

Original Article

Anthropometric Measurements to Predict NICU Admission for Infants of Diabetic Mothers

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Abstract:

Aim: Can NICU admission of IDM be predicted by anthropometric measurements like birth weight, length, head circumference (HC), mid upper arm circumference (MUAC) or triceps skin fold thickness (TSFT).

Method: Eighty-six-term IDMs were analyzed prospectively. MUAC, HC and TSFT were measured within 48 hours of life. Prenatal-natal-postnatal problems; NICU admission; maternal characteristics, HbA1c were recorded.

Results: Mean birth weight, gestational age were 3453.3±582.4g and 38.0±0.97weeks. 63.9% of IDMs was admitted to NICU. 56.3% hospitalized due respiratory problems; 32,7 % required endotracheal intubation. Mean MUAC, TSFT, HC and MUAC/HC ratio were 11.2±1.1 cm, 7.1±2.2 mm, 35.0±1.8 cm and 0.32±0.03 cm respectively for all. Although there was no significant relation between NICU admission and MUAC (p=0.071), TSFT and MUAC/HC were significantly higher in babies admitted to NICU (p=0.006 for TSFT, p<0.001 for MUAC/HC). HC was significantly low in babies followed in NICU (P<0.001). With increment of TSFT, MUAC/HC and HbA1c, NICU admission increases positively, but HC affects NICU admission negatively (OR for TSFT:1.6, OR for MUAC/HC: 2.1, OR for HbA1c: OR for HC:0,3). Mechanic ventilation requirement is affected positively by TSFT (p=0.008, OR:1.5) and affected negatively by HC (p=0.004, OR:0.6).

Conclusion: This preliminary study showed; TSFT, HC and MUAC/HC ratio are helpful criterias to predict NICU admission risk for IDMs and might be helpful for risk assesment in limited settings.

Keywords: Infants of diabetic mother; mid upper arm circumference; triceps skin fold thickness; head circumference; NICU; respiratory distress.

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Introduction

Diabetes is a modern world illness; prevalence of DM in Turkey and in the world is 12.8% and 8.8% respectively¹. Infants of diabetic mothers are known to be faced with many neonatal problems like respiratory distress,

hypoglycemia, polycythemia, hyperbilirubinemia, cardiomyopathy and they need NICU admission more frequently than their healthy peers².

Neonatal morbidity has been reported to be high in infants of diabetic mothers (IDM), especially

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due to respiratory problems³. Most of these babies are hospitalized after birth just for blood glucose monitorization⁴.

Infants of diabetic mothers store more fat and they are heavier for their gestational age due to the intrauterine metabolic effects of higher fetal glucose and insulin levels⁵. Their lean body mass is lower compared to their appropriate for gestational age peers. The more uncontrolled intrauterine effects of hyperglycemia, the heavier IDMs are. Maternal hyperglycemia, leading fetal hyperglycemia, in turn stimulates fetal beta cells to increase fetal insulin secretion. Excess amount of insulin leads to fetal macrosomia by its anabolic effects. Total body protein, fat and glycogen increase with hyperinsulinemia and internal organs, except from brain and kidney, are enlarged by cellular hyperplasia and hypertrophy. Fetal hyperinsulinemia plays a central role in macrosomia⁶.

Prediction of NICU admission might be important for IDMs when there is a shortage to access to health care; especially on weekends and night shifts and in resource limited settings.

We aimed to assess if we can predict the risk for Neonatal Intensive Care Unit (NICU) admission in IDMs by some simple anthropometric measurements like head circumference (HC), mid upper arm circumference (MUAC) and triceps skin fold thickness (TSFT).

Methods

Eighty-six term IDMs born in Ondokuz Mayıs University Obstetrics and Gynecology Department between 15.02.2010-15.02.2012 were prospectively included in the study following parental informed consent. Local ethics committee approved the study (no:2010/151).

