Associations of morbid obesity with late diagnosis of gestational diabetes, and with related obstetrical and neonatal outcomes

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Article

Keywords: late GDM, late OGTT, maternal obesity, macrosomia, neonatal hypoglycemia.

Posted Date: June 9th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1700136/v1

Abstract

Objective: To investigate associations of maternal obesity with late GDM diagnosis (>34 weeks) and related obstetrical and neonatal outcomes.

Study Design: This was a retrospective cohort study of 238 women who underwent late oral glucose tolerance tests (OGTT) (>34 weeks) for suspected macrosomia or polyhydramnios. Obstetrical and perinatal outcomes were stratified by GDM and morbid obesity (BMI≥35 kg/m^2) status. Obstetrical complications included pre-eclampsia, induction of labor, cesarean delivery, shoulder dystocia, and third or fourth-degree perineal tear. Neonatal outcomes included Apgar score, arterial cord pH, neonatal hypoglycemia, jaundice, the need for phototherapy, and polycythemia.

Results: Late GDM rate was 22.2% and increased the risk for macrosomia, large-for-gestational-age fetus, induction of labor; and neonatal hypoglycemia, jaundice, and need for phototherapy.

Conclusion: Adverse pregnancy outcomes are related to morbid obesity in women with late GDM; this population requires special surveillance. Repeat GDM screening beyond 34 weeks should be considered.

Introduction

The rate of obesity in women of reproductive age continues to grow [1]. According to the 2017–2018 U.S. National Health and Nutrition Examination Survey, the prevalence of obesity in women of reproductive age in the U.S. is 39.7% [2], and 8% of women of child-bearing age are extremely obese [3].

Maternal obesity and gestational diabetes mellitus (GDM) are both associated with pregnancy complication such as fetal macrosomia, shoulder dystocia, hypertension, and delivery by cesarean section (CS) [4, 5]. The worldwide increase in the prevalence of GDM has been shown to be partially explained by the increase in the incidence of obesity [6]. The risk of GDM correlates with body mass index (BMI). Women with BMI > 30 kg/m^2 have been found to have a threefold increase in GDM [6–8]; and the risk increases by 4- and 7-fold for BMI 35–40 kg/m^2 and BMI > 40 kg/m^2, respectively [8]. The American College of Obstetrics and Gynecology recommends early GDM screening before 12 weeks gestation for women with BMI > 25 kg/m^2 and one or more additional risk factors for GDM; and a repeated test, if initially negative, at 24–28 weeks gestation [9, 10].

Excessive weight gain during pregnancy is associated with a greater risk of developing GDM, macrosomia and a large-for-gestational-age (LGA) fetus [11]. Individualized guidelines are recommended for appropriate weight gain during pregnancy, based on pre-pregnancy BMI, to avoid excessive weight gain and to improve pregnancy outcomes [12]. Re-assessment of maternal BMI during the third trimester enables clinicians to further consider obesity-associated risks including GDM and macrosomia, and to appropriately plan for labor and delivery [13].

Recent studies have investigated the implications of late GDM diagnosis [14–16], when an oral glucose tolerance test (OGTT) is performed beyond the recommended 24–28 weeks gestation. Usually, late OGTT is performed based on clinical findings such as polyhydramnios or a suspected LGA fetus [16–17]. A recent study reported a late GDM diagnosis rate of 22% (> 29 weeks), of whom 36.8% were with BMI > 30 kg/m^2 [15]. Another study showed associations of abnormal near-term OGTT with both maternal and neonatal complications, and recommended that late third-trimester OGTT should be considered for the subset of women with suspected LGA fetuses or polyhydramnios [18–19]. However, only a few studies controlled for BMI in the late third trimester and examined its association with late GDM diagnosis [16]. In the current study, we aimed to investigate associations of maternal obesity with late GDM diagnosis (> 34 weeks) and with related obstetrical and neonatal outcomes.

Methods

Study design

This retrospective cohort study examined late OGTT (> 34 weeks) when performed for the evaluation of suspected macrosomia or polyhydramnios in women hospitalized in the maternal fetal unit of a tertiary hospital, between January 2017 and January 2022. The study was approved by the Institutional Review Board for clinical trials, Nahariya, Israel, 0115-20-NHR. The study was performed in accordance with the Declaration oof Helsinki.

Study population

Women were included if they had undergone late OGTT (> 34 weeks) during their hospitalization, due to a suspected LGA fetus or polyhydramnios. Exclusion criteria were a diagnosis of GDM prior the OGTT, twin pregnancy, fetal congenital malformations, and missing OGTT values. Women who underwent late OGTT (> 34 weeks) in our unit but delivered elsewhere were also excluded from the analysis.

