Available online at www.sciencedirect.com
SCIENCE DIRECT®
Diabetes Research and Clinical Practice 60 (2003) 41–47
DIABETES RESEARCH AND CLINICAL PRACTICE
www.elsevier.com/locate/diabres

Factors affecting perinatal morbidity and mortality in pregnancies complicated by diabetes mellitus in Sudan

M. Abdelgadir [a,b,*], M. Elbagir [a,b], A. Eltom [b,c], M. Eltom [b], C. Berne [a]

[a] Department of Medical Sciences, Uppsala University Hospital, SE-75185 Uppsala, Sweden
[b] Endocrinology and Diabetes Research Centre, Omdurman Teaching Hospital, Omdurman, Sudan
[c] Department of International Women and Child Health (IMCH), Uppsala University Hospital, SE-75185 Uppsala, Sweden

Received 9 May 2002; received in revised form 19 November 2002; accepted 25 November 2002

Abstract

To investigate the influence of obstetric factors and indices of maternal metabolic control on perinatal morbidity and mortality, 88 diabetic pregnant Sudanese women (type 1, $n = 38$; type 2, $n = 31$; gestational diabetes, $n = 19$) and 50 non-diabetic pregnant control women were studied. The mean fasting blood glucose was 11.1 ± 2.8 mmol/l and the mean HbA_{1c} at booking interview was $8.8 \pm 2.1\%$ in the diabetic women. Pregnancy complications such as Caesarean sections, urinary tract infections, pregnancy-induced hypertension and intrauterine foetal death were higher among diabetic compared with control women ($P < 0.0001$) and varied with the type of diabetes. Infants of diabetic mothers had a higher incidence of neonatal complications than those of non-diabetic women (54.4% vs. 20.0%; $P < 0.0001$). Infants without complications and who were born to diabetic mothers had better Apgar scores at 5 min (9.8 ± 0.5 vs. 8.9 ± 1.6; $P < 0.01$) and lower cord C-peptide when compared to infants with complications ($P < 0.05$). In conclusion, the prevalence of maternal and neonatal complications among Sudanese diabetic women and their infants is high. Maternal hyperglycaemia is an important factor affecting maternal wellbeing and neonatal morbidity and mortality.

Keywords: Diabetes mellitus; Gestational diabetes mellitus; Pregnancy; Perinatal morbidity and mortality; Sudan

1. Introduction

In Sudan, the prevalence of type 1 diabetes is 0.95/1000 among school children [1], and the prevalence of type 2 diabetes is 3.4% among adults [2]. Like other developing countries, diabetes imposes considerable costs on the individual and the nation as a whole [3]. Approximately, 50% of diabetic patients treated with insulin suffer from omission or reduction of the insulin dose due to insulin shortage or non-affordability [4]. Due to limited resources, most of the patients receive insufficient diabetes care and education, resulting in lower rates of clinic attendance and dietary non-compliance. Therefore, most patients are poorly controlled and exhibit a high prevalence of acute

* Corresponding author. Present address: Department of Medical Sciences, Uppsala University Hospital, SE-75185 Uppsala, Sweden. Tel.: +46-18-6114958; fax: +46-18-509297.
E-mail address: moawia.abdelgadir@medsci.uu.se (M. Abdelgadir).

0168-8227/02/$ - see front matter
PII: S0168-8227(02)00277-2

and chronic complications [3,5]. In pregnancy, intensified treatment aiming at normoglycaemia has improved foetal outcome but at fairly high expense, as it requires regular clinic attendance and good control of glycaemia.

Among the pregnant population, diabetes represents the most prevalent chronic medical disease, accounting for 0.2–0.5% of all births [6,7]. The adverse effects of maternal diabetes mellitus on the development and outcome of the foetus and newborn have long been recognised [8–15]. Maternal hyperglycaemia, considered to be the major factor causing perinatal morbidity, is associated with an increased incidence of congenital anomalies, neonatal hyperglycaemia and respiratory distress syndrome, all of which are associated with an increased perinatal mortality rate [12,16–18].

An improved outcome of pregnancy complicated by diabetes mellitus has been reported in recent studies. However, this achievement is not shared in full by African countries where the perinatal morbidity and mortality is still high, although reports are scarce [19–25].

This study is the first to be conducted in Sudan with the main purpose of addressing the impact of obstetric factors and indices of maternal metabolic control on perinatal morbidity and mortality.

