Peripartum and Perinatal Outcomes in Pregnant Women with Elevated Preconceptional Body Mass Index in a Maternity Hospital (Care Level IV)

Peripartales und perinatales Outcome bei präkonzeptionell erhöhtem Body-Mass-Index in einer Geburtsklinik (Versorgungsstufe IV)

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ABSTRACT

Introduction

Preconception obesity is a risk factor for pregnancy and delivery, which is why giving birth in a perinatal center (care levels I and II) is recommended. There are currently no studies which have investigated the birth outcomes of obese patients based on the care level of the maternity hospital. This study aims to assess the effect of a higher body mass index prior to conception on maternal and fetal outcomes in a maternity hospital (care level IV).

Patients and Methods

A total of 5616 pregnant women who gave birth between 2016 and 2023 were investigated in this retrospective cohort study, after taking the inclusion and exclusion criteria into account. Primary outcome parameter of this study was the transfer of the neonate to a neonatal intensive care unit. Other target parameters were the need to induce labor, delivery mode, Apgar score and pH value, and the incidence of complications (shoulder dystocia, higher-degree perineal tears, or peripartum hemorrhage).

Results

Overweight and obesity were associated with a higher rate of hypertensive disorders of pregnancy and gestational diabetes and were accompanied by higher rates of induction of labor and elective and secondary caesarean sections. Maternal outcome parameters such as intrapartum fever, preterm placental abruption, uterine rupture, higher-degree birth injuries and peripartum hemorrhage did not occur significantly more often in obese pregnant women. Fetal outcome parameters such as Apgar score and pH value did not differ from those reported for normal-weight pregnant women.

Multivariate regression analysis showed a high risk of transfer to a neonatal intensive care unit (OR = 1.97; p = 0.035) for neonates born to women in obesity class II (BMI 35–39.9 kg/m^2), women with gestational diabetes (OR = 1.71; p = 0.033), and nulliparous women (OR = 1.59; p = 0.005).

Conclusion

Obesity class II is associated with a slightly higher risk of transfer of the neonate to a pediatric intensive care unit but is not associated with worse Apgar scores or pH values. Pregnant women with a body mass index between 35 and 40 kg/m^2 should be informed of this and should consider giving birth in a facility with a neonatal department (care level I–III).

ZUSAMMENFASSUNG

Einleitung

Eine präkonzeptionelle Adipositas stellt ein Risiko für die Schwangerschaft und Geburt dar, weswegen die Geburt in einem Perinatalzentrum (Versorgungsstufen I und II) empfohlen wird. Studien, die das Outcome bei Geburten adipöser Patientinnen in Abhängigkeit von der Versorgungsstufe der Geburtsklinik untersuchten, liegen bislang nicht vor. Das Ziel dieser Arbeit ist, den Einfluss eines präkonzeptionell erhöhten Body-Mass-Indexes auf das maternale und fetale Outcome in einer Geburtsklinik (Versorgungsstufe IV) zu evaluieren.

Patientinnen und Methoden

In dieser historischen Kohortenstudie wurden zwischen 2016 und 2023, nach Berücksichtigung der Ein- und Ausschlusskriterien 5616 Schwangere untersucht. Primärer Outcome-Parameter dieser Studie war die Verlegung des Neugeborenen auf eine neonatologische Intensivstation. Weitere Zielgrößen waren unter anderem die Notwendigkeit einer Geburtseinleitung, der Geburtsmodus, Apgar- und pH-Werte sowie das Vorkommen von Komplikationen (Schulterdystokie, höhergradige Dammrisse oder peripartale Hämorrhagie).

Ergebnisse

Übergewicht und Adipositas waren mit einem Anstieg von hypertensiven Schwangerschaftserkrankungen und Gestationsdiabetes verbunden und gingen mit einer höheren Rate an Geburtseinleitungen, elektiven sowie sekundären Kaiserschnitten einher. Maternale Outcome-Parameter wie Fieber unter Geburt, vorzeitige Plazentalösung, Uterusruptur, höhergradige Geburtsverletzungen sowie eine peripartale Blutung traten bei adipösen Schwangeren nicht signifikant häufiger auf. Fetale Outcome-Parameter wie Apgar- und pH-Werte unterschieden sich nicht zu denen normgewichtiger Schwangerer. Die multivariate Regressionsanalyse ergab ein erhöhtes Risiko für eine Verlegung des Neugeborenen auf eine Intensivstation (OR = 1,97; p = 0,035) bei Adipositas Grad 2 (BMI 35–39,9 kg/m^2), Gestationsdiabetes (OR = 1,71; p = 0,033) und Nulliparität (OR = 1,59; p = 0,005).

Schlussfolgerung

Adipositas Grad 2 ist mit einem gering erhöhten Risiko für eine Verlegung des Neugeborenen auf eine pädiatrische Intensivstation verbunden, jedoch nicht mit schlechteren Apgar- oder pH-Werten. Schwangere mit einem Body-Mass-Index zwischen 35 und 40 kg/m^2 sollten hierüber informiert werden und die Entbindung in einer Einrichtung mit Kinderklinik (Versorgungsstufe I–III) in Erwägung ziehen.

Introduction

The numbers of overweight and obese women in countries with high and medium incomes has risen [1, 2]. In Germany, the percentage is currently 43.8 % [3]. The increase in the prevalence of obesity is particularly significant among young women aged between 18 and 29 years [4].