Interpretation of the OGTT results: The diagnostic 100-gram OGTT was interpreted according to the Carpenter–Coustan criteria [20]. The test was performed in the morning after overnight fasting of at least 8 hours. Two abnormalities above the threshold: fasting – 95 mg/dL; 1-hour – 180 mg/dL; 2-hours – 155 mg/dL; and 3-hours – 140 mg/dL were considered as positive for GDM. Women with one abnormal value were further screened. Accordingly, those with risk factors for GDM such as GDM in a previous pregnancy or obesity were directly diagnosed with GDM. Following the protocol of our unit, the other women were followed with thorough capillary blood glucose tests daily (7 times per day: at fasting state, before each meal, and 2 hours after each meal). These women did not receive a special diet and were diagnosed with GDM if the follow-up curve was considered abnormal.

Women with newly diagnosed late GDM were instructed by the fetal-maternal unit team to start diet control. Pharmacological therapy was initiated when 30% of capillary blood glucose tests were above the targeted value [21].

According to our departmental protocol we induce labor at 39–40 weeks in women with impending macrosomia.

Data collection

We searched our computerized database for women who underwent late OGTT (> 34 weeks) due to suspected macrosomia or polyhydramnios. We retrieved data that included demographic details, such as age and parity, and maternal biometry. Pre-pregnancy maternal weight was collected from the pregnancy medical records. Maternal weight and height were measured at the same admission at which OGTT was performed. Gestational weight gain, pregestational BMI, and BMI during admission were calculated. OGTT timing and results were collected. All the parameters were measured using an electronic measuring instrument (Healthweigh, SHEKEL, Israel). In addition, we collected estimated fetal weight (EFW) from the computerized database. Information regarding GDM screening performance earlier in pregnancy was also retreived. Information was not available regarding first trimester fasting glucose values. Gestational age (GA) at the time of testing was calculated by the last menstrual period, or crown-to-rump length if a discrepancy of 7 days was found in the first trimester [22]. EFW was calculated by the Hadlock formula using ultrasonography, and LGA was defined as birthweight more than the 90th percentile for GA. We used the global intergrowth-21 reference of percentile distributions of birth weight, and EFW was adjusted for gender and GA [23]. Polyhydramnios was defined as amniotic fluid index above 25 cm.

Data analysis

Obstetric and perinatal outcomes were stratified by GDM status and morbid obesity (BMI ≥ 35 kg/m^2). Obstetrical complications included pre-eclampsia, induction of labor, CS, shoulder dystocia, and third or fourth-degree perineal tear. Neonatal outcomes included Apgar score at 5 min < 7, arterial cord pH < 7.1, neonatal intensive care, hypoglycemia, jaundice, the need for phototherapy, and polycythemia.

Statistical analysis

Continuous variables are presented as means ± standard deviations (SD), or as medians and range values, according to the distribution shapes of the variables. Qualitative variables are presented as frequencies and percentages. Continuous variables were compared between those with and without a diagnosis of late GDM using either the independent sample *t*-test or the Mann–Whitney test, according to the sample sizes of the groups and the distribution shapes. Categorical variables were analyzed using Pearson's chi-squared test or Fisher exact test.

The sample size was calculated using the formula for comparing two groups (paired design). Based on the findings of a previous study, in which OGTT was performed beyond 34 weeks, after an initial negative screening at 24–28 weeks, the rate of GDM diagnosis for the total sample was 10% [16]. An effect size of 20% was considered as significant between women with normal weight and with obesity. According to previous studies, the rate of obesity in pregnancy is about 30% [6–8, 24]. With alpha = 0.05, power of 90%,

the sample size calculated was 216 (at least 50 women with obesity and 166 without obesity). A two-tailed *p* value of < 0.05 was considered statistically significant.

The statistical analyses were performed using IBM SPSS Statistics for Windows, version 27.0 (IBM Corp., Armonk, NY, USA).

Results

During the study period, late OGTT (> 34 weeks) was performed in 250 women who were admitted to the maternal-fetal medicine unit due to a suspected LGA fetus or polyhydramnios. Two women had twin pregnancies, 7 had delivered elsewhere, and 3 had missing OGTT values and were therefore excluded from the statistical analysis. Of the 238 women included in the analysis, 75 had BMI ≥ 35 kg/m^2 at OGTT, and 163 had BMI < 35 kg/m^2; this corresponded with our sample size calculation. Figure 1 presents a flow chart of the study population.

