Risk factors and perinatal outcomes of re-recurrent gestational diabetes mellitus: a retrospective cohort study in china

Xia Xu
College of Clinical Medicine for Obstetrics & Gynecology and Pediatrics, Fujian Medical University
Yanni Guo
College of Clinical Medicine for Obstetrics & Gynecology and Pediatrics, Fujian Medical University
Tingting Liao
College of Clinical Medicine for Obstetrics & Gynecology and Pediatrics, Fujian Medical University
Weijiao Xu
College of Clinical Medicine for Obstetrics & Gynecology and Pediatrics, Fujian Medical University
Jingxuan Sun
College of Clinical Medicine for Obstetrics & Gynecology and Pediatrics, Fujian Medical University
Jianying Yan (505633435@qq.com)
College of Clinical Medicine for Obstetrics & Gynecology and Pediatrics, Fujian Medical University

Research Article

Keywords: gestational diabetes mellitus, recurrence, risk factor, outcome

Posted Date: April 19th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1531435/v1

Abstract

Objective To explore the risk factors and perinatal outcomes of re-recurrent gestational diabetes mellitus (GDM).

Methods A retrospective cohort study of women with recurrent GDM who had two consecutive singleton deliveries was performed in Fujian Maternity and Child Health Hospital from January 1, 2012 and December 31, 2021. Datas on pregnancy characters and complications, neonatal and delivery outcomes were collected and analyzed.

Results (1) In total, 712 women were included and followed up. 90 women were excluded due to lack of oral glucose tolerance test after six weeks of postpartum and 13 women were lost in the follow up. As of the date of data cutoff, 94 women got third pregnancy and 46 of them delivered after 24 weeks . Among these 46 women , 32 (71.11%) complicated with GDM (case group) , 10 (21.74%) uncomplicated with GDM (control group) and the other 4 (8.70%) women complicated with pre-gestational diabetes mellitus (PGDM) in the third pregnancy . (2) There was no significant difference in age, lover age, qualifications, gravidity, parity, mode of conception, history of macrosomia , pre-pregnancy BMI and gestational weight gain between two groups (all P0.05). Interpregnancy interval (IPI) (months) to first (55.03±5.79 vs 69.10±3.14, P=0.000) and second (25.78±6.75 vs 41.30±5.95, P=0.000) pregnancy were significantly shorter in case group than control group. (3) OGTT 0 hPG and OGTT 1hPG during second pregnancy , TG before second delivery and FPG in first trimester showed no significant difference between two groups (all P0.05) . OGTT 2 hPG (8.94±1.25 vs 7.91±1.12, P=0.026), number of OGTT abnormal items (1.91±0.77 vs 1.40±0.52, P=0.027) , TC before second deliveryand glycosylated (6.82±1.03 vs 6.10±0.73, P=0.046) and hemoglobin A1c (HbA1c) in second trimester (5.62±0.39 vs 5.33±0.20, P=0.031) and before delivery (5.72±0.38 vs 5.13±0.30, P=0.000) during second pregnancy was significantly higher in case group than control group . TG (2.29±0.54 vs 1.85±0.41, P=0.021) and TC (5.12±0.67 vs 3.92±0.30, P=0.000) in first trimester and FPG before delivery (5.12±0.74 vs 4.17±0.38, P=0.000) was significantly higher in case group than control group. (4) There was no significant difference in the hospitalization days and expenses, gestational age, mode of delivery ,Apgar score at 1 min, weight of fetus and the rate of hypertensive disorders in pregnancy (HDP) , intrahepatic cholestasis of pregnancy (ICP), premature rupture of membranes (PROM) , precipitate labor, postpartum hemorrhage (PPH) , small for gestational age (SGA) between two groups (all P0.05). The rate of hypothyroidism in (34.38% vs 0%, P=0.31) case group were significantly higher than control group. The rate of large for gestational age (LGA) (28.13% vs 0%, P=0.058) and admission to NICU (34.38% vs 10.00%, P=0.14) in case group were higher than control group, but there was no statistically difference.