Obesity is defined as an increase in body fat beyond normal levels [5] and is based on the body mass index (BMI). BMI stands for the ratio of weight to height squared (kg/m^2) and is used by the international WHO weight classification for adults to differentiate between weight categories [6, 7].

Obese pregnant women are considered a high-risk group because of the higher risk of complications, both in pregnancy and during and after the birth. A recent meta-analysis which investigated the impact of maternal preconception BMI on maternal, fetal, and neonatal outcomes was able to show that overweight and obese mothers have a higher risk of induction of labor, caesarean section, gestational diabetes, gestational hypertension, preeclampsia, and postpartum hemorrhage compared to mothers with a normal BMI. Moreover, there is also a higher probability that neonates born to obese mothers will be transferred to a neonatal intensive care unit, have a 5-minute Apgar score of less than 7 and will be large for gestational age (LGA) [8]. Preconception obesity of the mother prior to pregnancy also increases the risk of shoulder dystocia [9].

Because of these risks, the AWMF guideline *Obesity and Pregnancy* (Registry Nr. 015–081) recommends that pregnant women with a preconception BMI of between 30–35 kg/m^2 consider their individual risks with regards to the place they wish to give birth and that pregnant women with a preconception BMI of > 35 kg/m^2 give birth in a perinatal center [5].

In accordance with the Quality Assurance Directive for Preterm and Term-born Neonates issued by the Joint National Committee of Germany, a perinatal center corresponds to care levels I and II [10]. The Quality Assurance Directive for Preterm and Term-born Neonates also regulates the admission and allocation criteria to a facility with the appropriate level of care. Other perinatal care facilities in Germany are hospitals with a perinatal department (care level III) and maternity hospitals (care level IV).

At present, no studies have investigated fetal and maternal outcomes of obese patients according to the care level of the birthing facility [5]. This study therefore aims to evaluate what impact a higher BMI has on maternal and fetal outcomes in a maternity hospital.

Patients and Method

Study design

This retrospective cohort study investigated the impact of preconception body mass index on maternal and neonatal outcomes in a maternity hospital. To do this, data obtained in accordance with the data-based cross-institutional quality assurance directive (DeQS-RL), which is mandatory in Germany, were analyzed. All liveborn singletons born at term (37 + 0 to 41 + 6 weeks of gestation) delivered between February 2016 and December 2023 in a maternity hospital (care level 4) were included. Cases where no information about BMI was available and women who were underweight (BMI < 18.5 kg/m^2) were excluded (▶ **Fig. 1**). Because of the more restrictive admission criteria for pregnant women with a BMI ≥ 40 kg/m^2, and the limited case numbers in this group (n = 47), these cases were also excluded. The data for each pregnancy of women who gave birth more than once in the maternity hospital over the course of the study were included.

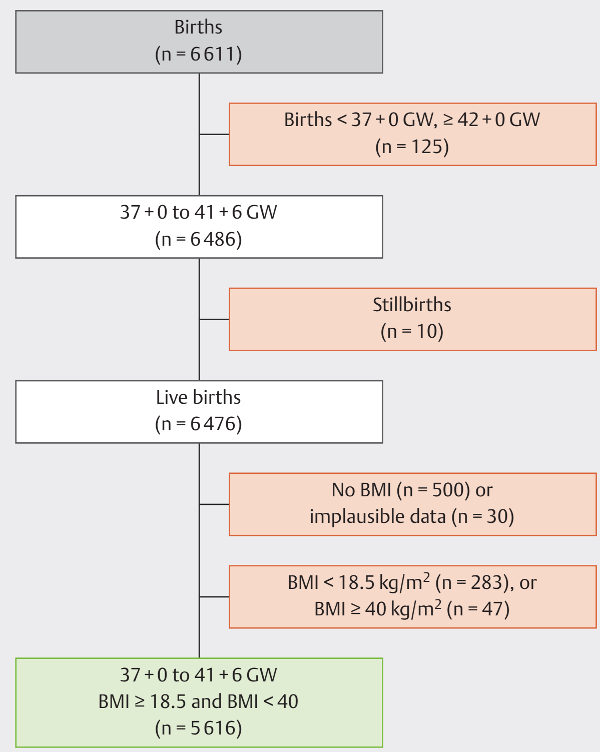
Patient population

The pregnant women who gave birth in our maternity hospital were a low-risk population. Low-risk pregnancies are defined as pregnancies for which no increased risks for the mother and/or the fetus have been identified and who do not require an intervention [11]. Pregnant women with imminent preterm birth before 36 + 0 weeks of gestation, with multiple pregnancy, who wished to delivery vaginally with breech presentation, where the estimated fetal weight was less than the 10 th percentile, with gestational diabetes requiring treatment with insulin, with preeclampsia, or with severe general disease requiring treatment were recommended to give birth in a hospital with the appropriate level of care.

All processes, from admission for delivery to the birth, were regulated by standard operating procedures (SOP).

Gestational age was determined based on the last menstrual period and was confirmed or corrected using biometric measurements carried out in early pregnancy in accordance with current recommendations [12].

Preconception BMI was calculated based on the height of the pregnant woman and the information she provided about her weight prior to the pregnancy. The women were categorized into four groups based on the international WHO weight classification for adults (▶ **Table 1**): normal weight (N), overweight (OV), obesity class I (O1) and obesity class II (O2).



▶ **Fig. 1** Flowchart – Patient cohort of a maternity hospital (care level IV) after application of inclusion and exclusion criteria.