2. Subjects and methods

This study was conducted over 2 years, and was planned to include an evaluation of the outcome of pregnancies complicated by diabetes mellitus in Sudan. Pregnant women were recruited at their first visit to the antenatal care clinic of Omdurman Maternity Hospital. This is the biggest referral maternity teaching hospital in Omdurman City, the national capital of the country, which has 3.2 million inhabitants. The antenatal care and delivery service is run on a daily basis by obstetricians, paediatricians and junior staff. About 20 pregnant women visit the clinic daily.

All subjects were informed about the purpose and methods of the study. After giving informed consent, 88 diabetic pregnant women who visited the clinic for their regular follow-up were included consecutively in the study. Of these, 38 had type 1 diabetes mellitus and 31 had type 2 diabetes ($n = 17$ treated by diet, $n = 14$ by insulin). Gestational diabetes was diagnosed in 19 women ($n = 11$ treated by diet, $n = 8$ by insulin) based on oral glucose tolerance testing using the criteria of the World Health Organisation (WHO) [26]. Fifty healthy pregnant women, matched for age, body mass index and parity, were selected to act as a reference group.

3. Biochemical analysis

Fasting blood glucose (FBG) was measured at all visits using portable glucose meters (Accutrend® Sensor, F. Hoffmann-La Roche). Venous whole blood from all patients was drawn in EDTA-containing tubes for the determination of HbA_{1c} at booking interview, and at delivery. Another sample was centrifuged for the measurement of C-peptide and the serum was separated within 2 h. All samples were stored and transported frozen at -20 °C until analysed in Uppsala, Sweden. HbA_{1c} was determined by high-performance liquid chromatography (reference range: 3.5–5.0% [27]). Serum C-peptide concentration was determined at booking interview and from umbilical cord blood by radioimmunoassay (detection limit: 0.05 nmol/l [28]). Two hours after delivery, capillary blood glucose was measured in all infants of the diabetic mothers.

4. Obstetric and neonatal data

Patients and controls were interviewed using a structured questionnaire, which included their demographic data and obstetric history. Gestational age was calculated from the last day of the last menstrual period. Body mass index (BMI; kg/m^2) was measured at booking interview, and the blood pressure, fundal height and weight were recorded at all visits for a minimum of four visits. Complete clinical examination was undertaken at every visit, including a thorough search for pregnancy complications. Pregnancy-induced hypertension was diagnosed if the blood pressure was $>140/90$ mmHg and pre-eclampsia if proteinuria

or oedema was also present. The diagnosis of polyhydramnios was based on ultrasound findings. Urinary tract infection was diagnosed when urine cultures were positive.

After delivery, all newborns were weighed and examined clinically. Apgar scores at 1 and 5 min, and birth weight and length were recorded. A paediatrician was responsible for the routine examination, and any neonatal complication was noted. Hypoglycaemia was defined when the blood glucose was <1.7 mmol/l. Jaundice was diagnosed clinically if it was considered to need treatment with phototherapy or exchange transfusion, and polycythaemia if the venous haematocrit value was $>70\%$. Prematurity was defined if delivery occurred at <37 weeks gestation. Macrosomic babies were defined when large for gestational age and weighed >90th percentile at birth, and small for gestational age was defined as weight <10th percentile.

5. Statistical analysis

Statistical analysis was performed using the program SAS for Windows 6.12 (SAS Institute, Cary, NC). Results are given as mean $\pm$S.D. unless otherwise specified. Comparisons between groups were performed with the Student's t-tests or its non-parametric version where relevant, and between frequencies with the x^2-test. Simple linear regression or Spearman rank correlation was used for normally and non-normally distributed data, respectively. A P-value of <0.05 was considered significant.

6. Results

The demographic and clinical data of the diabetic mothers, controls and their infants are presented in Table 1. When comparing each diabetic subgroup with the controls, type 1 diabetic subjects had significantly higher levels of HbA_{1c} at booking ($9.2\pm2.5\%$ vs. $4.2\pm0.6\%$, $P<0.05$). However, there were no statistical significant differences regarding the other variables.

Birth weight, gestational age at delivery, cord C-peptide and mean blood glucose at 2 h were similar in infants of diabetic mothers with gestational diabetes, type 1 or type 2 diabetes and infants of non-diabetic women (Table 1).

Table 2 shows the frequency of pregnancy and neonatal complications among the diabetic groups and the control subjects. The type 1 diabetic subjects showed the highest prevalence of complications, followed by women with type 2 diabetes. Women with gestational diabetes had lower complications.

