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Original Article

Frequency of iron deficiency among neonates of obese females

Sara Jamal[1], Naheed Khattak[2], Sundas Ali[3], Huma Abdul Shakoor[1], Sana Syed[1], Samina Tufail Amanat[1]

[1]Department of Pathology, PAEC General Hospital, Islamabad, Pakistan
[2]Department of Pathology, Gajju Khan Medical College/Bacha Khan Medical Complex, Swabi, Pakistan
[3]Department of Pathology, Haematology Section, Pakistan Institute of Medical Sciences (P.I.M.S), Islamabad, Pakistan

ABSTRACT

Background Obesity in pregnancy is a key risk factor for perinatal outcomes. It may result in maternal iron deficiency anaemia in later gestation, which could potentially cause decreased serum ferritin in neonates. This study aimed to determine the frequency of iron deficiency among neonates born to obese females.

Material and Methods The study enrolled 200 obese mothers who were either primigravida or multigravida, aged between 18 and 42 years and had gestational age over 37 weeks. Only newborns with normal birth weight were included in the study, while twins, premature babies, babies having infections, and underweight and overweight babies were excluded. Maternal height and weight close to the delivery date were recorded, and body mass index was calculated. The study performed a complete blood count and serum ferritin of neonates on cord blood, which were then entered into a Performa. All results were analyzed using SPSS version 20.

Results The mean age of the study population (mothers) was 31.64 + 5.42 years, ranging from 18 to 42 years. The mean body mass index was 36.4 + 3.05 kg/m2. The prevalence of anaemia among newborns was found to be 27%. The study found that among women in the severe obesity category, 10 (34.5%) newborns were anaemic, while in women with moderate obesity, 26 (26%) newborns had anaemia. Additionally, among women with mild obesity, 18 (25.4%) newborns were anaemic ($p = 0.615$).

Conclusions The study findings thus showed a higher prevalence of anaemia in newborns of severely obese mothers compared to moderate and mild levels of obesity, though the results were clinically insignificant.

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Address for Correspondence:
Sundas Ali , Pathology Department, Pakistan Institute of Medical Sciences (P.I.M.S), sector G-8/3, Islamabad, Pakistan.
E-mail: sundasali243@gmail.com

INTRODUCTION

Increasing worldwide obesity prevalence has been designated one of the most important global health threats in a joint WHO/FAO expert consultation.[1] According to World Health Organization's 2014 estimates, the worldwide incidence of obesity among adult women is 15%.[2] In Pakistan, this prevalence is at 13.5%.[2] Along with other associated risks, obesity in women of childbearing age group is also a key risk factor for perinatal outcome.[3] Worldwide obesity among pregnant women ranges from 1.8% to 25.3%.[1] Excessive weight gain in pregnancy may precipitate the development of maternal iron deficiency anaemia in later gestation.[3,4] Also, there is strong evidence that it may cause decreased serum ferritin in neonates.[5] Pregnancy normally stimulates a 6-fold increase in intestinal iron absorption to fulfil fetal needs.[6] However, obesity can functionally interfere with placental iron transfer and tissue partitioning via several pathways, including proinflammatory mediators such as interleukin-6 or hepcidin, impairing intestinal iron absorption.[7] Chronic inflammation linked to excessive adiposity may hinder iron absorption.[8] Sustained anaemia during infancy may impair neural development, emotionality and cognitive performance.[9] A study conducted by researchers in Wisconsin, USA, concluded that women with body mass index (BMI) ≥ 30 kg/m^2, compared with non-obese women, delivered offspring with lower serum ferritin concentrations (obese 6.8% vs non-obese 1.5%, $p < 0.002$).[5] Another Boston, USA, study associates maternal obesity with impaired maternal-fetal iron transfer, potentially through hepcidin upregulation.[10] The rationale of my research is to determine the frequency of iron deficiency in neonates born to obese mothers and to emphasize the need to recognize this risk factor as a possible cause of iron deficiency anaemia in neonates. The establishment of a significant relationship will allow for an approach of better counselling and lifestyle modification for these patients. There is very little evidence/studies establishing the connection and extent of neonatal iron deficiency among maternally obese women. This study explores iron deficiency exposure in newborns of obese women so that we can manage them early and reduce the morbidity rate.