Conclusions Perinatal care for women with history of GDM especially recurrent GDM must be started before pregnancy and after delivery. It is recommended to choose the appropriate length of IPI and control the plasm level of lipid and glucose to minimize the high risk of re-recurrent GDM . The management of plasm lipid and glucose still need to be further strengthened and studied to improve the prognosis of perinatal outcomes.

Background

Gestational diabetes mellitus (GDM) is an pathologic condition in which glucose intolerance and insulin resistance develop to different degrees during pregnancy. The prevalence of GDM is increasing in the worldwide including china [1–4]. Women with GDM have a higher odds of adverse maternal and fetal outcomes, such as preeclampsia, cesarean section, macrosomia and neonatal hypoglycemia[5–7]. Although 80% of diabetes diagnosed during pregnancy can recover after postpartum, patients with a history of GDM were at significantly increased risk for long-term glucose intolerance, such as recurrence of GDM in subsequent pregnancy[8]. According to current studies, the frequency of recurrent GDM in subsequent pregnancies was 30.0–84% [9–11].

In our previous and some other studies found an increased incidence of adverse perinatal outcomes in pregnants with recurrent GDM[10, 12]. So far, prior history of GDM have not be recommended to refrain from subsequent pregnancies in light of the limited available data. What about those women with twice of GDM? Should pregnant women with twice of GDM be recommended to refrain from the third time of pregnancy ? Currently, reports on risk factors and perinatal outcomes of subsequent pregnancy in women with twice of GDM are very rare.

Therefore, a population-based cohort study was performed to explore risk factors and subsequent perinatal outcomes of pregnant with twice of GDM according to present data .

Material And Methods

Study Population

The subjects in the present study were all women with consecutive twice of GDM between January 1, 2012 to December 31, 2021 at Fujian Maternity and Child Health Hospital, China. They were must singleton pregnancy and delivered after 24 weeks. Women with preexisting history of childbirth before 2012 were excluded from this analysis. And women who did not accept glucose tolerance test after delivery were excluded.

Diagnostic criteria

The diagnostic criteria of GDM was based on the International Association of the Diabetes and Pregnancy Study Group (IADPSG) specified diagnostic criteria[13], which are also the diagnostic criteria of GDM recommended by the guidelines for the management of GDM in China. In brief, pregnants were screened by a “one-step” standardized 75 g oral glucose tolerance test (OGTT) to diagnose GDM at 24~28 weeks of gestation . Women were diagnosed as having GDM once glucose values met or exceeded the diagnostic criteria: fasting glucose value≥5.1 mmol/L, 1-h glucose value≥10.0 mmol/L, and 2-h glucose value≥8.5 mmol/L.

Investigation content

All recruited women were checked if they had a subsequent pregnancy and followed-up till termination before December 12, 2021. Maternal and fetal datas of were collected from medical records for all participants, such as maternal age, gestational weight gain, gestational week of delivery, neonatal weight, fasting blood glucose in first trimester, glucose values at the 75-g OGTT and so on.

Statistical analysis

All continuous values were given as mean±SD or median (range), depending on Gaussian distribution and categorical values were given as number of cases (proportion). To examine the group differences, Student's t-test or ANOVA was used for continuous variables if Gaussian distribution was identitied. Otherwise, Mann–Whitney or Wilcoxon tests were used for unpaired and paired analysis, respectively. Chi-square test was used for categorical variables. Analyses were conducted using IBM SPSS Statistics v26.0, and a two-sided p-value < 0.05 was taken as the level of significance.