The same trend was seen in the neonatal findings. Infants of the mothers with type 1 and type 2 diabetes mellitus are more prone to complications compared with infants born to mothers with gestational diabetes and non-diabetic mothers.

Table 3 presents the obstetric factors in relation to neonatal complications among the diabetic women. The only significant differences were a lower Apgar score at 5 min in the babies of diabetic women with complications, and higher rates of current and previous pregnancy complications and a higher rate of Caesarean sections in the mothers themselves.

Maternal C-peptide level in the diabetic women whose infants had complications was lower than in diabetic women who had infants with no complications (Table 4), whereas their infants showed an increased levels of cord C-peptide. There were no other metabolic differences between the infants with and without complications or in the mothers of such infants.

7. Discussion

This study has addressed several contributory factors that relate to the outcome of pregnancy complicated by diabetes mellitus in a group of Sudanese women. A high frequency of perinatal complications in pregnancies complicated with diabetes mellitus compared with controls was found in this study similar to previous reports [10,11,29]. In a country like Sudan, where diabetes awareness is inadequate, late presentation to antenatal care clinics and inadequate diabetes

Table 1
Demographic and clinical data of the diabetic mothers, controls and their infants

	GDM ($n=19$)	Type 1 DM ($n=38$)	Type 2 DM ($n=31$)	Controls ($n=50$)
Mothers				
Age (years)	29.9±5.3	28.8±5.8	34.4±4.0	30.6±6.8
Gestational age at booking (weeks)	24.7±5.3	24.2±6.2	23.5±7.4	23.3±6.5
BMI at booking interview (kg/m^2)	28.8±6.7	23.5±3.8	28.9±4.1	26.2±3.7
Mean FBG (mmol/l)	9.9±1.5	11.3±3.4	10.9±1.6	5.0±0.6
HbA_{1c} at booking (%)	8.1±1.7	9.2±2.5	8.2±1.4	4.2±0.6
HbA_{1c} at delivery (%)	6.4±1.3	7.8±1.3	7.9±1.8	4.5±0.6
Maternal C-peptide (nmol/l)	0.40±0.17	0.16±0.08	0.43±0.19	0.62±0.32
Infants				
Gestational age at delivery (weeks)	38.2±1.2	37.8±1.2	38.5±1.6	39.2±1.4
Birth weight (g)	3523±676	3380±671	3511±711	3329±557
Cord C-peptide (nmol/l)	0.36±0.08	0.73±0.27	0.69±0.27	0.57±0.34
Blood glucose at 2 h (mmol/l)	2.0±0.2	2.1±0.2	2.5±0.2	–

Mean±S.D.

management may have contributed to the overall poor outcome. The nature and distribution of the complications associated with maternal diabetes were found not only to be linked to the degree of hyperglycaemia, but also to the type of diabetes [30,31]. Complications were more frequent among subjects with type 1 diabetes mellitus and their infants than among women with type 2 and gestational diabetes. Better beta cell function and glycaemic control in type 2 and gestational diabetes is likely to explain this variation in the frequency of complications.

Epidemiological data showed that pregnancy complicated by diabetes mellitus varies between

Table 2
Frequency of pregnancy and neonatal complications of the diabetic and controls

	GDM ($n=19$)	Type 1 DM ($n=38$)	Type 2 DM ($n=31$)	Controls ($n=50$)
Mothers, n (%)				
No complications	14 (73.7)	16 (42.1)	19 (61.3)	44 (88)
Pregnancy-induced hypertension	2 (10.5)	8 (21.0)	6 (19.3)	3 (6.0)
Polyhydramnios	0	2 (5.3)	2 (6.4)	1 (2.0)
Diabetic ketoacidosis	0	3 (8.0)	0	0
Intra-uterine foetal death	1 (5.3)	2 (5.3)	0	0
Urinary tract infection	4 (21.5)	7 (18.4)	6 (19.3)	3 (6.0)
Caesarean section	5 (26.3)	12 (31.6)	8 (25.8)	6 (12.0)
Neonates, n (%)				
No complications	11 (57.9)	14 (38.9)	18 (58.1)	40 (80)
Hypoglycaemia	4 (22.2)	16 (44.4)	7 (22.6)	0
Prematurity	2 (11.1)	4 (11.4)	3 (9.7)	3 (6.0)
LGA	4 (22.2)	6 (16.7)	5 (16.1)	4 (8.0)
SGA	1 (5.6)	2 (5.6)	3 (9.7)	3 (6.0)
Respiratory disorders	3 (16.7)	5 (13.9)	6 (19.3)	5 (10.0)
Polycythaemia	3 (16.7)	3 (8.1)	3 (9.7)	3 (6.0)
Jaundice	1 (5.6)	4 (11.4)	5 (16.1)	0
Neonatal death	0	1 (2.8)	3 (9.7)	0
Congenital malformation	0	1 (2.8)	2 (6.4)	0

Abbreviations: LGA, large for gestational age; SGA, small for gestational age.