MATERIAL AND METHODS

It was a descriptive cross-sectional study done for six months, from 1st June to 30th December 2021, after seeking approval from the Institutional Review Board. The sampling technique was consecutive non-probability sampling. The sample size calculated by the WHO calculator was 200, taking a confidence level of 95% and the anticipated population of obese as 6.8% with absolute precision of 3.5%. All mothers at delivery having antenatal cards, maternal age between 18-42 years, and primigravida and multigravida with full-term pregnancies were included in this study. Newborns of these mothers without infection or any other complications born via C-section or SVD, normal birth weight (2500-4000 g) were included in this study. However, twins, premature babies (< 37 weeks), neonates with infections, underweight (birth weight < 2500 g), or overweight (birth weight > 4000 g) were excluded. Patients fulfilling the inclusion criteria were selected after approval from the hospital ethics committee. Informed consent was obtained from each patient. Confidentiality of personal information was maintained. Exclusion criteria were strictly followed. Maternal height and weight was recorded close to the scheduled delivery date, and respective BMI was calculated subsequently using the formula (weight [kg]/length2[m^2]). Cord blood was obtained at delivery into serum and CP bottles for neonatal serum ferritin levels and complete blood counts (CBC), respectively. Serum ferritin was analyzed using Architect plus

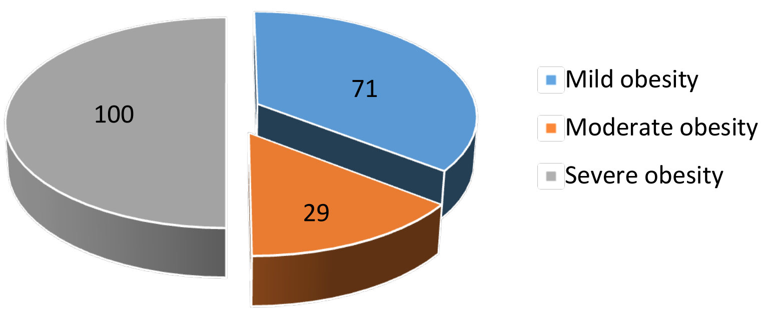

Figure 1. Severity of maternal obesity (n: 200)

2000SR. CBC was performed on a fully automated haematology analyzer (Sysmex XN-1000).

Statistical analysis

All values were entered in Performa. The data was entered and analyzed using SPSS version 20. Descriptive statistics were used to measure qualitative and quantitative variables. Qualitative variables, such as the presence of neonatal iron deficiency, were expressed in frequency and percentage. Quantitative variables such as gestational age, maternal BMI, and serum ferritin level of neonate were measured as mean ± standard deviation. Effect modifiers like the age of females and BMI were controlled by stratification. Post-stratification Chi-square test was applied. *P* value ≤ 0.05 was considered significant. As this study did not include any follow-up visits, none of the subjects dropped out or were lost at any point in this study.

RESULTS

A total of 200 obese women with age between 18-42 years and their full-term infants were included in this study. The median age of the study population (mothers) was 32 years, mean was 31.64 ± 5.42 years. 25% of the study population had an age below 28 years, while 25% had an age above 36 years. The median BMI of mothers was 36.50 kg/m^2. The mean BMI was 36.41 ± 3.05 kg/m^2 ranging from 30 to 43.9 kg/m^2. The 25th, 50th and 75th percentiles were 34.20 kg/m^2, 36.50 kg/m2 and 38.90 kg/m^2, respectively. Mild, moderate and severe obesity cut-off values were 30 to 35 kg/m^2, 35 to 40 kg/m^2 and more than 40 kg/m2, respectively. Out of two hundred, 71 (35.5%) were mild, 29 (14.5%) were moderate and 100 (50%) were severely obese (Figure 1). The median weight of the babies was 3.10 kg. The mean weight of the newborns was 3.18 ± 0.229 kg ranging between 2.60 to 4.20 kg. 25% of the study population had a weight below 3 kg, while 25% had a weight above 3.275 kg. The 25th, 50th and 75th weight percentiles were 3.09 g, 3.10 g and 3.28 g, respectively.

The prevalence of anaemia taking haemoglobin level less than 13 g/dL cut off among newborns was 27.0%. The study findings showed that the true population proportion of anaemia in women with BMI, as included in the study, ranges from 20.85% to 33.15%. The study findings showed that 26 (25.3%) had anaemia among female newborns, while 66 (71.7%) had no anaemia. Among male newborns, 28 (25.9%) they had anemia, while 80 (74.1%) had no anemia. The Chi-square was 0.137, which was not significant (*p* = 0.711). The study findings showed that males and females were equally affected, and no particular gender had a higher prevalence of anaemia (Table 1). Of 54 anaemic infants, 10 (18.52%) were infants of mothers with severe obesity, 26 (48.18%) newborns of mothers with moderate obesity, while in women with mild obesity, 18 (33.3%) newborns were anaemic. However, overall chi-square test was not significant (Chi-square value 0.972, *p* = 0.615 with 2 degree of freedom) (Table 2).