GDM diagnosis

Of the 238 women included in the analysis, 53 (22.3%) were diagnosed with GDM. Fifty women (94.3%) required only dietary intervention and the remaining three (5.7%) required pharmacological therapy for glucose control. For 108 women, OGTT was performed due to polyhydramnios (45.4%); and for 130 (54.6%), due to a suspected LGA fetus. The rate of GDM diagnosis was 21.2% among women who performed OGTT due to polyhydramnios, and 23.1% among women who performed OGTT due to a suspected LGA fetus (p = 0.742). The rate of GDM diagnosis among women with a previous normal GDM screening was 20.7%; and among those who did not perform previous screening, 25.6% (p = 0.404).

Patient characteristics stratified by GDM status are shown in Table 1. Statistically significant differences were not observed in maternal age, parity, family history of diabetes mellitus, or previous history of macrosomia, between those with and without late GDM. Women diagnosed with late GDM were more likely to have had GDM in a previous pregnancy (p = 0.01). Overall, 63 women (26.5%) had pregestational BMI ≥ 30 kg/m^2; 16 (6.7%) had BMI ≥ 35 kg/m^2. The rates of pregestational BMI ≥ 30 kg/m^2 and ≥ 35 kg/m^2 were higher in women with than without GDM (p = 0.01 and p = 0.032, respectively). The proportions of women diagnosed with GDM were 34.9% and 43.7% among those with BMI ≥ 30 kg/m^2 and BMI ≥ 35 kg/m^2, respectively.

Table 1
Characteristics of women who performed late oral glucose tolerance tests, according to gestational diabetes mellitus (GDM) status.

	GDM n = 53	No GDM n = 185	p-value
Age, years	32.30 ± 5.44	32.16 ± 5.37	0.900
Parity	2 (0–6)	2 (0–10)	0.881
History of diabetes in a first-degree family member	10 (18.9%)	36 (19.5%)	1
Previous history of macrosomia	43 (81.1%)	28 (15.1%)	0.526
GDM in a previous pregnancy	3 (5.7%)	1 (0.5%)	0.01
Normal GCT in current pregnancy	34 (64.2%)	130 (70.3%)	0.404
Pregestational biometry			
Pregestational weight (kg)	74.87 ± 21.31	70.14 ± 14.63	0.024
Pregestational BMI (kg/m^2)	28.07 ± 7.30	26.26 ± 5.16	0.04
Pregestational BMI ≥ 30 kg/m^2	22 (41.5%)	41 (22.2%)	0.01
Pregestational BMI ≥ 35 kg/m^2	7 (13.2%)	9 (4.9%)	0.032
At OGTT biometry			
Weight at OGTT (grams)	90.34 ± 18.36	86.21 ± 16.55	0.706
BMI (kg/m^2) at OGTT	33.66 ± 6.16	32.33 ± 5.76	0.578
BMI at OGTT ≥ 30 kg/m^2	35 (66.0%)	116 (62.7%)	0.747
BMI at OGTT ≥ 35 kg/m^2	25 (47.2%)	50 (27.0%)	0.007
Weight gain, kg	15.61 ± 7.98	15.87 ± 9.03	0.976
Height, cm	163.33 ± 5.24	163.22 ± 6.28	0.207
EFW percentile	86.76 ± 19.41	78.7082 ± 25.25	0.049
EFW percentile > 90%	40 (75.5%)	100 (54.1%)	0.007
Polyhydramnios (%)	23 (43.4%)	93 (50.3%)	0.437
Delivery week	39.31 ± 1.035	39.46 ± 1.44	0.105

GCT- glucose challenge test, BMI- body mass index, OGTT-oral glucose tolerance test, EFW- estimated fetal weight.

The data are presented as mean ± standard deviation or as median (range) or as number (percentage).

Maternal BMI at the time of late OGTT (> 34 weeks) was significantly higher than pregestational BMI; 151 (63.4%) women had BMI ≥ 30 kg/m^2, and 75 (31.5%) had BMI ≥ 35 kg/m^2. Women with late GDM had a higher rate of BMI ≥ 35 kg/m^2 (p = 0.007). The risk of late GDM diagnosis according to BMI at OGTT performance was 23.2% among women with BMI ≥ 30 kg/m^2, and 33.3% according to the cutoff of BMI ≥ 35 kg/m^2. Weight gain during pregnancy, maternal height, and previous GDM screening did not differ between women with versus without late GDM diagnosis. EFW and EFW percentile were higher in the late GDM than non-GDM group, while the rate of polyhydramnios was not different. Delivery week was similar between the groups, and all the women delivered at term.