Results

Study population

During 9 years from 2012 to 2020, 712 women with consecutive twice of GDM accepted antenatal examination and delivered at the Department of Obstetrics, Fujian Maternity and Child Hospital, a regional hospital in southeast of China. Of those, 90 women were excluded due to lack of oral glucose tolerance test after six weeks of postpartum and 622 who met the inclusion criteria were eventually recruited .Among all recruited women ,13 women were lost in the follow up and 94 women got pregnancy again. 46 of them delivered after 24 weeks while other 48 women accepted abortion before 24 weeks. Among these 46 women, 32 (71.11%) complicated with GDM (case group), 10 (21.74%) uncomplicated with GDM (control group) and the other 4 (8.70%) women complicated with pre-gestational diabetes mellitus (PGDM) in the third pregnancy (Fig. 1) .1of woman complicated with PGDM was diagnosed by fasting glucose (7.29 mmol/l) at 18 weeks and occurred stillbirth finally at 28 weeks due to hyperosmolar hyperglycemic state.The other three was diagnosed by OGTT at 8 to 15 weeks and delivered by vagina smoothly.

Maternal baseline characteristics

There was no significant difference in age, lover age, qualifications, gravidity, mode of conception, history of macrosomia, pre-pregnancy BMI and gestational weight gain between two groups (all P 0.05). Interpregnancy interval (IPI) (months) to first (55.03 ± 5.79 vs 69.10 ± 3.14, P = 0.000) and second (25.78 ± 6.75 vs 41.30 ± 5.95, P = 0.000) pregnancy were significantly shorter in case group than control group (Table 1).

Table 1
Baseline characteristics betweem two groups

Variables	Case group (n = 32)	Control group (n = 10)	t/H/χ2	P
Maternal age (year)	32.19 ± 3.36	30.00 ± 2.63	1.88	0.07
Lover age (year)	32.47 ± 7.03	35.40 ± 3.69	-1.26	0.22
Qualifications			3.89	0.14
Junior or high school	3 (9.38%)	2 (20%		
upgraduate	20 (62.50%)	8 (80%)		
postgraduate	9 (28.13)	0		
Gravidity(n)	4.34 ± 1.23	4.20 ± 1.13	1.03	0.75
Mode of conception,			1.67	0.20
natural conception(n, %)	30(93.75%)	8(80.00%)		
assisted reproduction(n, %)	2(6.25%)	2(20%)		
History of macrosomia (n, %)	1(3.13%)	0	0.32	0.57
Pre-pregnancy BMI (kg/m^2)	23.08 ± 3.81	21.79 ± 4.15	-1.95	0.067
Gestational weight gain (kg)	12.68 ± 4.08	15.03 ± 4.07	-1.53	0.13
IPI to first pregnancy (months)	55.03 ± 5.79	69.10 ± 3.14	-7.31	0.00
IPI to second pregnancy (months)	25.78 ± 6.75	41.30 ± 5.95	-6.51	0.00
Note body mass index (BMI), Interpregnancy interval(IPI)				

The level of lipid and glucose in serum during second pregnancy

Oral glucose tolerance test (OGTT) 0 hour plasm glucose (0 hPG) and OGTT 1 hour plasm glucose (1hPG) during second pregnancy and triglycerides (TG) before second delivery showed no significant difference between two groups (all P 0.05). OGTT 2 hour plasm glucose (2 hPG) (8.94 ± 1.25 vs 7.91 ± 1.12, P = 0.026), number of OGTT abnormal items (1.91 ± 0.77 vs 1.40 ± 0.52, P = 0.027), total cholesterol (TC) before second deliveryand glycosylated (6.82 ± 1.03 vs 6.10 ± 0.73, P = 0.046) and glycosylated hemoglobin A1c (HbA1c) in second trimester (5.62 ± 0.39 vs 5.33 ± 0.20, P = 0.031) and before delivery (5.72 ± 0.38 vs 5.13 ± 0.30, P = 0.000) during second pregnancy was significantly higher in case group than control group (Table 2).