Babies were allocated into two groups: those who were admitted to NICU and followed in the maternity ward. Babies were weighted by calibrated scale, whole naked (Arcelik ®). Head circumference, MUAC and TSFT were measured within 48 hours of life by the same researcher (FCC). Head circumference and MUAC were measured by rigid tape. Head circumference or occipital frontal circumference was measured over the most prominent part on the back of the head (occiput) and just above the eyebrows (supraorbital ridges). Measurements were obtained from left arms, with arms hanging down loosely. Lange caliper, having a pressure of 10 g/mm² on contact surface area, was used for TSFT. Triceps

skin fold thickness and MUAC were measured on the midway between acromion and olecranon, on the back of the arm. The skin fold was pulled away from the muscle and measured with the calipers, obtaining a reading 4 seconds after the release of the calipers. Three measurements for HC, MUAC and TSFT were taken and the average was recorded. The ratio of MUAC to HC was also recorded.

Prenatal, natal and postnatal characteristics of all babies were recorded.

Recorded maternal parameters were: age, body mass index (BMI), pregnancy weight gain and HbA1c levels.

Gestational age was determined by first trimester ultrasound measurements. Last-menstrual-period dating was used for those women for whom 1st trimester sonography was not available.

Pre-gestational diabetes was defined as the presence of diabetes diagnosed before pregnancy. Gestational diabetes mellitus (GDM) was defined as the presence of hyperglycemia of varying severity, with the onset during pregnancy. The diagnostic criteria were: Presence of two recordings of fasting blood glucose levels of ≥ 5.8 mmol/l; a 1-hour blood glucose level of ≥ 7.8 mmol/l and fasting blood glucose level of ≥ 5.8 mmol/l with 50 g glucose screening test; or two abnormal glucose values on a fasting 75-g oral glucose tolerance test (fasting level > 5.6 , 1-hour level > 10.3 , 2-hour level > 8.6 , 3-hour level > 6.7 mmol/L).

Body mass index was defined as the body mass divided by the square of the body height (kg/m²).

Small for gestational age (SGA) was defined as $< 10^{\text{th}}$ percentile of birth, large for gestational age (LGA) as $\geq 90^{\text{th}}$ percentile and appropriate for gestational age as 10-90th percentile⁷. Birth weight < 2500 g defined as low birth weight (LBW).

Neonatal outcomes, like NICU admission, NICU problems (respiratory problems, hypoglycemia, hypocalcemia, congenital abnormalities) were also analyzed. Babies with respiratory distress and multiple congenital anomalies directly followed up in NICU, patients with metabolic problems like hypoglycemia, hypocalcemia in maternity ward, if uncontrolled transferred to NICU. Respiratory problems of the neonates consisted of transient tachypnea of the newborn (TTN), respiratory distress syndrome (RDS), and need for oxygen and/or endotracheal intubation. Hyperglycemia

was defined as blood glucose level <2.6 mmol/l (<47 mg/dL)⁸. A value of <2.0 mmol/l (<8 mg/dL) was accepted as hypocalcemia⁹. Respiratory distress syndrome (RDS) is a respiratory disorder chiefly of premature infants that is characterized by deficiency of the surfactant of the lungs resulting in labored breathing, lung collapse, and hypoxemia¹⁰. Transient tachypnea of newborn (TTN) is a parenchymal lung disorder characterized by pulmonary edema resulting from delayed resorption and clearance of fetal alveolar fluid¹¹.

Statistical Analysis

All quantitative data were checked for normality assumption. Parametrical statistical methods were used for the data which were met normality assumption, otherwise nonparametric methods were used to analysis data. The descriptive statistics mean \pm SD and also median (min;max) values were used for quantitative data. The frequencies and percentages were used as descriptive statistics for qualitative data. To find out which is the more effective predictive factor of NICU admission for IDM, the receiver operating characteristics (ROC) analysis were used to compare AUC (Area under

curve), sensitivities and specificities for MUAC, MUAC/HC, TSFT, HC and HbA1c. The logistic regression analysis was done to find out significant risk factors for mechanic ventilation requirement, hypoglycemia, hypocalcaemia, septal hypertrophy and HbA1c.