▶ **Table 1** WHO weight classes for adults according to BMI [6, 7].

Category	**BMI (kg/m^2)**
Underweight	< 18.5
Normal weight (N)	18.5–24.9
Overweight (OV)	25.0–29.9
Obesity class I (O1)	30–34.9
Obesity class II (O2)	35–39.9
Obesity class III	≥ 40

Primary and secondary target parameters

The primary outcome parameter for this study was transfer of the neonate to a neonatal intensive care unit. Other target parameters were the need to induce labor, the delivery mode, the birth weight, the 5-minute Apgar score, arterial cord blood pH and arterial base excess and, for maternal outcomes, uterine rupture, preterm placental abruption, intrapartum fever, shoulder dystocia, higher-degree perineal tear (grade 3 or 4) and the occurrence of peripartum hemorrhage, defined as a blood loss of > 500 ml for vaginal delivery or > 1000 ml after caesarean section [13].

▸Table 2 Demographic and clinical characteristics of mothers in the different weight groups.

	Group N	Group OV	Group O1	Group O2	P value (OV vs. N)	P value (O1 vs. N)	P value (O2 vs. N)
All	3773 (100 %)	1222 (100 %)	464 (100 %)	157 (100 %)			
Age	M 31.19 (SD 4.81)	M 31.12 (SD 5.02)	M 31.69 (SD 4.93)	M 30.78 (SD 5)	0.667	0.039	0.317
Age > 35 years	715 (19 %)	240 (19.6 %)	100 (21.6 %)	27 (17.2 %)	0.624	0.201	0.656
Nulliparity	2105 (55.8 %)	601 (49.2 %)	210 (45.3 %)	62 (39.5 %)	< 0.001	< 0.001	< 0.001
Previous caesarean section (percentages in relation to para > 0)	393/1668 (23.6 %)	166/621 (26.7 %)	94/254 (37 %)	43/95 (45.3 %)	0.13	< 0.001	< 0.001
Gestational age	M 39.81 (SD 1.05)	M 39.83 (SD 1.11)	M 39.81 (SD 1.1)	M 39.69 (SD 1.14)	0.544	0.99	0.194
Hypertensive disorders of pregnancy	70 (1.9 %)	47 (3.8 %)	38 (8.2 %)	18 (11.5 %)	< 0.001	< 0.001	< 0.001
▪ chronic hypertension	5 (0.1 %)	3 (0.2 %)	8 (1.7 %)	7 (4.5 %)	0.414	< 0.001	< 0.001
▪ gestational hypertension	30 (0.8 %)	18 (1.5 %)	21 (4.5 %)	8 (5.1 %)	0.052	< 0.001	< 0.001
▪ preeclampsia	38 (1 %)	27 (2.2 %)	10 (2.2 %)	3 (1.9 %)	0.002	0.049	0.224
▪ HELLP syndrome	3 (0.1 %)	2 (0.2 %)	0 (0 %)	0 (0 %)	0.602	1	1
Gestational diabetes	147 (3.9 %)	93 (7.6 %)	54 (11.6 %)	15 (9.6 %)	< 0.001	< 0.001	0.001
▪ not requiring insulin	145 (3.8 %)	89 (7.3 %)	49 (10.6 %)	14 (8.9 %)	< 0.001	< 0.001	0.003
▪ requiring insulin	2 (0.1 %)	4 (0.3 %)	5 (1.1 %)	1 (0.6 %)	0.035	< 0.001	0.115

Numbers are shown as absolute and relative frequencies for the respective weight group. Continuous variables are presented as mean (M) and standard deviation (SD). P values are for descriptive purposes only. vs. = versus; Normal weight (N), Overweight (OV), Obesity class 1 (O1), Obesity class 2 (O2)

Ethical statement

In the department where the study was carried out, all data are routinely collected and completely anonymized. Work routines were not affected by the study. There were therefore no ethical concerns regarding the analysis of the data on the part of the Ethics Committee of Friedrich-Alexander University Erlangen-Nürnberg (24–16-Br).

Statistical analysis

To compare weight groups with the reference group of normal-weight women and for secondary outcome parameters, chi-square test was used for dichotomous variables and Welch's unpaired t-test for continuous variables. These p values were not adjusted for multiple testing and merely support the descriptive information. Clopper-Pearson 95 % confidence intervals were calculated for the raw transfer rates. A multivariable logistic regression model was adapted to the adjusted impact of BMI on the transfer rate, with additional influencing factors selected based on content-related considerations. Univariate analysis of baseline factors to determine their impact on the rate of transfer confirmed this selection, also based on statistical criteria (selection according to p values, analysis not shown). The variables "parity" and "previous caesarean section" were combined, as a previous caesarean section ist not possible in cases of nulliparity. P values < 0.05 were considered statistically significant for analysis of the primary outcome.

Results

A total of 6611 births occurred in the study period. After the inclusion and exclusion criteria were applied, 5616 cases were available for analysis (▸ **Fig. 1**): 3773 women with a BMI of between 18.5–24.9 kg/m^2, 1222 women with a BMI of between 25–29.9 kg/m^2, 464 women with a BMI of between 30–34.9 kg/m^2 and 157 cases women with a BMI of between 35–39.9 kg/m^2.