Table 2
The level of lipid and glucose during 2nd pregnancy between two groups

Variables	Case group (n = 32)	Control group (n = 10)	t	P
OGTT 0hPG (mmol/L)	4.78 ± 0.51	4.60 ± 0.48	0.99	0.33
OGTT 1hPG (mmol/L)	10.43 ± 1.01	10.64 ± 0.92	-0.59	0.56
OGTT 2hPG (mmol/L)	8.94 ± 1.25	7.91 ± 1.13	2.31	0.026
TG before second delivery (mmol/L)	4.43 ± 1.94	3.78 ± 1.08	1.03	0.31
TC before second delivery (mmol/L)	6.82 ± 1.03	6.10 ± 0.73	2.06	0.046
number of OGTT abnormal items (n)	1.91 ± 0.77	1.40 ± 0.52	2.37	0.026
HbA1c in second trimester (%)	5.62 ± 0.39	5.33 ± 0.20	2.23	0.031
HbA1c before second delivery (%)	5.72 ± 0.38	5.13 ± 0.30	4.47	0.000
Note Oral glucose tolerance test (OGTT), glycosylated hemoglobin A1c (HbA1c), triglycerides (TG), total cholesterol (TC)				

The level of lipid and glucose in first trimester during third pregnancy

TG (2.29 ± 0.54 vs 1.85 ± 0.41, $P = 0.021$) and TC (5.12 ± 0.67 vs 3.92 ± 0.30, $P = 0.000$) in first trimester and fasting plasma glucose (FPG) before delivery (5.12 ± 0.74 vs 4.17 ± 0.38, $P = 0.000$) was significantly higher in case group than control group (Table 3). FPG in first trimester showed no significan difference between two groups (P 0.05).

Table 3
The level of lipid and glucose in first trimester during 3rd pregnancy between two groups

Variables	Case group (n = 32)	Control group (n = 10)	t	P
TG in first trimester (mmol/L)	2.29 ± 0.54	1.85 ± 0.41	2.41	0.02
TC in first trimester (mmol/L)	5.12 ± 0.67	3.92 ± 0.30	5.46	0.00
FPG before delivery (mmol/L)	5.12 ± 0.74	4.17 ± 0.38	3.92	0.00
FPG in first trimester (mmol/L)	4.8972 ± 0.49	4.67 ± 0.36	1.34	0.19
Note triglycerides (TG), total cholesterol (TC), fasting plasma glucose (FPG)				

Perinatal outcomes

Perinatal outcomes of two groups are shown in Table 4. There was no significant difference in the hospitalization days and expenses, gestational week of delivery, mode of delivery ,Apgar score at 1 min, weight of fetus and the rate of hypertensive disorders in pregnancy (HDP), intrahepatic cholestasis of pregnancy (ICP), premature rupture of membranes (PROM), precipitate labor, postpartum hemorrhage (PPH), small for gestational age (SGA) between two groups (all P 0.05). The rate of hypothyroidism (34.38% vs 0%, P = 0.31) in case group were significantly higher than control group. The rate of large for gestational age (LGA) (28.13% vs 0%, P = 0.058) and admission to neonatal intensive care unit (NICU) (34.38% vs 10.00%, P = 0.14) in case group were higher than control group, but there was no statistically difference.

