	7 (58.3%)	84 (65.6%)	0.01

FBS-Fasting blood sugars, PLBS-Post lunch blood sugars

Table 3: Neonatal complications

Neonatal complications	Diet *n*=37	Diet + metformin *n*=48	Diet + metformin + insulin *n*=31	Diet + insulin *n*=12	Total (128)	*P*
Birth weight in kilograms (mean)	2.84±0.63	2.84±0.50	2.96±0.65	2.97±0.49		0.001
1 min Apgar <7	1 (2.7%)	3 (6.2%)	3 (9.6%)	2 (16.66%)	9 (7%)	0.37
5 min Apgar <7	-	3 (6.25%)	4 (12.9%)	3 (25%)	10 (7.8%)	0.02
IUD	-	-	-	2 (16.7%)	2 (1.5%)	0.01
Shoulder dystocia	-	2 (4.2%)	2 (6.5%)	1 (8.3%)	5 (3.9%)	0.27
Respiratory distress	10 (27.02%)	7 (14.6%)	10 (32.3%)	4 (33.3%)	31 (24.2%)	0.09
NICU admission >24 hours	3 (8.1%)	5 (10.4%)	9 (29%)	4 (33.3%)	21 (16.4%)	0.03
Neonatal hypoglycaemia	1 (2.7%)	3 (6.2%)	5 (16.1%)	4 (33.3%)	13 (10.1%)	0.01
Early neonatal death <1 week	-	-	-	1 (8.3%)	1 (0.7%)	0.01

IUD-Intra-uterine death, NICU-Neonatal intensive care unit

also associated with an increased risk of developing type 2 diabetes in the long term.[3,4] Adverse perinatal outcomes include prematurity, macrosomia, shoulder dystocia, stillbirth and neonatal hypoglycaemia.[5,6]

The standard therapy for women with gestational diabetes requiring drug treatment is insulin. However, several studies have also studied oral agents as a potential alternative to insulin for their easier administration, lower cost and better acceptance.[7,8] The use of oral agents is increasing, and in some settings, they are the first option when drug treatment is required for women with GDM.[9-11]

However, there are limited studies from India comparing the adverse outcomes with respect to diet, metformin, insulin

and combination treatment. The relevance to primary care physicians is that they play a key role in the screening, diagnosis, management and follow-up of women with GDM. They can provide individualised and comprehensive care to women with GDM, addressing their medical, nutritional, psychological and social needs. With this background, this study aims to study the adverse outcomes with respect to treatment modalities in women with GDM.

Methods

The study was conducted from January 2019 to March 2020 in the Department of Obstetrics and Gynaecology No: EC/17/X1/2K18(4-40), Date of approval: 19/11/2018. Women with multiple pregnancies, overt diabetes and chronic hypertension were excluded from the study. After taking informed consent, 50 gm of glucose dissolved in 200 ml of water, was given to the patient to be consumed over a 5 min period {without regard to time of day or time of last meal} and plasma venous glucose was estimated after 1 hour by glucose hexokinase method. The threshold value of ≥140 mg/dl was considered positive and positive patients were subjected to an oral glucose tolerance test. Patients were advised to have an unrestricted diet for 3 days before the test. The glucose tolerance test was performed in the morning after an overnight fast of 8-14 hours. A fasting blood sample was withdrawn. Following this, 75 gm of glucose dissolved in 200 ml of water was given; thereafter, blood samples were drawn and plasma venous glucose values were measured hourly for the next three hours. Patients were diagnosed according to IADPSG 2010 criteria (fasting value-92 mg/dl or 5.2 mmol/l, 1-hour value-180 mg/dl or 10 mmol/l, 2-hour value 153 mg/dl or 8.5 mmol/l).

Women who met one or more of the venous plasma glucose concentrations indicated were diagnosed with GDM. The initial management was by diet modification for 2 weeks, and if the glucose control was not optimised they were offered metformin at a dose between 500 mg to 1500 mg per day titrated according to response in glucose control. Insulin was added to optimise glucose control if metformin did not control glucose levels. The targets were to optimise the fasting blood glucose level below 95 mg/dl and a postprandial blood glucose level below 120 mg/dl.

All the pregnant women diagnosed with GDM were followed up every 2 weeks till 36 weeks and weekly till delivery.