The demographic and clinical characteristics of the mothers are shown in ▸ **Table 2**. The mean age only differed between groups by maximally half a year and the percentage of women aged over 35 years was also comparable between groups. Nulliparity decreased significantly with increasing BMI and ranged from 39.5 % (Group O2) to 55.8 % (Group N). In the group of multiparous women, the percentage of women who had a previous caesarean section increased strongly with higher BMI (Group N: 393/1668 [23.6 %], Group OV: 166/621 [26.7 %], Group O1: 94/254 [37.0 %], Group O2: 43/95 [45.3 %]). The mean gestational age was 39.79 weeks of gestation and there were no significant differences between groups. The percentage of women with hypertensive disorders of pregnancy increased with increasing BMI (Group N: 70 [1.9 %], Group OV: 47 [3.8 %], Group O1: 38 [8.2 %], Group O2: 18 [11.5 %]), as did the percentage of women with gestational diabetes (Group N: 147 [3.9 %], Group OV: 93 [7.6 %], Group O1: 54 [11.6 %], Group O2: 15 [9.6 %]).

▶Table 3 Unadjusted transfer rates of neonates to a neonatal intensive care unit in the different weight groups.

Category	Number per category	Number of transfers	Raw transfer rate	95% confidence interval
All	5616	214	3.81%	[3.33%; 4.34%]
Group N	3773	145	3.84%	[3.25%; 4.51%]
Group OV	1222	37	3.03%	[2.14%; 4.15%]
Group O1	464	20	4.31%	[2.65%; 6.58%]
Group O2	157	12	7.64%	[4.01%; 13.0%]

Normal weight (N), Overweight (OV), Obesity class 1 (O1), Obesity class 2 (O2)

▶Table 4 Multivariable logistic regression model for the target variable "transfer of the neonate to a neonatal intensive care unit".

Influencing factors	Odds ratio	95% confidence interval	P value with regards to reference category	Joint p value from ANOVA for more than 2 categories
BMI (reference category N)				0.060
▪ Group OV	0.77	[0.53; 1.10]	0.167	
▪ Group O1	1.06	[0.63; 1.68]	0.823	
▪ Group O2	1.97	[1.00; 3.55]	0.035	
Age > 35 years	1.02	[0.71; 1.45]	0.897	
Hypertensive disorders of pregnancy	1.81	[0.95; 3.18]	0.054	
Gestational diabetes	1.71	[1.01; 2.74]	0.033	
Parity, previous caesarean section (reference parity > 0, no previous caesarean section)				0.011
▪ Nulliparity	1.59	[1.15; 2.21]	0.005	
▪ Previous caesarean section	1.09	[0.65; 1.77]	0.733	

ANOVA = analysis of variance. Normal weight (N), Overweight (OV), Obesity class 1 (O1), Obesity class 2 (O2)

Primary outcome parameter "transfer to a neonatal intensive care unit"

When evaluating weight groups for the primary fetal outcome parameter "transfer to a neonatal intensive care unit," groups with obesity had higher rates compared to Group N (Group N: 145 [3.8%], Group O1: 20 [4.31%], Group O2: 12 [7.6%], ▶ **Table 3**). Multivariable regression analysis identified obesity class 2 as a significant risk factor for neonatal transfer (OR = 1.97; 95% CI: 1.00–3.55; p = 0.035, ▶ **Table 4**). Other factors which also had a significant impact on neonatal transfer were nulliparity (OR = 1.59; 95% CI: 1.15–2.21; p = 0.005) and gestational diabetes (OR = 1.71; 95% CI: 1.01–2.74; p = 0.033). The absolute and relative frequences of the diagnostic reasons for transfer are shown in ▶ **Table 5**.

Secondary fetal outcome parameters

Evaluation of other fetal outcome parameters (▶ **Table 6**) showed an increase in the number of infants with a birth weight above the 90 th percentile with increasing maternal BMI (Group N: 277 [7.3%], Group OV: 138 [11.3%], p < 0.001; Group O1: 54 [11.6%], p = 0.002; Group O2: 22 [14%], p = 0.003). No differences were found for the parameters "pathological CTG" (7.6% to 8.9%) and "fetal blood analysis" (1.3% to 2%). However, green-stained amniotic fluid occurred more often in Groups O1 and O2 compared to the reference group (Group N: 268 [7.1%], Group O1: 54 [11.6%], p = 0.001; Group O2: 19 [12.1%], p = 0.028). The outcome parameters "5-minute Apgar score < 5," "arterial cord blood pH < 7.0," "arterial base excess < − 16". Shoulder dystocia and malformations were similar in all groups, with a comparable prevalence of at most 1%. There were no neonatal deaths during the entire investigation period.

▶**Table 5** Absolute and relative frequencies for diagnoses relating to the transfer of the neonate to a neonatal intensive care unit.