Late GDM outcomes – obstetrical

Among women with compared to without late GDM, rates were higher of mean birthweight percentile (87.74 ± 21.06 vs. 76.51 ± 25.07, p = 0022), macrosomia (47.2% vs. 24.3%, p = 0.002), a LGA fetus (73.6% vs. 37.83%, p = 0.001) and induction of labor (47.1% vs. 28.1%, p = 0.02). Obstetrical complications including pre-eclampsia, shoulder dystocia, and third or fourth degree perineal tear were similar between the groups (Table 2). Among women with versus without a late GDM diagnosis, the odds ratio (OR) for macrosomia was 2.77 (95% confidence interval [CI] = 1.47–5.24, p = 0.002); for a LGA fetus, 4.57 (95% CI 2.32–9.02 p < 0.001); and for induction of labor, 2.28 (95% CI = 1.20–4.27, p = 0.01).

Table 2
Outcomes for women with and without late gestational diabetes mellitus (GDM) (> 34 weeks)

	GDM, n = 53	No GDM, n = 185	p-value
Birthweight (grams)	3908.32 ± 418.33	3677.85 ± 498.52	0.085
Birthweight percentile	87.74 ± 21.06	0	0.022
Macrosomia > 4000 grams	25 (47.2%)	45 (24.3%)	0.002
Birthweight > 4500 grams	3 (5.7%)	16 (8.6%)	0.772
LGA > 90% (intergrowth-21) [23]	39 (73.6%)	70 (0	< 0.001
Cesarean section	28 (52.8%)	76 (41.0%)	0.158
Induction of labor	25 (44.6%)	52 (28.1%)	0.02
Shoulder dystocia	0 (0%)	1 (0.5%)	1
Pre-eclampsia	2 (3.8%)	2 (1.1%)	0.215
3rd or 4th degree perineal tear	0 (0%)	1 (0.5%)	1
Neonatal outcomes			
Cord pH < 7.1	1(1.9%)	2 (1.1%)	0.642
Apgar 5 < 7	2 (3.8%)	5 (2.7%)	0.684
Hypoglycemia	11 (20.8%)	8 (4.3%)	0.001
Polycythemia	1 (1.9%)	3 (1.6%)	1
Jaundice	29 (54.7%)	71 (38.4%)	0.04
Need for phototherapy	9 (17.0%)	12 (6.5%)	0.026
NICU admission	2 (3.8%)	9 (4.9%)	1
Hospitalization length (days)	3.60 ± 2.92	3.63 ± 2.04	0.965
Respiratory distress	2 (3.8%)	7 (3.8%)	1
Need for ventilation support	2 (3.8%)	7 (3.8%)	1

GDM – gestational diabetes mellitus, LGA – large for gestational age, NICU – neonatal intensive care unit.

The data are presented as mean ± standard deviation or as number (percentage).

Late GDM outcomes – neonatal

Among neonates born to women with than without a late GDM diagnosis, rates were higher of hypoglycemia (20.8% vs. 4.3%, p = 0.001), jaundice (54.7% vs 38.4%, p = 0.04) and the need for

phototherapy (17% vs. 6.5%, p = 0.026). Neonatal parameters such as cord pH < 7.1, Apgar score 5 < 7, admission to the neonatal intensive care unit (NICU), hospitalization length, respiratory distress and the need for ventilation did not differ according to late GDM diagnosis. Among neonates of women with versus without a late GDM diagnosis, the OR for neonatal hypoglycemia was 11.38 (95%CI 4.58–28.22, p < 0.001); for neonatal jaundice, 1.94 (95%CI 1.05–3.56, p = 0.035); and for the need for phototherapy, 2.95 (95%CI 1.17–7.44, p = 0.022).

The association of morbid obesity (BMI ≥ 35 kg/m^2) with late GDM diagnosis and outcomes