Table 4
Perinatal outcomes between two groups

Variables	Case group (n = 32)	Control group (n = 10)	t/χ2	P
Hospitalization days	5.59 ± 2.89	4.90 ± 1.97	-0.26	0.80
Hospitalization expenses (yuan)	6615.01 ± 3317.00	6906.35 ± 2481.62	0.71	0.49
Gestational week of delivery (w)	38.63 ± 1.88	39.20 ± 029	-0.93	0.36
Mode of delivery (n,%)			3.74	0.053
Vaginal delivery	28 (87.50%)	6 (60.00%)		
C-setion	4 (13.5%)	4 (40.00%)		
HDP (n,%)	10 (31.25%)	1 (10.00%)	1.78	0.18
Hypothyroidism (n,%)	11 (34.38%)	0	4.68	0.031
ICP (n,%)	2 (6.25%)	0	0.66	0.42
PROM(n,%)	13(40.63%)	1 (10.00%)	3.43	0.064
Precipitate labor (n,%)	8 (25.00%)	1 (10.00%)	1.02	0.31
PPH(n,%)	6 (18.75)	1 (10.00%)	0.42	0.52
SGA (n,%)	1 (3,13%)	0	0.32	0.57
LGA (n,%)	9 (28.13%)	0	3.58	0.058
Apgar score at 1 min (score)	9.94 ± 0.25	10.00 ± 0.00	-0.80	0.43
Weight of fetus (gram)	3803.91 ± 567.55	3342.00 ± 363.75	0.20	0.84
Admission to NICU (n,%)	11 (34.38%)	1 (10.00%)	2.22	0.14

Note hypertensive disorders in pregnancy (HDP), intrahepatic cholestasis of pregnancy (ICP), premature rupture of membranes (PROM), postpartum hemorrhage (PPH), small for gestational age (SGA), large for gestational age (LGA), neonatal intensive care unit (NICU)

Discussion

This study demonstrated that the frequency of re-recurrent GDM for women with recurrent GDM in the third pregnancy was nearby 70%. Many studies evaluated and reported the rates of recurrence of GDM that range widely from 30 to 84%[14]. The finding of this study is reasonable since the reported average frequency of GDM recurrence was 48%[1]. Since primiparous women experienced a lower rate of GDM recurrence than multiparous women, the frequency will increased along with parity. Women with twice of GDM have cumulative damage in every additional pregnancy, such as theirβ-cell reserves are diminished[10], and therefore are at higher increased risk for GDM recurrence in third pregnancy.

The literature on risk factors for gestational diabetes mellitus recurrence is inconsistent and sometimes contradictory until now. In Israel, Schwartz N et al[15] performed a cross-sectional cohort study that included 788 women with GDM in ten years and had consecutive deliveries. The study revealed that shorter inter-pregnancy interval and less weight gain were preferable. In order to further demonstrate the role of inter-pregnancy interval and BMI gain between the pregnancies, the authors calculated two scenarios with fixed information and different combinations of the main risk factors. They got that by losing weight between the pregnancies (a reduction of 0.5 BMI units) instead of gaining weight (increase of 1.5 BMI units), and waiting one year between the pregnancies (instead of two years), the woman will have a decrease of 15 ~ 19% in the probability of GDM recurrence. A possible explanation is that among women who suffered from GDM, theβ-cell reserves are already diminished and therefore longer inter-pregnancy interval suggests a longer time in which the reserve is decreased even further. However, some studies[16, 17] found that a short interval between pregnancies were risk factors for recurrence of GDM. There are two possible explanation. One is that the damage ofβ-cell reserves caused by GDM can recover to a certain extent in some interval of inter-pregnancy, and the other is that there is no enough time to recover or lose weight, which is a protective factor for recurrence of GDM. In this study, the mean interval to first pregnancy and second pregnancy were respectively 4 years and 31 months for women with re-recurrent GDM and which were shorter than women without re-recurrent.

This study found that the level of plasma lipid and glucose during previous pregnancy and first trimester of this pregnancy may be risk factors for the recurrence of GDM. The results are consistent with some other studies [18, 19]. Higher levels of lipid and FPG are associated with insulin resistance and β-cell dysfunction. With the development of pregnancy, insulin resistance aggravate, β -Cells secrete unenough insulin, insulin sensitivity decrease and GDM recurrent at last for women with higher levels of lipid and FPG in early pregnancy

The rate of common obstetric complications showed no significant difference in re-recurrent GDM women except hypothyroidism. The relationship between hypothyroidism and GDM is still controversial. Some studies conclude that hypothyroidism during pregnancy is mostly caused by Hashimoto's thyroiditis and inflammatory factors in these patients may lead to oxidative stress injury and increase insulin resistance and cause GDM[20, 21]. The limitation of the study is that it is not clear whether hypothyroidism occurs before or after pregnancy.