Diagnosis for transfer	Group N	Group OV	Group O1	Group O2
All	145 (100 %)	37 (100 %)	20 (100 %)	12 (100 %)
Respiratory adaptation disorders	68 (46.9 %)	20 (54.1 %)	8 (40 %)	8 (66.7 %)
Neonatal infection	27 (18.6 %)	4 (10.8 %)	2 (10 %)	2 (16.7 %)
Hypoglycemia	9 (6.2 %)	5 (13.5 %)	3 (15 %)	0 (0 %)
Neonatal jaundice	7 (4.8 %)	2 (5.4 %)	4 (20 %)	1 (8.3 %)
Malformation	6 (4.1 %)	1 (2.7 %)	0 (0 %)	1 (8.3 %)
Feeding problems	3 (2.1 %)	1 (2.7 %)	0 (0 %)	0 (0 %)
Intrauterine hypoxia	3 (2.1 %)	0 (0 %)	0 (0 %)	0 (0 %)
Mild or moderate asphyxia	2 (1.4 %)	1 (2.7 %)	0 (0 %)	0 (0 %)
Severe asphyxia	2 (1.4 %)	1 (2.7 %)	0 (0 %)	0 (0 %)
Heart rate or cardiac rhythm disorder	3 (2.1 %)	0 (0 %)	0 (0 %)	0 (0 %)
Neonatal bleeding	2 (1.4 %)	0 (0 %)	0 (0 %)	0 (0 %)
Syndrome	2 (1.4 %)	0 (0 %)	0 (0 %)	0 (0 %)
Other/no information	12 (8.3 %)	1 (2.7 %)	3 (15 %)	0 (0 %)

The numbers are presented as absolute and relative frequencies for the respective weight group. Normal weight (N), Overweight (OV), Obesity class 1 (O1), Obesity class 2 (O2)

Impact of BMI on onset of labor and delivery mode

The results for onset of labor and delivery mode are shown in ▶ **Table 7**. As BMI increased, the rate of elective caesarean sections also increased (Group N: 430 [11.4 %], Group OV: 185 [15.1 %], $p = 0.001$; Group O1: 102 [22 %], $p < 0.001$; Group O2: 41 [26.1 %], $p < 0.001$) as did the rate of labor inductions (Group N: 684 [18.1 %], Group OV: 320 [26.2 %], $p < 0.001$; Group O1: 111 [23.9 %], $p = 0.003$; Group O2: 48 [30.6 %], $p < 0.001$). In the groups with a higher BMI, the rate of secondary caesarean sections also increased strongly. This applied both to induction of labor (Group N: 121 [17.7 %], Group OV: 66 [20.6 %], Group O1: 35 [31.5 %], Group O2: 15 [31.2 %]) and caesarean section after spontaneous onset of labor (Group N: 309 [11.6 %], Group OV: 110 [15.3 %], Group O1: 53 [21.1 %], Group O2: 19 [27.9 %]). The increasing rates of secondary caesarean section were accompanied by decreasing rates of vaginal and vaginal-operative births. When labor was induced, the rate of vaginal births dropped from 70.2 % to 62.5 % and the percentage of vaginal-operative deliveries decreased from 12.1 % to 6.2 %. In the group of women with spontaneous onset of labor, vaginal births decreased from 77.8 % to 66.2 % and from 10.5 % to 5.9 % for vaginal-operative births.

Impact of BMI on maternal complications

The rates of maternal adverse events "uterine rupture," "preterm placental abruption" and "intrapartum fever" were similar for all groups and occurred in less than 1 % of cases. The rate of higher-degree perineal tears (grade 3 and 4) in the group of vaginal and vaginal-operative deliveries rose from 1.1 % in Group O1 to a 3.7 % in Group O2, but none of these figures were significant compared to the reference normal-weight group (▶ **Table 6**). There were also no significant differences between groups for the parameters "increased postpartum bleeding," which occurred with a frequency of between 1.3 and 3.9 %, and "hemoglobin value of less than 10 g/dl at discharge" (16.6–21 %).

Discussion

This study investigated the impact of higher preconception body mass index on maternal and fetal outcome parameters in a maternity hospital (care level IV). The analysis showed that preconception obesity class 2, i.e., a BMI between 35 and 40 kg/m^2, has a significant impact on the transfer of neonates to an intensive care unit. The transfer rate was not significantly higher for the overweight and obesity class 1 groups, an observation which was also made by Khalifa et al. in their cross-sectional study of 600 neonates born at term (transfer rate of 5.5 % for normal weight, 7 % for overweight, and 10 % for obesity class 1 group, $p = 0.220$) [14]. However, in their retrospective cohort study, Indarti et al. reported that higher BMI had no impact on the transfer rate, even for obesity class 2 and 3 groups (transfer rates of 18 % and 3.6 %, respectively; $p = 0.318$); however, their study only had a small sample size ($n = 111$) [15]. Similarly, Loh et al. found no higher transfer rates for overweight and obese pregnant women (transfer rate for neonates born to overweight/obesity mothers was 8.1 % versus 7.9 % for normal weight mothers, $p = 0.937$) in their prospective study [16]. In contrast, the transfer rate in the study by Addicott et al. was already higher for neonates born to mothers in obesity class 1 (18 % versus 15 %, $p = 0.002$), although this result has only limited validity because of the small number of cases in this group

▶**Table 6** Secondary outcome parameters for the neonate, the birth process, and the mother.