Ethical clearance: Local ethics committee approved the study (no:2010/166)

Results

Mean birth weight and gestational ages of IDMs were 3453.3 \pm 582.4 (2530.0-5040.0) g and 38 \pm 0.97 (37.0-41.0) weeks. Ninety-five percent babies were born via caesarian section and 50% were girls. 63.9% of the study population was followed in NICU. Infants followed in NICU and in the maternity ward were similar according to birth weight, gestational age, route of delivery and sex (for all $p>0.05$). Gestational diabetes was present in 76.7%, Type 1 DM in 4.7%, and Type 2 DM in 18.6% of mothers. No significant difference was found regarding maternal characteristic between two groups, except HbA1c levels were higher in mothers of babies admitted to NICU ($p=0.022$).

Table 1: Maternal Characteristics

	Admission to NICU (n=55)	Followed in Maternity ward (n=31)	Total n(86)	p
Age (years)* (mean \pm SD)(median) (min-max)	33.9 \pm 5.2 34 (21-45)	32.7 \pm 4.4 34(24- 40)	33.5 \pm 4.9 34(21-45)	0.268
Body Mass Index* (mean \pm SD) (median) (min-max)	31.2 \pm 6.9 (30.4) (17.0-52.3)	31.5 \pm 5.3 31.3(18.5-47.8)	31.3 \pm 6.3 30.8(17.0-52.3)	0.836
Weight Gain During Pregnancy* (kg) (mean \pm SD) (median) (min-max)	11.5 \pm 4.7 (11.0) (2.0-26.0)	13.4 \pm 4.2 13.0(7.0-25.0)	12.2 \pm 4.6 12.0(2.0-26.0)	0.065
Gestational DM n (%)	41(74.5%)	25(80.6%)	66(76.7)	0.527
Type 1 DM n (%)	2(3.6%)	2(6.5%)	4(4.7)	
Type 2 DM n (%)	12(21.8%)	4(12.9)	16(18.6)	
Diet regulated n (%)	46(83.6%)	26(83.9%)	72(83.7%)	1.000
Insulin Requirement n (%)	23(41.8%)	12(36.0%)	35(40.7%)	0.958
HbA1c (%) (mean \pm SD) (median) (min-max)	6.8 \pm 1.1 6.5(5.3-10.6)	6.2 \pm 0.8 6.2(4.7-8.5)	6.6 \pm 1.1 6.5 (4.7-10.6)	0.022

*Values are given as average \pm Standard Deviation (min-max)

NICU:Neonatal Intensive Care Unit, DM:Diabetes Mellitus.

Table 2: Characteristics of study population

	Admitted to NICU (n=55)	Followed in Maternity ward (n=31)	Total n (n=86)	P
*Birth Weight (g) (mean± SD) (median) (min-max)	3470.0±590.6 3470.0 (2530.0-5040.0)	3423.5±575.8 3380.0 (2640.0-4640.0)	3453.3±582.4 3430.0 (2530.0-5040.0)	0.725
Gestational Age (week) (mean± SD) (median) (min-max)	37.9±0.93 38.0(37.0-41.0)	38.3±1.00 38.0(37.0-40.0)	38.0±0.97 38.0(37.0-41.0)	0.057
LGA n (%)	18 (32.7)	6 (19.3)	24 (27.9)	0.281
Cesarean/ vaginal birth (%)	96.4/3.6	93.5/6.5	95.3/4.7	0.617
Male/Female (%)	50.9/49.1	48.4/51.6	50.0	1.000
Ventricular Septal Hypertrophy n(%)	21(77.8)	6 (22.2)	27 (31.3)	0.021
HC (cm) (mean± SD)(min-max)	34.4±1.7 (30-38)	35.9±1.8 (32-42)	35.0±1.8 (30-42)	<0.001
*MUAC (cm) (mean± SD) (median) (min-max)	11.4±1.1 11.3(9.4-14.3)	10.9±1.2 11.0(8.5-13.0)	11.2±1.1 11.0(8.5-14.3)	0.071
*TSFT (mm) (mean± SD)(median) (min-max)	6.9±2.3 7.0 (4.0-13.0)	6.2±1.9 6.0 (4.0-10.5)	7.1±2.2 7.0(4.0-13.0)	0.003
*MUAC/HC (mean± SD) (median) (min-max)	0.32±0.03 0.33(0.28-0.42)	0.30±0.03 0.30(0.25-0.36)	0.32±0.03 0.32(0.25-0.42)	<0.001