Table 3
Obstetric factors in relation to neonatal complications among the diabetic women and Apgar score

	No neonatal complications ($n=42$)	Neonatal complications present ($n=43$)
Body mass index (kg/m^2)	25.8±4.5	27.5±5.8 NS
Gestational age at booking (weeks)	23.9±6.1	24.2±6.9 NS
Pregnancy complications present	12 (27.9)	28 (65.1)**
Parity	3.4±2.5	4.6±2.6 NS
Past pregnancy complications	5 (14.3)	18 (48.6)**
Caesarean section	3 (7.0)	22 (51.2)***
Gestational age at delivery (weeks)	38.9±0.9	37.4±1.3 NS
Apgar at 5 min	9.8±0.5	8.9±1.6**
Birth weight	3286±307	3625±884 NS

NS = non-significant. *$P<0.05$.
** $P<0.01$.

Table 4
Metabolic factors in relation to neonatal complications among the diabetic women

	No neonatal complications ($n=42$)	Neonatal complications present ($n=43$)
Mean systolic blood pressure (mmHg)	115.3±8.3	119.6±11.3 NS
Mean diastolic blood pressure (mmHg)	75.0±6.8	79.2±9.6 NS
Mean fasting blood glucose (mmol/l)	10.6±1.7	10.9±2.8 NS
HbA_{1c} at booking interview (%)	8.4±1.9	8.8±2.0 NS
HbA_{1c} at delivery (%)	7.1±1.7	7.9±1.9 NS
Maternal C-peptide (nmol/l)	0.32±0.17	0.29±0.21*
Cord C-peptide (nmol/l)	0.55±0.29	0.57±0.25*
Blood glucose at 2 h after delivery (mmol/l)	2.9±0.73	1.6±0.80 NS

Mean+S.D. NS = non-significant.
* $P<0.05$.

0.2 and 4% of all pregnancies [32–34]. However, there are no such data available for Sudan. Changes in the incidence of gestational diabetes may reflect the high prevalence of diabetes, particularly type 2, in the general population [2]. In this study, women with gestational diabetes showed increased evidence of pregnancy complications compared with the control subjects, which is in accord with other reports [19–24]. This might raise a question not only about the glycaemic control of this group, but also about the organisation of antenatal care as a whole for pregnant women with diabetes, as no special local protocol for dealing with gestational diabetes has been developed yet.

Blood pressure and HbA_{1c} at booking and delivery were similar in the diabetic women with infants who did and did not have complications. The significantly lower level of maternal C-peptide, which is associated with increased cord C-peptide in those infants with complications, reflects the higher glucose levels in their mothers. This exaggerated foetal insulin secretion contributed to foetal macrosomia, delayed lung maturation and neonatal hypoglycaemia among those infants. This data are in agreement with Pedersen's hypothesis and other reports [35,36]. The findings show that hyperinsulinaemia in the infants of the diabetic mothers is related to the major complications that occurred to those infants, and this is supported by the fact that infants of the diabetic mothers who had no complications have higher Apgar score; however, this might not have a clinical significance.

Complications in previous diabetic pregnancies could also be a predictor for complications in the current pregnancy, and this might require additional care to improve the outcome and to prevent or to reduce neonatal complications. Congenital anomalies are present only in infants of mothers with type 1 and type 2 diabetes mellitus, but not infants of control women or women with gestational diabetes [37]. Hyperglycaemia and hyperinsulinaemia in diabetic pregnancies stimulates erythropoiesis causing polycythaemia, which predisposes to hyperbilirubinaemia in this group.

In conclusion, we showed in this study of a large cohort of Sudanese diabetic mothers and their

infants, the patterns and nature of some maternal and neonatal complications. Maternal hyperglycaemia is the main factor influencing not only maternal wellbeing, but also foetal and neonatal morbidity and mortality. Prevention and reduction of maternal and neonatal complications among Sudanese diabetic mothers and their infants could be achieved by achieving adequate control protocol targeted towards careful management of diabetes in pregnancy.