	Group N	Group OV	Group O1	Group O2	P value (OV vs. N)	P value (O1 vs. N)	P value (O2 vs. N)
All	3773 (100 %)	1222 (100 %)	464 (100 %)	157 (100 %)			
Birth weight	M 3.42 (SD 0.42)	M 3.5 (SD 0.43)	M 3.51 (SD 0.43)	M 3.5 (SD 0.46)	< 0.001	< 0.001	0.022
▪ > 4000 g	325 (8.6 %)	142 (11.6 %)	52 (11.2 %)	24 (15.3 %)	0.002	0.078	0.006
▪ < 2500 g	35 (0.9 %)	5 (0.4 %)	3 (0.6 %)	0 (0 %)	0.095	0.793	0.401
▪ > 90 th percentile	277 (7.3 %)	138 (11.3 %)	54 (11.6 %)	22 (14 %)	< 0.001	0.002	0.003
▪ < 10 th percentile	380 (10.1 %)	89 (7.3 %)	35 (7.5 %)	14 (8.9 %)	0.004	0.1	0.737
5-minute Apgar < 7	24 (0.6 %)	9 (0.7 %)	4 (0.9 %)	0 (0 %)	0.862	0.54	0.623
5-minute Apgar < 5	6 (0.2 %)	1 (0.1 %)	0 (0 %)	0 (0 %)	1	1	1
pH < 7.1	114 (3 %)	38 (3.1 %)	12 (2.6 %)	3 (1.9 %)	0.849	0.771	0.629
pH < 7.0	9 (0.2 %)	2 (0.2 %)	0 (0 %)	0 (0 %)	1	0.61	1
Base excess < − 12	119 (3.2 %)	32 (2.6 %)	10 (2.2 %)	2 (1.3 %)	0.387	0.314	0.239
Base excess < − 16	12 (0.3 %)	3 (0.2 %)	0 (0 %)	0 (0 %)	1	0.632	1
Malformation	38 (1 %)	8 (0.7 %)	2 (0.4 %)	1 (0.6 %)	0.343	0.311	1
Pathological CTG	298 (7.9 %)	93 (7.6 %)	37 (8 %)	14 (8.9 %)	0.792	1	0.755
Fetal blood sampling	67 (1.8 %)	25 (2 %)	6 (1.3 %)	3 (1.9 %)	0.626	0.572	0.758
Green-stained amniotic fluid	268 (7.1 %)	108 (8.8 %)	54 (11.6 %)	19 (12.1 %)	0.053	0.001	0.028
Shoulder dystocia	16 (0.4 %)	4 (0.3 %)	2 (0.4 %)	1 (0.6 %)	0.798	1	0.501
Uterine rupture	7 (0.2 %)	2 (0.2 %)	0 (0 %)	0 (0 %)	1	1	1
Preterm placental abruption	6 (0.2 %)	3 (0.2 %)	1 (0.2 %)	1 (0.6 %)	0.464	0.556	0.248
Intrapartum fever	19 (0.5 %)	9 (0.7 %)	2 (0.4 %)	1 (0.6 %)	0.467	1	0.558
Perineal tear grade 3 or 4 (percentages refer to vaginal deliveries)	76/2913 (2.6 %)	21/861 (2.4 %)	3/274 (1.1 %)	3/82 (3.7 %)	0.877	0.181	0.814
Peripartum hemorrhage	146 (3.9 %)	43 (3.5 %)	9 (1.9 %)	2 (1.3 %)	0.637	0.05	0.129
Hb-value at discharge < 10 g/dl	700 (18.6 %)	257 (21 %)	83 (17.9 %)	26 (16.6 %)	0.061	0.776	0.599

Numbers are presented as absolute and relative frequencies for the respective weight groups. Continuous variables are presented as mean (M) and standard deviation (SD). vs. = versus; Normal weight (N), Overweight (OV), Obesity class 1 (O1), Obesity class 2 (O2)

(n = 58) and the increased rate of preterm births in the group with higher BMI [17]. The cohort study of Melchor et al. also found a significantly higher transfer rate of neonates born to women with a BMI > 30 kg/m^2 (7.8 % versus 5.5 %, p = 0.001) [18]. However, one limitation of their study is the lack of differentiation according to the level of obesity (classes 1–3). The meta-analysis of Vats et al., which included 86 studies and more than 20 million pregnant women, showed a significantly higher risk of transfers to an intensive care unit for neonates born to women who were overweight (OR = 1.12; 95 % CI: 1.03–1.21; p < 0.001) and obese (OR = 1.42; 95 % CI: 1.28–1.58; p < 0.001) [8]. But in this study, the rate of preterm neonates born at < 37 weeks of gestation (GW) and < 32 GW born to women in both weight groups (BMI > 25 kg/m^2 and BMI > 30 kg/m^2) was also significantly higher, which could be an explanation for the higher rates of transfer. This study also did not stratify transfer rates according to the severity level of obesity.

In addition to obesity class 2, other significant factors influencing the transfer rate to a neonatal intensive care unit were gestational diabetes and nulliparity. In their study on risk factors for the transfer of neonates born at term to intensive care units, Talisman et al. identified gestational diabetes (OR = 2.52; 95 % CI: 2.09–3.03; p < 0.001) and nulliparity (OR = 1.19; 95 % CI: 1.07–1.33; p = 0.002) as common causes [19]. In our study, the percentage of women with gestational diabetes increased with increasing BMI, which also corresponds to data in the literature [17, 20]. However, the percentage of nulliparous women decreased significantly with increasing BMI, an observation which was also reported by Melchor et al. in their study [18]. Brodowski et al. found a positive correlation between parity and increased maternal BMI; in their study, weight-dependent risk factors for the unborn child increased with the number of births, while birth-dependent maternal adverse events occurred less often in multiparous women [21].

▶**Table 7** Onset of labor (spontaneous onset of labor, induction of labor, elective caesarean section) and delivery mode (spontaneous delivery, vaginal-operative birth, secondary caesarean section) for the different weight groups.