The OR for late GDM among women with morbid obesity (BMI ≥ 35 kg/m^2) at OGTT > 34 weeks was 3.3 (95%CI = 1.45–7.49, p = 0.035). The OR for late GDM among women with BMI ≥ 30 kg/m^2 was not statistically significant, 1.97 (95%CI = 0.945–3.88, p = 0.071). Thus, the cut-off of BMI ≥ 35 kg/m^2 was chosen for a subgroup analysis. The results of a sub-group analysis stratified by late GDM status and morbid obesity status (BMI ≥ 35 kg/m^2) are shown in Table 3 and Fig. 2. Among women with morbid obesity, the proportion of those who performed previous GDM screening at 24–28 weeks was similar between those with or without late GDM (80% vs. 72%, p = 0.452). Higher mean birthweight was observed among women with morbid obesity and a late GDM diagnosis (4008.84 ± 312.48) than among women with morbid obesity without GDM (3816 ± 410.34, p = 0.043), and than among those without morbid obesity yet with a late GDM diagnosis (3810 ± 406, p = 0.023). The rate of macrosomia was higher among women with morbid obesity and with a late GDM diagnosis (64%) than among women with morbid obesity without GDM (26%, p = 0.002), and than among those without morbid obesity yet with late GDM (32%, p = 0.001). The rate of LGA fetuses was higher among women with morbid obesity and a late GDM diagnosis (84%) than among those with morbid obesity and without GDM (44%, p > 0.001), and than among those without morbid obesity yet with late GDM (36%, p < 0.001). The rate of induction of labor was higher among women with morbid obesity and late GDM (60%) than among those with morbid obesity and without late GDM (21%, p = 0.002). The rate of induction of labor of those with morbid obesity and late GDM was higher, though without statistical significance, than among those without morbid obesity yet with late GDM (60% vs. 36%, p = 0.077). The rates of CS were similar between the groups. The rates of neonatal complications were similar between the groups except for the rate of neonatal hypoglycemia, which was higher among women with morbid obesity and late GDM than among women with morbid obesity and without late GDM (28% vs 8%, p = 0.021).

Table 3

Subgroup analysis stratified by GDM status and BMI ≥ 35 kg/m^2 at late OGTT (> 34 weeks)

	Morbid obesity with late GDM (1) N = 25	Morbid obesity without late GDM (2) N = 50	No morbid obesity, with GDM (3) N = 28	p-value 1 vs. 2	p-value 1 vs. 3
Normal screening at 24–28 weeks	20 (80%)	36 (72%)	14 (50%)	0.452	< 0.001
Birthweight (gram)	4008.84 ± 312.48	3816 ± 410.34	3810 ± 406	0.043	0.023
Macrosomia (> 4000 gram)	16 (64%)	13 (26%)	9 (32.1%)	0.002	0.001
LGA (90%)	21 (84%)	22 (44%)	10 (35.7%)	< 0.001	< 0.001
Induction of labor	15 (60%)	11 (22%)	10 (35.7%)	0.002	0.077
Cesarean section	12 (48%)	23 (46%)	13 (46.4%)	1	0.90
Elective cesarean section	8 (32%)	13 (26%)	8 (28.6%)	0.569	0.786
Neonatal outcomes					
Hypoglycemia	7 (28%)	4 (8%)	4 (14%)	0.021	0.219
Polycythemia	1 (4%)	0 (0%)	0 (0%)	0.333	0.471
Jaundice	16 (64%)	23 (46%)	13 (46%)	0.141	0.199
Phototherapy	4 (16%)	6 (12%)	5 (18%)	630	0.857
NICU administration	2 (8%)	1 (2%)	0 (0%)	0.256	0.217
Hospitalization length	4 ± 2.92	3.56 ± 2.10	3.14 ± 1.33	0.505	0.227
Respiratory distress	2 (8%)	2 (4%)	0 (0%)	0.597	0.217
Need for ventilatory support	2 (8%)	2 (4%)	0 (0%)	0.597	0.217

GDM – gestational diabetes mellitus, OGTT- oral glucose tolerance test, LGA – large for gestational age, NICU – neonatal intensive care unit.

Discussion

Main findings

Among women who underwent late OGTT (> 34 weeks) due to suspected LGA or polyhydramnios, the late GDM rate was 22.2%. The GDM rate was similar for both indications. Factors associated with late GDM diagnosis included a personal history of GDM in a previous pregnancy, pre-pregnancy BMI ≥ 30 kg/m^2, and BMI ≥ 35 kg/m^2 at late OGTT (> 34 weeks). The results were similar between women who did and did not undergo previous screening for GDM in the current pregnancy. Late GDM diagnosis increased the risk for macrosomia, LGA, and induction of labor; and for neonatal complications including hypoglycemia, jaundice, and the need for phototherapy. Women with morbid obesity and with a late GDM diagnosis had higher susceptibility to macrosomia and neonatal hypoglycemia than women with only one of these conditions.