Acknowledgements

This work was supported by grants from In-Develop Uppsala. We thank Björn Kjellander, Roche Diagnostics, Scandinavia, Stockholm, for provision of the blood test strips, the staff of Omdurman Maternity Hospital, Sudan, and the study subjects for co-operation.

References

[1] A. Elamin, M. Omer, Y. Hofvander, T. Tuvemo, Prevalence of IDDM in school children in Khartoum, Sudan, Diabetes Care 12 (1989) 430–432.
[2] M. Elbagir, M. Eltom, M. Elmahadi, I. Kadam, C. Berne, A population-based study of the prevalence of diabetes and impaired glucose tolerance in adults in northern Sudan, Diabetes Care 19 (1996) 1126–1128.
[3] M. Elmahadi, A. Kaballo, E. Mukhtar, Features of NIDDM in the Sudan, Diabetes Res. Clin. Pract. 11 (1991) 59–63.
[4] M. Elbagir, M. Eltom, H. Rosling, C. Berne, Glycaemic control of IDDM in the Sudan—influence of insulin shortage, Diabetes Res. Clin. Pract. 30 (1995) 43–52.
[5] M. Elmahadi, A. Salih, E. Mukhtar, Patterns of diabetes mellitus in the Sudan, Trop. Geogr. Med. 4 (1989) 353–355.
[6] The Centre for Diseases Control. Perinatal mortality and congenital malformations in infants born to women with insulin-dependant diabetes mellitus—Unites States, Canada and Europe, 1940–1988. J. Am. Med. Assoc. 264 (1990) 437–440.
[7] F.A. Connel, C. Vadheim, I. Manuel, Diabetes in pregnancy: a population-based study of incidence referral for care and perinatal mortality, Am. J. Obstet. Gynecol. 151 (1985) 598–603.
[8] M. Hod, Y.Z. Diamant, The offspring of diabetic mothers: short-and long-range implications, Isr. J. Med. Sci. 28 (1992) 81–86.
[9] L. Cordero, M.B. Landon, Infant of the diabetic mother, Clin. Prinatol. 20 (1993) 635–648.
[10] S.P. Chan, Gestataional diabetes mellitus, Med. Dig. 19 (12) (1993) 5–9.
[11] I.A. al-Dabbous, J.A. Owa, Z.A. Nasserallah, I.S. al-Qurash, Perinatal morbidity and mortality in offspring of diabetic mothers in Qatif, Saudi Arabia, Eur. Obstet. Gynecol. Reprod. Biol. 65 (1996) 165–169.
[12] I.F. Casson, C.A. Clarke, C.V. Howard, et al., Outcomes of pregnancy in insulin-dependant diabetic women: results of a five years population cohort study, Br. Med. J. 315 (1997) 275–278.
[13] G. Hawthorne, S. Robson, E.A. Ryall, D. Sen, S.H. Roberts, M.P. WardPlatt, Prospective population-based survey of outcome of pregnancy in diabetic women: results of the Northern Diabetic Pregnancy Audit, 1994, Br. J. Med. 315 (1997) 279–281.
[14] J. Svare, B. Hansen, L. Molsted-Pedersen, Perinatal complications in women with gestational diabetes mellitus significance of a diagnosis early in pregnancy, Acta Obstet. Gynecol. Scand. 80 (2001) 899–904.
[15] R. Bernice, J. Kong, E. Kozak, C. Marshal, S. Tong, D. Thompson, Normal perinatal mortality in type 1 diabetes mellitus in a series of 300 consecutive pregnancy outcomes, Am. J. Perinatol. 19 (2002) 169–176.
[16] J.D. Coustan, Perinatal mortality and morbidity in diabetes mellitus in pregnancy, Vol. 23, Churchill Livingstone, 1995, pp. 361–367.
[17] A. Vambergue, M. Nuttenst, O. Verier-Mine, C. Dognin, P. Cappoen, P. Fontaine, Is mild gestational hyperglycaemia associated with maternal and neonatal complication? The Digest Study, Diabetic Med. 17 (2000) 203–208.
[18] K. Howorka, J. Pumprla, M. Gabriel, et al., Normalization of pregnancy outcome in pregestational diabetes through functional insulin treatment and modular outpatient education adapted for pregnancy, Diabetic Med. 18 (2001) 965–972.
[19] K. Huddle, M. England, A. Nagar, Outcome of pregnancy in diabetic women in Sweto, South Africa, 1983–1992, Diabetic Med. 10 (3) (1993) 290–294.
[20] D.G. McLarty, C. Politt, A.B. Swai, Diabetes in Africa, Diabetic Med. 7 (1990) 670–684.
[21] O.A. Kadiki, M.R. Reddy, M.A. Sahli, H. Shawar, S. Rao, Outcome of pregnant diabetic patients in Benghazi (Libya) from 1984 to 1991, Diabetes Res. Clin. Pract. 21 (1) (1993) 39–42.
[22] J.M. Lutale, A. Justeen, R.S. Lema, A.B. Swai, D.G. McLarty, Outcome of pregnancy in diabetic patients in Dar es Salaam, Tanzania, Diabetes Med. 8 (9) (1991) 881–884.
[23] M.A. Rutherford, V. Chawla, Infants of diabetic mothers: a prospective study of neonatal complications in Harare, Zimbabwe, Ann. Trop. Paediatr. 9 (4) (1989) 191–193.
[24] A. Daponte, F. Guidozzi, D. Moiscuc, A. Marineanu, Management of diabetic pregnant patients in a tertiary center in the developing world, Int. J. Gynaecol. Obstet. 64 (2) (1999) 141–146.