We also found that the rate of admission to NICU and LGA in re-recurrent GDM was much higher. The high levels of HbA1c and FPG before delivery may explain this result, and also indicate the importance of blood glucose management for pregnant women with re-recurrent GDM.

Studies with greater numbers of subjects are required to clarify the exact re-recurrence rate of GDM. Prospective studies regarding reduction of the subsequent GDM by advice on the interval with the next pregnancy are required. Although a prospective study is required, our study demonstrates that there is a possibility that the adequate advice concerning IPI and the level of plasm of lipid and glucose could help prevent the recurrence of GDM and improve the prognosis of perinatal outcomes.

Declarations

Fundings

This work was supported by Guide Fund for the Development of Local Science and Technology from the Central Government (2020L3019), Natural Science Foundation of Fujian Province of China (2020J01314), Joint Funds for the innovation of science and Technology Fujian province (2020Y9161), Joint Funds for the innovation of science and Technology Fujian province (2020Y9134).

Ethical approval

This cohort study was approved by Ethics Committee of Fujian Maternity and Child Health Hospital (Number:2020-2049).

The access to medical records should be approved by Director, Science and Education department and Medical Records department in sequential order.

Each patient's personal information and medical record was also strictly protected.

Non-financial interests

None.

Disclosure of interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Authors'contributions

The first author XX made contributions to analysis and interpretation of data, and been involved in drafting the manuscript. GYN, LTT, XWJ ,HSY and SJX helped to get the acquisition of data, sort out data, make sure the patients meet the grouping criteria and revised the original paper on grammatical errors. YJY, as my supervisors and mentor, helped me design this study and revised the paper critically on its structure, the main findings in Results section and how to better interpret the findings in Discussion section. Moreover, all the listed authors approved the revised version to be published and agreed to be accountable for all aspects of the work.

References

1. Schwartz N, Nachum Z, Green MS. The prevalence of gestational diabetes mellitus recurrence--effect of ethnicity and parity: a metaanalysis[J]. Am J Obstet Gynecol, 2015,213(3):310-317. DOI: 10.1016/j.ajog.2015.03.011.
2. Juan J, Yang H. Prevalence, Prevention, and Lifestyle Intervention of Gestational Diabetes Mellitus in China[J]. Int J Environ Res Public Health, 2020,17(24)DOI: 10.3390/ijerph17249517.
3. Chu L, Sugiyama T, Ma R. Recent updates and future perspectives on gestational diabetes mellitus: An important public health challenge[J]. J Diabetes Investig, 2021,DOI: 10.1111/jdi.13670.
4. Al-Rifai RH, Abdo NM, Paulo MS, et al. Prevalence of Gestational Diabetes Mellitus in the Middle East and North Africa, 2000-2019: A Systematic Review, Meta-Analysis, and Meta-Regression[J]. Front Endocrinol (Lausanne), 2021,12:668447. DOI: 10.3389/fendo.2021.668447.
5. Shah BR, Feig DS, Herer E, et al. Increased risk for microvascular complications among women with gestational diabetes in the third trimester[J]. Diabetes Res Clin Pract, 2021,180:109068. DOI: 10.1016/j.diabres.2021.109068.
6. Li C, Zhou P, Cai Y, et al. Associations between gestational diabetes mellitus and the neurodevelopment of offspring from 1 month to 72 months: study protocol for a cohort study[J]. BMJ Open, 2020,10(11):e040305. DOI: 10.1136/bmjopen-2020-040305.
7. Kim C. Maternal outcomes and follow-up after gestational diabetes mellitus[J]. Diabet Med, 2014,31(3):292-301. DOI: 10.1111/dme.12382.
8. Wang YY, Liu Y, Li C, et al. Frequency and risk factors for recurrent gestational diabetes mellitus in primiparous women: a case control study[J]. BMC Endocr Disord, 2019,19(1):22. DOI: 10.1186/s12902-019-0349-4.
9. Kim C, Berger DK, Chamany S. Recurrence of gestational diabetes mellitus: a systematic review[J]. Diabetes Care, 2007,30(5):1314-1319. DOI: 10.2337/dc06-2517.
10. Guo Y, Xu X, Xu W, et al. Subsequent perinatal outcomes of pregnancy with two consecutive pregnancies with gestational diabetes mellitus: A population-based cohort study. J Diabetes. 2022 Apr 3. DOI: 10.1111/1753-0407.13263.
11. Egan AM, Enninga E, Alrahmani L, et al. Recurrent Gestational Diabetes Mellitus: A Narrative Review and Single-Center Experience[J]. J Clin Med, 2021,10(4)DOI: 10.3390/jcm10040569.