*Values are given as average± Standard Deviation (min-max)

LGA: Large for Gestational Age, NICU: Neonatal Intensive Care Unit, MUAC: Mid Upper Arm Circumference, TSFT: Triceps Skin Fold Thickness, HC: Head Circumference.

Of all 86 babies 63.9% (55 infant) were admitted to NICU. Of 55 babies; 56.3% hospitalized due respiratory problems (RDS, TTN, transitional delay) and 32.7% required endotracheal intubation. One baby died due intractable diarrhea and sepsis in NICU. All babies went through echocardiographic evaluation and ventricular septal hypertrophy, ventricular septal defect, atrial septal defect were diagnosed in 31.4%, 16.2 %, 7% respectively. Hypocalcemia and hypoglycemia were diagnosed in 34.5 % and 10.9% of 86 babies, respectively. Characteristics of mothers and infants are shown in Tables 1 and 2. Mean MUAC, TSFT, HC and MUAC/HC ratio were 11.2±1.1 cm, 7.1±2.2 mm, 35.0±1.8 cm and 0.32±0.03 cm respectively for all babies.

Characteristics of Infants followed in NICU are shown in Table 3.

Table 3: Characteristics of Infants followed in NICU

	n =55
Respiratory distress n(%)	31(56.3)
RDS n(%)	1 (1.8)
Transient Tachypnea n(%)	23 (41.8)
Transitional delay n(%)	7 (12.7)
Need for mechanic ventilation n (%)	25 (45.4)
Endotracheal intubation n (%)	18 (32.7)
CPAP n (%)	25 (45.4)
Hypocalcemia n(%)	19 (34.5)
Hypoglycemia n(%)	6 (10.9)
Length of stay in NICU (days) (mean±SD) (min-max)(median)	7.8±10.1(1.0-65.0) 5.0
Exitus n(%)	1(1.8)

NICU: Neonatal Intensive Care Unit, CPAP: Continuous Positive Airway Pressure, RDS: Respiratory Distress Syndrome

There was no statistically significant relation between hospitalization and MUAC (p=0.071), but TSFT and MUAC/HC were significantly higher in babies admitted to NICU (p=0.003 for TSFT, p<0.001 for

MUAC/HC).

NICU admission was positively increased according to increment in the level of MUAC/HC ratio, TSFT, but when HC decreased NICU admission increased. Odds ratio for MUAC/HC ratio was 2.1 (95 % confidence interval 1.047-4.360), for TSFT was 1.6 (95 % confidence interval 1.084-2.528), and for HC was 0.3 (95 % confidence interval 0.195-0.572). Receiver Operating Characteristic (ROC) curve is in the Figure 1. The most powerful parameters for NICU admission were MUAC/HC ratio and HC (AUC for MUAC/HC=0.74, AUC for 1/HC=0.72).