The maternal outcomes studied were:

Gestational hypertension – defined as new onset hypertension with BP ≥140/90 on two occasions at least 4 hours apart after 20 weeks gestation[12]

Preeclampsia-defined as hypertension with proteinuria or other end-organ effects, including thrombocytopenia <100 × 109/L, renal insufficiency with serum Cr >1.1 mg/dL or doubling from baseline, impaired liver function with transaminases greater than twice normal, pulmonary oedema and new onset headache unresponsive to medications or visual symptoms[12]

Polyhydramnios – defined as an excessive amount of amniotic fluid of 2000 ml or more with AFI >25 cm or the deepest vertical pocket of >8 cm. The prevalence of polyhydramnios in maternal cases with diabetes mellitus is 18.8%.[13]

Preterm birth – defined as the parturition that occurs when birth occurs between 20 0/7 weeks of gestation and 36 6/7 weeks[14]

Caesarean section – defined as a fetal delivery through an open abdominal incision (laparotomy) and an incision in the uterus (hysterotomy)[15]

The neonatal outcomes studied were:

Birth weight

Macrosomia-defined as birth weight over 4,000 g irrespective of gestational age or greater than the 90th percentile for gestational age after correcting for neonatal sex and ethnicity[16]

Apgar score

Stillbirth – defined as a dead fetus of 1000 g or more at birth, or after 28 completed weeks of gestation, or attainment of at least 35 cm crown-heel length according to WHO[17]

Shoulder dystocia – defined as a delivery that requires additional obstetric manoeuvres to release the shoulders after gentle downward traction has failed[18]

Neonatal intensive care unit (NICU) admission

Early neonatal death

Statistical analysis

Primary data was entered in MS Excel and analysed using SPSS 20v. The descriptive statistics frequency and percentage were calculated. The association between the categorical variables was analysed by Chi-square test and Fischer-exact test with a 5% level of significance.

Results

In the study period, among 1548 deliveries, 128 pregnant women were diagnosed as GDM with a prevalence of 8.2% [Table 1]. Of 128 patients, 37 (28%) were managed with diet alone, 48 (37%) were managed with diet and metformin and 31 (24%) required insulin in addition to diet and metformin. Twelve (9%) patients were managed with diet and insulin without metformin, which mostly included patients booked in outside hospitals and started on insulin treatment among

the study groups. Though the mean age and weight gain were matched, the number of elderly women (>30 years) and the number of women who gained >11 kgs were significantly higher in insulin-required groups. A significant proportion of women with BMI > 25 and a previous history of GDM were noted in insulin-required groups [Table 2]. Among the maternal complications, gestational hypertension and preeclampsia were found to be significantly higher in insulin-treated groups [Table 3]. A significantly higher number of women in diet and metformin groups achieved the desired glycaemic control 1 week after delivery when compared to insulin-required groups. The mean birth weight was significantly higher in insulin-required groups. A significantly higher proportion of newborns had a 5 min Apgar score <7, NICU admission >24 hours and neonatal hypoglycaemia in insulin-required groups.

Discussion

The prevalence of GDM in the present study was 8.2%, which was comparable to the Rajesh Rajput *et al.*[19] study (7.1%) and Swami SR *et al.*[20] study (7.7%), whereas Reddy KM *et al.*[21] study conducted in the same hospital in 2015 showed a prevalence of 1.83%, showing a rise in the prevalence of GDM over the years. However, Seshiah *et al.*[22] study from south India found a higher prevalence of 17.8% in urban area, 13.8% in semi-urban area and 9.9% in rural area. Chanda S *et al.*[23] study conducted in the rural population of Assam showed a prevalence of 16.7%, suggesting a variable prevalence across different areas and population groups within the country.

Majority of women belonged to low socioeconomic status and got married around the age of 20 years and conceived soon after. Hence, the mean maternal age was 26.04 ± 4.17 in the diet group, 26.4 ± 4.7 in the metformin group, 26.49 ± 4.22 in the metformin and insulin group and 25.89 ± 4.29 in the insulin group, which is comparable with Gupta S *et al.*[24] study (26.2 ± 4.6 in the metformin group, 26.8 ± 4.2 in the insulin group, 26.3 ± 4 in the MNT group, 27.6 ± 4.1 in the metformin + insulin group) but lower compared to Thomas *et al.*[25] study (rural) (29.2 ± 4.1 in the insulin group and 29.5 ± 4.1 in the metformin group), Rai L *et al.*[26] (peri-urban) (30.7 ± 3.8 in the metformin group and 30.5 ± 3.7 in the insulin group).

The present study showed that obese women tend to require insulin, suggesting BMI is an important risk factor for GDM. This was also established by Seshiah V *et al.*[22] study in which the highest prevalence of GDM was observed in women with a mean BMI of ≥25 Kg/m^2 and Kalra *et al.*[27] study in which a significantly higher percentage of women had a mean BMI ≥25 kg/m^2 in women with GDM (67%) when compared to women without GDM (26%).