Comparison with previous studies

A previous three-year retrospective study by our group [15] included women who performed OGTT beyond 29 weeks for various indications, not only suspected LGA and polyhydramnios. The rate of late GDM diagnosis was similar (22%). Late GDM was correlated with higher rates of LGA, labor induction, and CS, although no correlation with macrosomia was demonstrated. In the current five-year study, only women who performed OGTT beyond 34 weeks were included, and data regarding maternal biometry and neonatal outcomes were added. In contrast to our previous findings [15], in the current study we demonstrated higher rates of macrosomia in late GDM diagnosis. This might be explained by the higher rate of OGTT performed due to suspected LGA in this compared with the previous study (54.6% vs 33.9%). Another explanation might be the proximity to term. In a prospective study by Kandauda et al [16], OGTT was repeated beyond 34 weeks regardless of risk factors. The late GDM rate was lower than that reported herein (8.2% vs. 22.2%). The discrepancy could be due to differences between the study populations. In the current study, the OGTT was performed in a high-risk population and not routinely for pregnant women. The increased rate of labor induction was similar to previously reported rates [14–15]. The rate of CS was not increased in women with late GDM, possibly due the increased rate of labor induction. However, in a previous study that examined labor induction at 39 weeks for impending macrosomia, the rate of CS was decreased [25].

Controversy continues regarding the impact of late GDM diagnosis on neonatal outcomes. Previous studies showed higher pooled rates of neonatal complications [19]; and higher rates of low APGAR score at 1 min, NICU admission [26], and hypoglycemia [27]. However, significant neonatal complications were not shown in late GDM diagnosis [28, 29]. We found higher rates of neonatal hypoglycemia, jaundice, and the need for phototherapy. Maternal obesity was shown to be related to a higher incidence of neonatal hypoglycemia and jaundice [30, 31]. The relatively high proportion of women with obesity in our sample may explain the discrepancy in results.

The association of BMI with late GDM diagnosis

Late GDM was diagnosed at a higher rate among women with than without morbid obesity; the conjunction of late GDM and morbid obesity conferred higher rates of macrosomia, LGA, induction of labor, and neonatal hypoglycemia.

Pregnancy in women with obesity is associated with significant increases in fat mass, basal metabolic rate and reliance on lipids; the latter is accompanied by a concomitant decrease in carbohydrate metabolism [32]. Leptin, an adipocytokine produced by adipose tissue, has a major role in GDM development [33], and is believed to act as a pro-inflammatory cytokine [34]. Serum leptin concentrations correlate with BMI and the percentage of body fat in humans; and are associated with GDM, pre-eclampsia, and macrosomia [33]. TNF-*α*, another adipocytokine, has also been studied as a contributor to GDM development. TNF-*α* is produced under the condition of insulin resistance, which aggravates inflammation and metabolic dysfunction [35]. TNF-*α* also suppresses the production of adiponectin by adipocytes. Because of the insulin-sensitizing effects, low levels of adiponectin might further aggravate insulin resistance in GDM. These factors produce a vicious cycle in which GDM eventually develops [35].

Hendler et al. [36] demonstrated that maternal leptin levels in the third trimester are increased in women with obesity. However, Carlhäll S et al [33] showed higher leptin levels during and after pregnancy in women with morbid obesity compared to women with obesity class I (BMI 30–35 kg/m^2). These results might explain the mechanism behind the significantly increased GDM rate among women with morbid obesity (class 2 obesity) in the late third trimester compared with class 1 obesity, as we demonstrated.

Limitations and strengths

First, the retrospective design is a limitation of the study. Second, as the OGTT test was performed in high-risk women, the conclusions do not apply to all pregnant women. Additionally, we do not have follow-up data on postpartum screening results. Subgroup analysis for BMI status is a strength of the study. To our knowledge, we are the first to include such analysis in late GDM diagnosis. Furthermore, we focused on various neonatal outcomes such as hypoglycemia, jaundice, and the need for phototherapy, which were not investigated in most previous studies.

Clinical interpterion

The highest rates of GDM (33%) and macrosomia (64%) were demonstrated in women with morbid obesity who presented with polyhydramnios or suspected LGA in the late third trimester. The late GDM diagnosis resulted in targeted medical intervention, including diet and pharmacological therapy, and planned labor induction. The latter may have lowered the rates of CS, which eventually were not increased.

The study results support repeating the OGTT at > 34 weeks in women with morbid obesity, as previous GDM screening did not affect the incidence of late GDM diagnosis among women with obesity. Therefore, routine additional late OGTT should be considered in women with BMI ≥ 35 kg/m^2, even in the absence of additional risk factors (polyhydramnios and suspected LGA).

Among women with GDM and morbid obesity, rates of macrosomia and LGA were higher than among those with only one of these conditions. The rate of shoulder dystocia was not higher, possibly due to the relatively small sample size and the increase in labor induction upon impending macrosomia. Newborns of women with morbid obesity and late GDM had a higher risk for neonatal hypoglycemia, which usually develops in the first 24 hours. Hypoglycemia can be asymptomatic or accompanied by non-specific symptoms. Late GDM diagnosis enables early neonatal diagnosis and treatment, including early feeding, blood glucose monitoring, and ongoing assessment of the clinical condition [37].