	Group N	Group OV	Group O1	Group O2	P value (OV vs. N)	P value (O1 vs. N)	P value (O2 vs. N)
All	3773 (100 %)	1222 (100 %)	464 (100 %)	157 (100 %)			
Elective caesarean section	430 (11.4 %)	185 (15.1 %)	102 (22 %)	41 (26.1 %)	0.001	< 0.001	< 0.001
Induction of labor – all	684 (18.1 %)	320 (26.2 %)	111 (23.9 %)	48 (30.6 %)	< 0.001	0.003	< 0.001
Caesarean section after induction of labor (percentages refer to induction of labor – all)	121 (17.7 %)	66 (20.6 %)	35 (31.5 %)	15 (31.2 %)	0.305	0.001	0.032
Vaginal-operative delivery after induction of labor (percentages refer to induction of labor – all)	83 (12.1 %)	35 (10.9 %)	8 (7.2 %)	3 (6.2 %)	0.657	0.176	0.321
Spontaneous delivery after induction of labor (percentages refer to induction of labor – all)	480 (70.2 %)	219 (68.4 %)	68 (61.3 %)	30 (62.5 %)	0.628	0.076	0.339
Spontaneous onset of labor – all	2659 (70.5 %)	717 (58.7 %)	251 (54.1 %)	68 (43.3 %)	< 0.001	< 0.001	< 0.001
Caesarean section after spontaneous onset of labor (percentages refer to spontaneous onset of labor – all)	309 (11.6 %)	110 (15.3 %)	53 (21.1 %)	19 (27.9 %)	0.009	< 0.001	< 0.001
Vaginal-operative delivery after spontaneous onset of labor (percentages refer to spontaneous onset of labor – all)	280 (10.5 %)	64 (8.9 %)	12 (4.8 %)	4 (5.9 %)	0.234	0.005	0.299
Spontaneous delivery after spontaneous onset of labor (percentages refer to spontaneous onset of labor – all)	2070 (77.8 %)	543 (75.7 %)	186 (74.1 %)	45 (66.2 %)	0.249	0.201	0.033

Numbers are presented as absolute and relative frequencies for the respective weight groups or for the respective subgroup according to mode of delivery. P values refer to the respective subgroup. vs. = versus; Normal weight (N), Overweight (OV), Obesity class 1 (O1), Obesity class 2 (O2)

In our study, the most common diagnoses leading to transfer to an intensive care unit were respiratory adaptation disorders (48.6 %), neonatal infection or suspicion of infection (16.4 %), neonatal hypoglycemia (7.9 %), and neonatal jaundice (6.5 %). These findings correspond to the results given in the international literature [22, 23, 24].

Our investigation of other fetal outcome parameters showed that as BMI increased, an increasing number of neonates were born with a birth weight above the 90 th percentile. This observation corresponds to the meta-analysis of Vats et al. [8] and can most probably be ascribed to the increasing number of women with gestational diabetes in these weight classes. A meta-analysis showed that, first and foremost, the occurrence of LGA depended on maternal weight increase during pregnancy: women whose weight increase remained below the recommendations of the Institute of Medicine (IOM) had a lower risk of LGA neonates in all weight classes, whereas a weight increase above the recommendations of the IOM resulted in a significant increase in LGA neonates [25]. In their prospective cohort study of more than 6000 pregnant women, Bouvier et al. showed that maternal weight increase above the IOM recommendations resulted in an increased risk of perinatal complications and that the risk of complications, which included hypertensive diseases of pregnancy, caesarean section and LGA, could be lowered by reducing excessive weight gain (2.8 % versus 5.3 %, p = 0.008; 16.9 % versus 22 %, p = 0.006; 7 % versus 13.2 %, p < 0.001) [26].

Our study did not find any differences for the parameters “pathological CTG” (7.6 % to 8.9 %) and “fetal blood analysis” (1.3 % to 2 %). However, the incidence of meconium-stained amniotic fluid was higher for the groups with maternal obesity (about 12 % versus 7 %), a finding that has also been confirmed in other studies [18, 27]. In their evaluation of the German Perinatal Survey, Briese et al. found that a pathological CTG and green-stained amniotic fluid occurred significantly more often in women with a BMI > 30 kg/m^2 compared to normal-weight women (OR = 1.38; 95 % CI: 1.32–1.44; p < 0.001 and OR = 1.64; 95 % CI: 1.55–1.73; p < 0.001) [28]; however, their study only investigated primiparous women and also included preterm births, without adjusting the multivariate analysis of risks for these disturbance variables.

In Germany, a critical fetal outcome is defined as a 5-minute Apgar score of less than 5, an arterial cord blood pH of less than 7.0 and/or a base excess of less than − 16. When this is compared with the international literature, it is important to be aware that less critical threshold values are often used in assessments (e.g., 5-minute Apgar score < 7, pH < 7.1 or base excess < − 12) or that only mean values were compared. When we looked at these outcome parameters, our study found no differences between the different BMI groups for either the standard threshold values used in Germany or for the threshold values used in the international literature. The studies by Addicot et al. and Magann et al. also did not find higher rates of 5-minute Apgar scores below the defined threshold values (7 for Addicot et al. and 4 for Magann et al.) for neonates born to obese pregnant women [17, 27]. A study carried out in France in a cohort of 314 851 pregnant women only showed lower Apgar scores for neonates born to women with a BMI of 40 kg/m^2 and above (adjusted OR = 1.63; 95 % CI: 1.10–2.42) [29]. In contrast, the meta-analysis of Vats et al. already identified a higher risk of 5-minute Apgar scores of less than 7 for the group of neonates born to overweight women (OR = 1.29; 95 % CI: 1.12–1.48; p < 0.001). One limitation of their meta-analysis is, however, the significant clinical, methodological, and statistical heterogeneity of the analyzed studies, something that the authors of the meta-analysis already point out themselves. Our study found that both arterial cord blood pH values and base-excess values were comparable for the different groups. This corresponds to the study by Magann et al. where a pH-value of less than 7.1 occurred significantly less often in women with obesity class 1 (aOR = 0.34; 95 % CI: 0.15–0.77; p = 0.018) [27]. In contrast, the study by Melchor et al. reported that a pH-value < 7.1 occurred more often in women with a BMI > 30 mg/kg^2 (OR = 1.33; 95 % CI: 1.12–1.56; p = 0.001) [18]. One limitation of their study is the lack of differentiation according to level of obesity.