Positive family history of diabetes was noted in 27% of women in the present study, which was comparable to Kalra *et al.*[27] study (33.3%), and Kumari *et al.*[28] study (22.4%). On the contrary, Mahalakshmi *et al.*[29] and Bhat *et al.*[30] studies showed a high positive family history of diabetes mellitus in 70% and 69% of the women, respectively. The low prevalence of positive family history of diabetes may be explained by the younger age of their parents, and thus, type 2 diabetes mellitus was not yet manifested in them.

It is estimated that the recurrence rate of GDM is around 30-69% based on different population groups studied and diagnostic criteria used.[31,32] In the current study, past history of GDM was found in 18.7%, which was comparable to Kalra *et al.*[27] (12.12%) and Bhat *et al.*[30] (7%) studies. However, few other studies showed higher rates of recurrence of 25-30% and 52%.[33,34]

When comparing the risk factors among the groups, the number of women with a past history of GDM was higher in insulin-required groups whereas, in Rai L *et al.*[26] study, no difference was noted between metformin and insulin groups.

The mean gestational age of diagnosis of GDM was 27.8 ± 1.8 weeks in diet group, 28 ± 1.8 weeks in metformin group, 28.05 ± 1.96 weeks in metformin + insulin and 27.85 ± 1.9 weeks in insulin groups, which did not vary significantly. This can be explained by the fact that the maximum insulin resistance occurs at this age due to pregnancy-related hormones such as progesterone, placentally derived growth hormone, prolactin, cortisol and cytokines such as tumour necrosis factor.[35] This was also seen in Rai L *et al.*[26] study where 47% of women in the metformin group and 63% of women in the insulin group were ≥28 weeks. Women who required insulin had higher weight gain during pregnancy compared to the other treatment groups. This could also be due to the presence of more obese women in insulin-required groups and also due to the poor glycaemic profile in the insulin-treated groups when compared to diet and metformin groups. These findings were comparable to Shirin N *et al.*[36] study.

Mean fasting and postprandial glycaemia were significantly lower in the diet and metformin group than in the metformin and insulin and insulin group.

The better glycaemic profiles in the metformin-treated groups, when compared to insulin-treated groups, were also seen in the Hughes RC *et al.* study[37] and Rai L *et al.*[26] study.

Thirty-one women required supplemental insulin in 79 women treated with metformin (39.2%) which is comparable to Janet A Rowan *et al.*[7] (46.3%) and Jahanara Ainuddin *et al.* studies[38] (42.7%).

It has been found that women with GDM have an increased risk of developing preeclampsia. A part of this risk is due to coexisting mutual risk factors between GDM and preeclampsia.[39] GDM *per se* is an independent risk factor for the development of preeclampsia, with the relative risk ranging from 1.4 to 2.5.[40,41] Gestational hypertension and preeclampsia were significantly more in the insulin-treated group. It is now believed that metformin may reduce preeclampsia in GDM women by

reducing the endothelial activation and maternal inflammatory response of insulin resistance. This was also supported by Jahanara Ainuddin *et al.*[38] study in which preeclampsia was significantly less in metformin-treated groups when compared to the insulin group and Rai L *et al.*,[26] Thomas *et al.*,[25] Janet A studies which showed no increase in the incidence of PIH in metformin-treated groups.

Polyhydramnios complicates 5–26% of diabetic pregnancies, which is much higher when compared to normal pregnancy.[13]

The various underlying mechanisms include fetal hyperglycaemia causing fetal polyuria resulting in increased osmotic diuresis, placentomegaly increasing the surface area of the placenta leading to increased amniotic fluid volume, associated congenital anomalies and metabolic derangements.[13] Many studies have shown an increased association of preterm labour with GDM, and this can be attributed to coexisting preeclampsia, placental abruption, recurrent urinary tract infection and polyhydramnios.[42,43] There was no significant difference in the incidence of polyhydramnios, preterm birth, PROM and IOL with respect to the treatment modalities in the present study. This was comparable to Thomas *et al.*,[25] Rai L *et al.*[26] and Benhalima *et al.*[44] studies, whereas in Janet A Rowan *et al.*[7] study, preterm births were significantly higher in the metformin group (12.1%) when compared to the insulin group (7.6%) (*P* value is 0.006). This could be due to chance or to an unrecognised effect of metformin on the labour process.

The caesarean delivery rate in the current study was 40.6%. The most common indication is elective LSCS in view of previous LSCS, which was comparable to Thomas *et al.*[25] study with a caesarean delivery rate of 42.8%. Whereas Mahalakshmi *et al.*,[29] Kalra *et al.*[27] and Kumari *et al.*[28] studies showed a higher rate of caesarean deliveries of 65.4%, 79% and 50% respectively. This may be due to careful antenatal and intrapartum monitoring and a higher number of trials of labours in the present study. Assisted deliveries were seen in 16.4% of women which was in concordance with Thomas *et al.*[25] study with a rate of 18.7%, but it is quite high when compared to Mahalakshmi *et al.*[29] (<4.1%) and Kumari *et al.*[28] (4.7%) studies probably because women with GDM were induced where criteria were met for induction and continuous electronic fetal monitoring was performed.