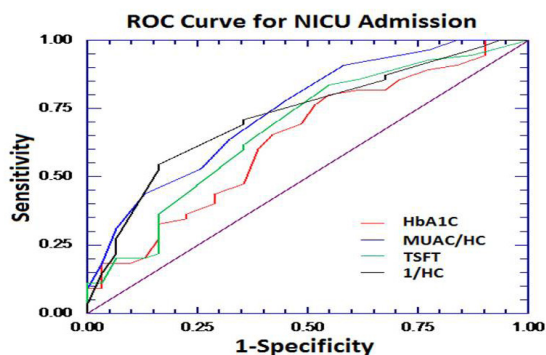


Figure 1: Receiver Operating Characteristic (ROC) curve for nicu admission

Mechanic ventilation requirement (either intubation or nasal positive pressure) is affected by TSFT in positive way ($p=0.008$, OR:1.5) and affected negatively by HC ($p=0.004$, OR:0.6). It was not affected by MUAC. Intubation was not affected by TSFT ($p=0.121$) and MUAC ($p=0.630$), but HC affected intubation need in a negative manner ($p<0.001$, OR:0.4).

Hypoglycemia was not affected by MUAC ($p=0.549$), TSFT ($p=0.200$) and HC ($p=0.254$).

Hypocalcemia was not affected by TSFT $p=0.743$. MUAC affected hypocalcemia positively ($p=0.003$, OR:3.4) but, HC affected hypocalcemia negatively ($p=0.006$, OR:0.5).

Septal hypertrophy was affected by TSFT positively ($p=0.006$, OR:0.5), but by HC negatively ($p=0.036$, OR:0.7), and not affected by MUAC.

Discussion

The present study added evidence that IDMs are at

risk for neonatal problems. In a study from Turkey, TTN was reported as 33%, RDS was reported as 2%, hypocalcemia was 35%, hypoglycemia 22% and 69% of babies had at least one of these problems. Mortality rate was 2% in that study¹².

In our study, 63.9 % of IDMs required NICU admission. In the study by Cordero et al,¹³ NICU admission in IDMs was reported as 49%. Respiratory disorders like RDS, TTN, transitional delay was observed in 36% of the term study population in our study and 20.9% of them required intubation. Respiratory disorders have been reported as 21%, 52,6 % in the literature^{14,15}, similar to our results.

Since the incidence of DM is rising in our country, like other parts of the world, NICU requirements will be increasing as well¹⁵. This may affect maternal-newborn contact and breastfeeding negatively¹⁶⁻¹⁸.

MUAC, TSFT are reliable, low-cost measure for monitoring infant body fat deposition in preterm and term infants¹⁹. In a study by McFarland, IDMs had larger extremity circumferences, thicker upper extremity skinfolds and significantly higher body fat compared with non-diabetic controls with similar birth weight and birth length²⁰. This data supports the association between neonatal fat deposition and maternal glucose levels^{5,21}.

Birth weight and gestational age have prognostic value on morbidity of infants²². But, clinical implications of regional anthropometric measures like MUAC, TSFT are not well studied. It was reported that regional anthropometric measurements are strongly correlated with fat and lean body mass²³ that may be important for macrosomia, its complications and admission to NICU requirement.

In this study we analyzed if MUAC, HC, MUAC/HC ratio and TSFT or all can be predictive factors of NICU admission for IDM. Unfortunately there is no data on Turkish newborns for comparison. In a study analyzing 195 IDMs, TSFT of was reported as 4.7 ± 1.1 mm and mean birth weight was 3.398 ± 550 g²⁴. In our study, mean TSFT was 7.1 ± 2.2 mm and mean birth weight was 3453.3 ± 582.4 g. While average birth weight is similar in two studies, the difference between average TSFT values might be due to genetic and ethnic characteristics.

In our knowledge this is the first study trying to

find a relation between MUAC, HC, MUAC/HC ratio, TSFT and NICU admission. There was no statistically significant relation between hospitalization and MUAC, but TSFT and MUAC/HC ratio were significantly higher in babies followed in NICU in our study. This preliminary study might help to choose and transfer the babies at risk for NICU admission before a severe situation develops.

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Authors' Contributors:

FCC: Planned the study, recorded and analyzed the data, wrote the manuscript

CA: Planned the study, reviewed the manuscript

GT: Review the anthropometric measurements.

SK: Review the article.

YB: Performed the statistical analysis

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