[25] K. Challis, A. Melo, A. Bughalo, J. Jeppsson, S. Bergstrom, Gestational diabetes mellitus and fetal death in Mozambique: an incident case-referent study, Acta Obstet. Gynecol. Scand. 81 (2002) 560–563.
[26] Diabetes mellitus, WHO Technical Report Series 727, Report of a WHO Study Group, World Health Organization, Geneva, 1985.
[27] J.O. Jeppsson, P. Jerntorp, G. Sundkvist, H. Englund, V. Nylund, Measurement of HbA1c by a new liquid-chromatographic assay: methodology, clinical utility and relation to glucose tolerance evaluated, Clin. Chem. 32 (1986) 1867–1872.
[28] L.G. Heding, Radioimmunological determination of human C-peptide in serum, Diabetologia 11 (1975) 541–548.
[29] G.L. Neilsen, P.H. Neilsen, Outcome of 328 pregnancies in 205 women with insulin-dependent diabetes mellitus in the country of Northern Jutland from 1976 to 1990, Eur. J. Obstet. Gynecol. Reprod. Biol. 50 (1993) 33–38.
[30] H.A. Nasrat, M. Salleh, M. Ardawi, H. Ghafouri, Outcome of pregnancy in diabetic mothers, Int. J. Gynecol. Obstet. 43 (1993) 29–34.
[31] D.R. Hollingsworth, Alternation of maternal metabolism in normal and diabetic pregnancies: differences in insulin-dependent, non-insulin-dependent and gestational diabetes, Am. J. Obstet. Gynecol. 146 (1983) 417.
[32] Y. Omori, S. Minei, T. Tetsuo, K. Nemoto, M. Shimizu, M. Sanaka, Current status of pregnancy in diabetic women: a comparison of pregnancy in IDDM and NIDDM mothers, Diabetes Res. Clin. Pract. Suppl. 24 (1994) 273–278.
[33] P. Garner, Type of diabetes mellitus and pregnancy, Lancet 346 (1995) 157–161.
[34] R. Gregory, A.R. Scott, M. Mohajer, R.B. Tattersall, Diabetic pregnancy 1977–1990: Have we reached a plateau?, J. R. Coll. Physicians London 26 (2) (1992) 162–166.
[35] I.R. Sosenko, J.L. Kitzmiller, S.W. Loo, P. Blix, A.H. Rubenstein, K.H. Gabbay, The infant of the diabetic mother, correlation of increased cord C-peptide level with macrosomia and hypoglycaemia, N. Engl. J. Med. 301 (16) (1979) 859–862.
[36] J. Pedersen, B. Bojsen-Moller, H. Poulsen, Blood sugar in new-born infants of diabetic mothers, Acta Endocrinol. 15 (1954) 33–52.
[37] J.L. Kitzmiller, L.A. Gavin, G.D. Gin, L. Jovanovic-Peterson, E.K. Main, W.D. Zigrang, Preconception care of diabetes: glycemic control prevents congenital anomalies, J. Am. Med. Assoc. 265 (1991) 731–736.