12. Morikawa M, Yamada T, Saito Y, et al. Predictors of recurrent gestational diabetes mellitus: A Japanese multicenter cohort study and literature review[J]. J Obstet Gynaecol Res, 2021,47(4):1292-1304. DOI: 10.1111/jog.14660.
13. Panel IAoDaPSGC. International Association of Diabetes and Pregnancy Study Groups Recommendations on the Diagnosis and Classification of Hyperglycemia in Pregnancy[J]. DIABETES CARE, 2015,33DOI: 10.2337/dc10-0544.
14. Filardi T, Tavaglione F, Di Stasio M, et al. Impact of risk factors for gestational diabetes (GDM) on pregnancy outcomes in women with GDM[J]. J Endocrinol Invest, 2018,41(6):671-676. DOI: 10.1007/s40618-017-0791-y.
15. Schwartz N, Green MS, Yefet E, et al. Modifiable risk factors for gestational diabetes recurrence[J]. Endocrine, 2016,54(3):714-722. DOI: 10.1007/s12020-016-1087-2.
16. Kotzaeridi G, Blätter J, Eppel D, et al. Recurrence of Gestational Diabetes Mellitus: To Assess Glucose Metabolism and Clinical Risk Factors at the Beginning of a Subsequent Pregnancy[J]. J Clin Med, 2021,10(20)DOI: 10.3390/jcm10204794.
17. Nohira T, Kim S, Nakai H, et al. Recurrence of gestational diabetes mellitus: rates and risk factors from initial GDM and one abnormal GTT value[J]. Diabetes Res Clin Pract, 2006,71(1):75-81. DOI: 10.1016/j.diabres.2005.05.011.
18. Bao W, Dar S, Zhu Y, et al. Plasma concentrations of lipids during pregnancy and the risk of gestational diabetes mellitus: A longitudinal study[J]. J Diabetes, 2018,10(6):487-495.DOI: 10.1111/1753-0407.12563.
19. Li M, Lin Q, Shi J, et al. The Impact of Lifestyle Intervention on Dietary Quality among Rural Women with Previous Gestational Diabetes Mellitus-A Randomized Controlled Study[J]. Nutrients, 2021,13(8)DOI: 10.3390/nu13082642.
20. Al-Khaldi A, Sultan S. The expression of sirtuins, superoxide dismutase, and lipid peroxidation status in peripheral blood from patients with diabetes and hypothyroidism. BMC Endocr Disord[J]. 2019. 19(1): 19.DOI: 10.1186/s12902-019-0350-y.
21. Gu L, Yang J, Gong Y, et al. Lower free thyroid hormone levels are associated with high blood glucose and insulin resistance; these normalize with metabolic improvement of type 2 diabetes. J Diabetes[J]. 2021. 13(4): 318-329. DOI: 10.1111/1753- 0407.13118