Finally, women with morbid obesity and late GDM are at increased risk for type 2 diabetes mellitus in the long term, compared to women with either morbid obesity or GDM [38]. Diagnosing GDM in the late third trimester represents an opportunity for advising this population to adopt a healthy lifestyle. Maternal weight management during the postpartum period should be advised, especially for those with higher BMI [38].

Conclusion

Higher rates of late GDM and macrosomia were demonstrated in women with morbid obesity who underwent OGTT at > 34 weeks gestation. Previous GDM screening did not affect the incidence of late GDM in women with morbid obesity. Further prospective studies are needed to examine the utility of repeat OGTT in women with obesity or morbid obesity, regardless of risk factors.

Declarations

Conflicts of interest: None of the authors has a conflict of interest related to this work.

Availability of Data and Materials: Data will be available upon reasonable request to the corresponding author.

***Funding*:** The authors declare that no funding was received by any source for this study.

Author Contributions:

R. Abu Shqara- Protocol/project development, data collection, data analysis, manuscript writing

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Y. Wiener- Manuscript editing,

L. Lowenstein - Manuscript editing, interpretation of the data

M. Frank Wolf - Protocol/project development, data analysis, manuscript editing.

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Figures

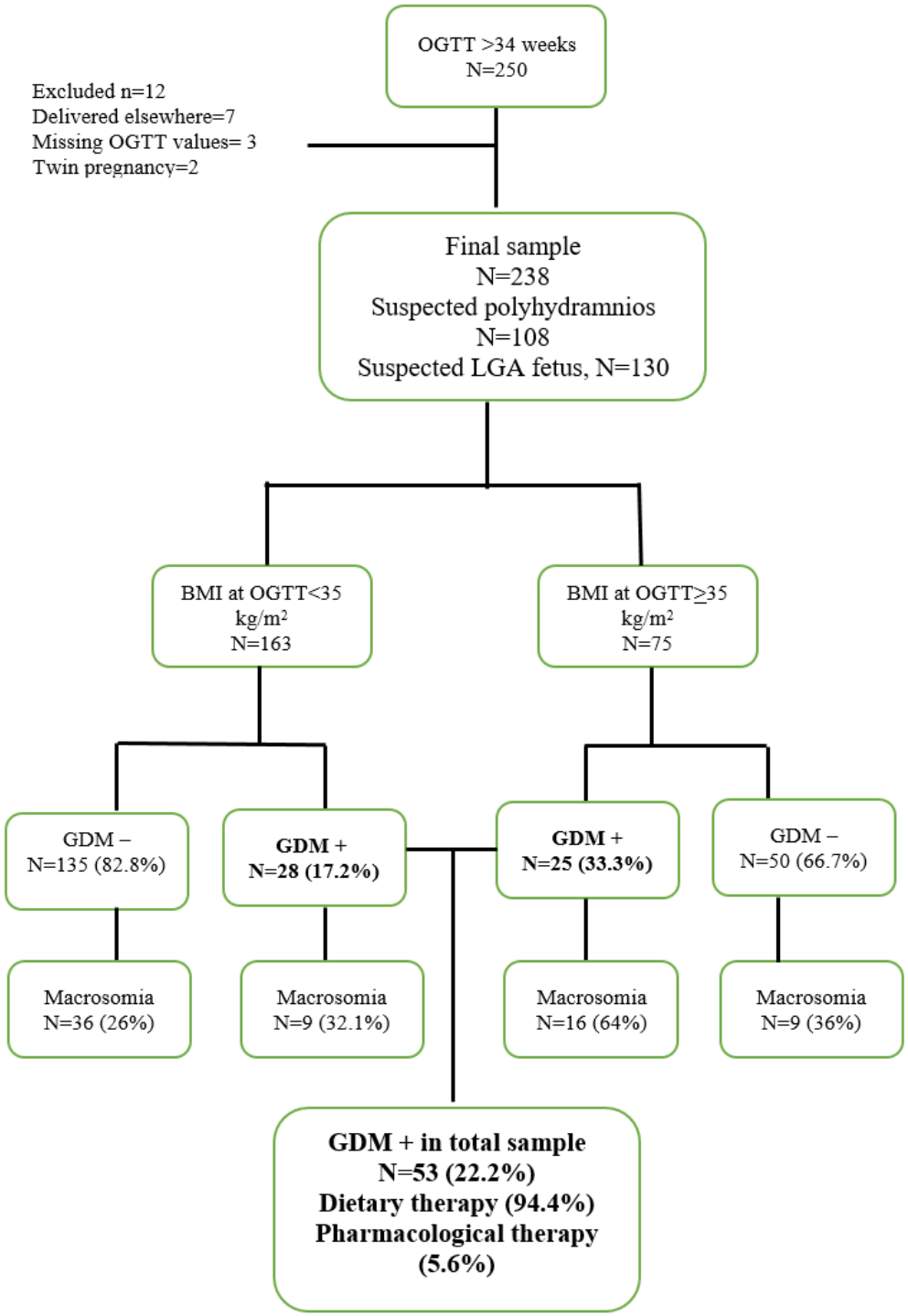

Figure 1

Flow chart of the study population

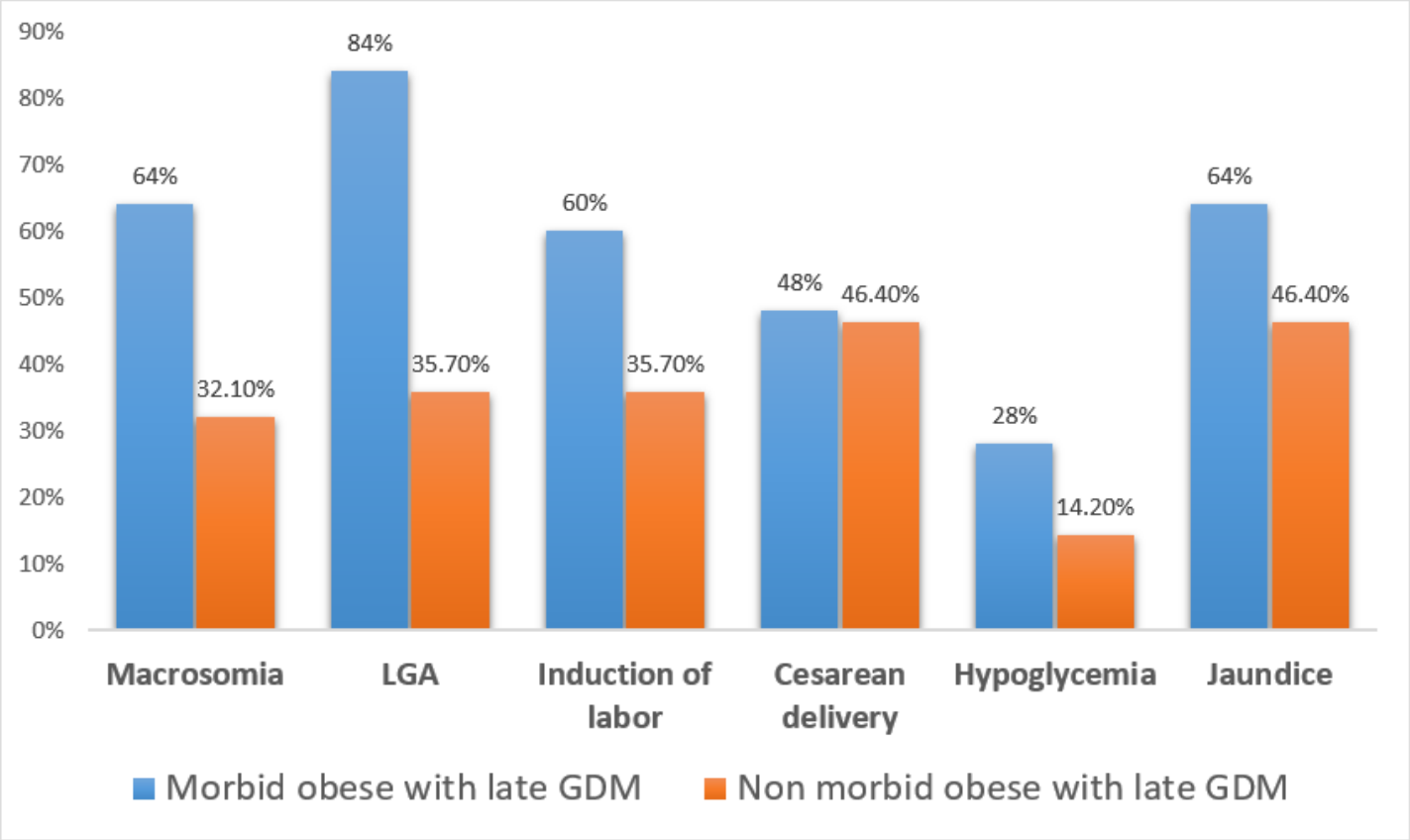

Figure 2

Obstetrical and neonatal outcomes of women with a late diagnosis of gestational diabetes, stratified by morbid obesity status

GDM- gestational diabetes mellitus, LGA- large for gestational age.