The study findings showed that the mean weight of anaemic newborns was 3.1593 g, with a standard deviation of ± 0.234. The mean weight of the non-anaemic newborn was 3.188 g, with a standard deviation of ± 0.228. The study findings show that although anaemic babies have less weight (0.29) compared to healthy newborns, the effect was insignificant, a test value of 0.795, 2 degree of freedom of 198, and a p-value of 0.428.

DISCUSSION

Among healthy human beings, pregnant women and rapidly growing infants are most vulnerable to iron deficiency. Both groups have to absorb substantially more iron than is lost from the body, and both are at a considerable risk of developing iron deficiency under ordinary dietary circumstances. The body iron requirement for an average pregnancy is approximately 1,000 mg. The total iron requirements of a pregnancy (excluding blood loss at delivery)

Table 1. Bivariate analysis - relationship of anemia of neonate with gender.

Gender of the Neonate	Anaemia		Total	Chi square test statistics
	Yes	No		
Female	26 (28.3%)	66 (71.7%)	92 (100%)	Chi square value = 0.137, df = 1
Male	28 (25.9%)	80 (74.1%)	108 (100%)	*p* = 0.711
Total	54 (27.0%)	146 (73.0%)	200 (100%)	

Table 2. Bivariate analysis - association between maternal body mass index and anaemia of neonate.

Obesity level of mothers	Anaemia		Total	Chi square test statistics
	Yes	No		
Mild	18 (25.4%)	53 (74.6%)	71 (100%)	Chi square value = 0.972, df = 2
Moderate	26 (26%)	74 (74.0%)	100 (100%)	$p = 0.615$
Severe	10 (34.5%)	19 (65.5%)	29 (100%)	
Total	54 (27.5%)	146 (73%)	200 (100%)	

average about 1,040 mg. Permanent iron losses during pregnancy include loss to the fetus and placenta, blood loss at delivery, and basal losses, totalling 840 mg.[11] Obesity is a significant public health issue globally, with pregnant women often affected by the condition. Low-grade inflammation is often present in people living with obesity. Inflammation can impact iron uptake and metabolism through elevation of hepcidin levels. Maternal obesity is associated with increased pregnancy risks, including iron deficiency and iron deficiency anaemia, conditions already highly prevalent in pregnant women and their newborns. Inflammation during pregnancy may aggravate iron deficiency by increasing serum hepcidin and reducing iron absorption. This could restrict iron transfer to the fetus, increasing the risk of infant iron deficiency and its adverse effects. Compared with normal weight, obese pregnant women fail to upregulate iron absorption in late pregnancy, transfer less iron to their fetus, and their infants had lower body iron stores. These impairments were associated with inflammation independently of serum hepcidin. In normal-weight pregnancy, circulating hepcidin falls by pregnancy week 20 and remains suppressed until term. The cause of hepcidin suppression during pregnancy is unclear, but decreasing body iron stores may play a role. In pregnant women with obese weight and iron deficiency, inflammation could induce hepcidin synthesis despite low iron stores. this could reduce iron absorption and be particularly detrimental in late pregnancy.[12] Obesity is considered a global health problem. Its incidence and prevalence are rising steadily throughout the world. Populations in wealthy countries are as at risk as populations in poor countries. In Pakistan, its incidence is 28% for men and 38% for women, making it one of the most frequent high-risk obstetrics.[13] As obesity and obesity-related disorders in pregnancy and their complications are common, investigations of the iron status of newborns of obese mothers are also necessary because obesity is increasingly prevalent in women of childbearing age. Normal fetal growth and development are dependent upon maternal iron sufficiency during pregnancy.

Across sectional study carried out in Karachi showed that the mean age of obese mothers was 24.3 ± 2.8 years.[14] Our results are also comparable with those of the demographic and health survey conducted in 2012-2013, in which women's median age at first birth was 25-49 years.[15] A study by Balarajan16 also showed increases in the prevalence of overweight and obesity among women of reproductive age in Bangladesh, Nepal, and India. Obesity was more common in childbearing age.[16] A study of Najmi[17] showed that the mean age of their study population was 26.93 ± 11.32 years, ranging from 19 to 35 years. Another study showed that the mean age of their study population is 26.71 ± 9.32 years, ranging from 17 to 35 years.18