Figures

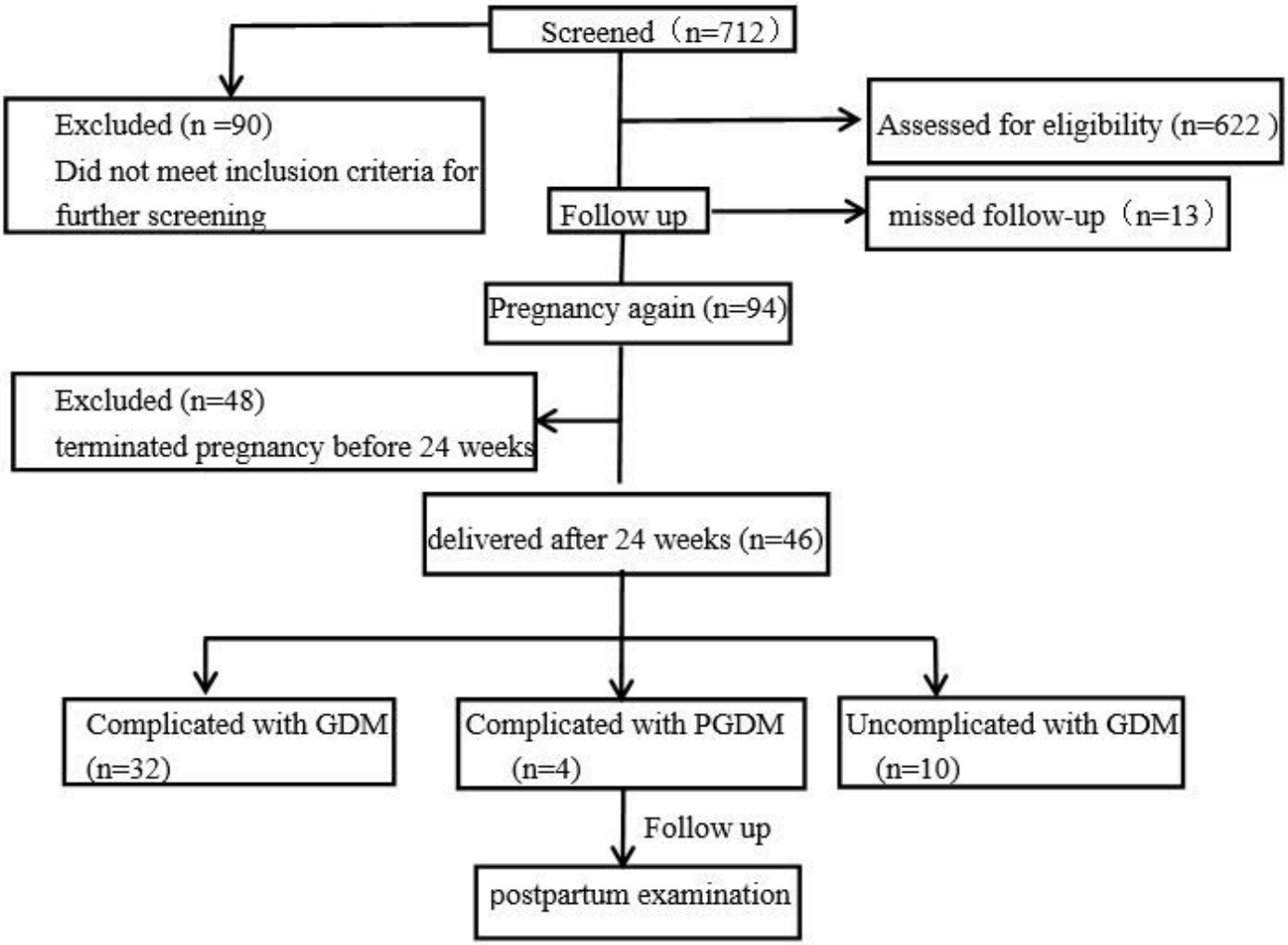

Figure 1

Flow chart of the study population. GDM, gestational diabetes mellitus