In our cohort, shoulder dystocia occurred in 0.4 % of cases, which is at the lower spectrum of the range of 0.3–3 % usually reported in the literature [30, 31]. Our study found no increased incidence of shoulder dystocia in the groups with higher body mass index, an observation also made by Bracken et al. in their study [32]. A recent German multicenter retrospective analysis of more than 13 000 pregnancies identified an estimated fetal weight ≥ 4250 g (OR = 3.8; 95 % CI: 1.5–9.4), an abdomen-to-fetal-head-circumference ratio ≥ 2.5 cm (OR = 3.1; 95 % CI: 1.3–7.5) and (gestational) diabetes (OR = 2.2; 95 % CI: 1.2–4.0) as independent risk factors for the occurrence of shoulder dystocia; however, obesity, excessive weight increase, and induction of labor were not significant risk factors [33]. In contrast, the meta-analysis of Zhang et al. showed a higher risk for shoulder dystocia in women who were obesity class 1 (RR = 1.29; 95 % CI: 1.06–1.57), obesity class 2 (RR = 1.94; 95 % CI: 1.26–2.98) and obesity class 3 (RR = 2.47; 95 % CI: 1.56–3.93) [9]. One limitation of their meta-analysis is that they did not take disturbance variables in the analyzed studies and the differences in disturbance variables in the different studies into consideration. The study of Avram et al. showed a connection between higher preconception BMI and a higher risk of brachial plexus paralysis in vaginal births, both with and without shoulder dystocia [34].

The evaluation of our data showed no higher rate of malformations. When interpreting this finding, however, it must be remembered that pregnant women with prenatally diagnosed malformations were referred to a maternity clinic with an affiliated children's hospital or pediatric surgery department. Not a single neonatal death occurred in our cohort during the entire study. The results of a meta-analysis indicated that the probability of infant death is higher for overweight mothers and that this risk can increase with higher maternal BMI or weight; according to the authors, however, this finding could also be explained by disturbance variables [35].

In our study cohort, labor was induced significantly more often in the higher BMI groups. This corresponds to the results of the meta-analysis by Vats et al., where the risk of induction of labor was higher for overweight (OR = 1.23; 95 % CI: 1.17–1.30; p < 0.001) and obese mothers (OR = 1.55; 95 % CI: 1.36–1.77; p < 0.001) [8]. The induction of labor in women with a high BMI is associated with a longer induction-to-birth interval and a higher rate of caesarean sections [36]. But studies have shown that sequential use of a balloon catheter and misoprostol can improve the induction success rate [37]. In our study cohort, elective caesarean sections were carried out significantly more often in overweight and obese women, and this was also reported in a meta-analysis [8]. The rate of secondary caesarean sections increased with increasing BMI, both after spontaneous onset of labor and after induction of labor. A meta-analysis of 33 studies published in 2007 calculated an unadjusted risk for elective or emergency caesarean section of 1.46 (95 % CI: 1.34–1.60), 2.05 (95 % CI: 1.86–2.27) and 2.89 (95 % CI: 2.28–3.79) for overweight, obese, and morbidly obese pregnant women, respectively [38]. Recent retrospective cohort studies also show that preconception BMI affects the caesarean section rate [17, 32].

Similar to the findings in the cohort study of 314 851 women by Deruelle et al., our study also observed that higher-degree perineal tears (grade 3 and 4) did not occur more often in pregnant women with higher BMI compared to women with a normal BMI (perineal tear grade 3: 0.5–0.6 %, perineal tear grade 4: 0–0.1 %) [29]. Likewise, the risk of increased peripartum bleeding was not higher in higher BMI groups, and this finding was confirmed in a recent meta-analysis of 27 studies [39].

One of the strengths of our study is that it provides a selective observation of the outcomes of low-risk pregnancies delivered in a maternity hospital. The limitations of our study include its retrospective design and the lack of an analysis of weight increase during pregnancy and frequency of maternal transfer to an intensive care unit. These aspects should be considered in future studies.

Conclusion

Our results show that while a body mass index > 35 kg/m^2 resulted more often in transfer of the neonate to an intensive care unit, the Apgar scores and pH values of neonates born to women with a body mass index > 35 kg/m^2 were no worse than those of neonates born to pregnant women who were not overweight or obese prior to conception. Pregnant women with a BMI of between 35 and 40 kg/m^2 should be informed about this risk and should consider giving birth in a facility with an associated pediatric department (care levels I–III), especially if additional pregnancy risks such as gestational diabetes or nulliparity are present.

Conflict of Interest

The authors declare that they have no conflict of interest.

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