With respect to the mode of delivery, there was no statistically significant difference among the treatment groups, which was consistent with Thomas *et al.*[25] study. But Rabia Arshad *et al.*[45] study showed that surgical deliveries due to fetomaternal disproportion were higher in insulin-treated patients than in metformin-treated patients, with a ratio of 7:2, respectively.

The mean birth weight was significantly higher in the insulin group (2.97 ± 0.4) (*P* = 0.001). Similar findings were found in Shirin N *et al.*,[36] Rabia Arshad *et al.*[45] and Benhalima *et al.*[44] studies. However, Thomas *et al.*[25] Gupta S *et al.*[24] and Rai L *et al.*[26] studies did not show a significant difference in the birth weight between metformin and insulin groups.

One-minute Apgar scores did not show a significant difference between the groups. Apgar scores at 5 mins were less in women treated with diet and insulin when compared to other groups (*P* = -0.02), whereas in Gupta S *et al.*,[24] Janet A Rowan *et al.*[7] study and Rabia Arshad *et al.*[27] studies, there was no significant difference in Apgar scores.

The neonates with low Apgar were born to women with GDM who were mostly unbooked or booked late and hence had poor control of their blood sugars.

Neonatal hypoglycaemia is seen in 30-50% of infants of diabetic mothers in the first few hours of life due to fetal hyper-insulinemia, which persists in the newborn at birth after the maternal supply of glucose is cut off.[46] The incidence of neonatal hypoglycaemia is 10.1% in the current study, which was similar to Thomas *et al.*[25] (9.3%), Mahalakshmi *et al.*[30] (10.4%), Kalra *et al.*[27] (9.09%) studies, and it was significantly higher in the metformin and insulin group and insulin group when compared to the diet and metformin group.

Gestational diabetes is one of the risk factors for shoulder dystocia. The excessive shoulder and trunk fat that commonly characterises the macrosomic newborn of a diabetic mother theoretically predisposes such neonates to shoulder dystocia.[47,48] Maternal hyperglycaemia results in increased transplacental transfer of glucose to fetus, and this, in turn, stimulates fetal pancreatic beta cells to release insulin, an important growth factor that results in fetal macrosomia. This effect is described by Pedersen's hypothesis.[49] Evidence shows that hyperinsulinism in fetus inhibits surfactant production by lungs and can result in respiratory distress syndrome and increased rates of neonatal intensive care admission for respiratory support.[50]

Increased rates of preterm birth and elective caesarean section due to macrosomia seen in women with GDM also contribute to an increased risk of neonatal respiratory distress syndrome.[51]

There was no significant difference in the incidence of shoulder dystocia, respiratory distress, or early neonatal death within 1 week between the treatment groups, which was consistent with Janet A Rowan *et al.*,[7] Benhalima *et al.*[44] and Gupta S *et al.*[24] studies. NICU admission for >24 hours was required in 16.4% of neonates, which was lower when compared with Kalra *et al.*[28] study (27.2%) and Rai L *et al.*[26] study (23.1%) and it was significantly higher in the insulin group when compared to diet, metformin, metformin and insulin groups, which were also consistent with Rai L *et al.*[26] and Janet A Rowan *et al.*[7] studies.

The risk of fetal death is higher in women with diabetes. Hyperglycaemia-mediated hypoxia due to chronic aberrations in oxygen and fetal metabolite transport may underlie these unexplained fetal deaths.[52] There were two intrauterine deaths in the insulin group in the present study. Similar findings were found in Rabia Arshad *et al.*,[45] Janet A Rowan *et al.*[7] There were no stillbirths in the study, whereas other studies reported a

stillbirth rate of 2.8% in Mahalakshmi *et al.*[29] study and 9.09% in Kalra *et al.*[27] study. Thus, perinatal mortality was lower than what has been reported in other studies. This probably reflects better perinatal care as it is a tertiary care centre and also because 89% of women diagnosed with GDM were booked cases.

Based on the present study, primary care physicians can advise personalised care to women with GDM and also help in the delay of development of type 2 DM by promoting lifestyle interventions.

Limitations of the study could be the number of women with GDM who required insulin constituted a small group and baseline characteristics of the women might have influenced the fetomaternal outcomes.

Conclusions

Universal screening of women for GDM and multidisciplinary management of women once diagnosed tends to lessen the maternal and fetal complications in women with GDM. Metformin can be an effective, cheaper and non-invasive alternative to insulin in the management of GDM.

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Conflicts of interest

There are no conflicts of interest.

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