According to Fleming's study, the BMI of females was 34.21 ± 3.01 kg/m^2, ranging from 30 to 37. 82% of women had BMI below 35 kg/m^2, while 18% had BMI above 35 kg/m^2. Quite differently presenting our study results, the mean BMI is 36.41 + 3.057 kg/m^2, ranging from 30 to 43. 90% of the study population had BMI below 34.22 kg/m^2, while 25% had a BMI above 38.9 kg/m^2. According to their study, out of 100 hundred, 35 (35%) were mild, 15 (15%) were moderate, and 50 (50%) were severely obese.19 These results are very similar to our study in which we found that out of 200 hundred, 71 (35.5%) were mild, 29 (14.5%) were moderate, and 100 (50%) were severely obese. Similarly, a study by Balarajan16 showed that the BMI of females presenting to that study was 32.21 ± 6.10 kg/m^2, ranging from 25 to 37 kg/m^2. 67% of women had BMI below 30 kg/m2 while 33% had BMI above 30 kg/m^2.16 Our study results showed that the mean BMI is 36.41 ± 3.057 kg/m^2 with a range of 30 to 43 kg/m^2. 90% of the study population had BMI below 34.22 kg/m^2, while 25% had BMI above 38.9 kg/m^2. 25% were mildly obese, 65% were moderate, and 10% were severely obese. Another study showed that 76% of females had a BMI below 30, while 24% had BMI above 30. They divided obesity into two categories, moderate obesity and severe obesity, 41% were moderate, and 59% were severely obese.[19] In contrast, our study divided obesity into three categories, mild, moderate and severe obesity. 71 (35.5%) were mild, 29 (14.5%) were moderate, and 100 (50%) were severely obese.

The prevalence of anaemia in the Villamor *et al.*[19] study is 20%. Among newborns of obese females, 20 (20%) had anaemia, while 80 (80%) had no anaemia. Among newborns of non-obese females, 5 (5%) had anaemia, while 95 (95%) had no anaemia.[19] Our study showed that 26 (25.3%) had anaemia among female newborns, while 66 (71.7%) had no anaemia. Regarding male gender, 28 (29%) had anemia while 80 (71%) had no anemia. The Chi-square test was 0.137, which was insignificant ($p = 0.711$). In our study, the prevalence of anaemia among newborns was 27%. Among women in the severe obesity category, 10 (34.5%) newborns were anaemic; in women with moderate obesity, 26 (26%) newborns had anaemia, while in women with mild obesity, 18 (25.4%) newborns were anaemic ($p = 0.615$). Comparison with different studies showed that the prevalence of anaemia in (population) in Fleming's study is 39%. Among newborns of obese females, 29 (29%) had anaemia, while 71 (71%) had no anaemia. Among newborns of non-obese females, 2 (2%) had anemia, while 98 (98%) had no anaemia.[12] Similarly, the prevalence of anaemia in the Balarajan study[16] is 23%. Among children of obese females, 29 (19%) had anaemia, while 81% had no anaemia. Among newborns of non-obese females, 8% had anaemia, while 92% had no anaemia. A study by Najmi[17] showed the prevalence of anaemia was 27%. Among newborns of obese females, 27% had anaemia, while 73% had no anaemia. Among newborns of non-obese females, 7% had anaemia, while 93% had no anaemia. Chi-square was 0.137, which was not significant ($p = 0.711$).[17]

The studies above show that newborns of obese mothers are more prone to anaemia than newborns of non-obese mothers. However, our study did not show a significant association between maternal obesity and neonatal anaemia. In our study, the mean weight of the newborns was 3.18 ± 0.229 kg ranging between 2.60 to 4.20 kg, comparable with an investigation by Najmi17 in which the mean birth weight of the newborns was 2.91 kg.16 The weight of 78% of babies ranged from 2.5 to 4 kg, 19% had low birth weight, and 3% of neonates weighed above 4 kg.

CONCLUSIONS

The study findings showed a more significant number of anaemia in newborns of severely obese mothers compared to moderate and mild levels of obesity. However, the results were not statistically significant (p = 0.615). More studies of the topic with greater power and study designs like case-control studies are recommended.

Conflict of Interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Ethical Approval

The protocol of the study was approved by the Medical Ethics Committee of Department of Pathology, PAEC General Hospital, Islamabad, Pakistan. (Decision number: PGHI-IRB(Dme)-RCD-06-014, date: 17.10.2020).

Authors' Contribution

Study Conception: SJ; Study Design: SJ, HAS; Literature Review: NK; Critical Review: SA, SS; Data Collection and/or Processing: HAS, SA, SS; Analysis and/or Data Interpretation: HAS; Manuscript preparing: SJ, HAS.

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