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study, causes restricted range of mothers' age and maternal BMI, that made us not able to judge the significant correlation to neonatal Apgar score. Also, missing some data from hospital documents was another obstacle.

Conclusion:

LGA neonates should be given special medical and supportive care, especially during resuscitation after birth. The decision for cesarean section should be a last resort. Apgar score can be used in evaluation of neonatal morbidities especially among this group of neonates.

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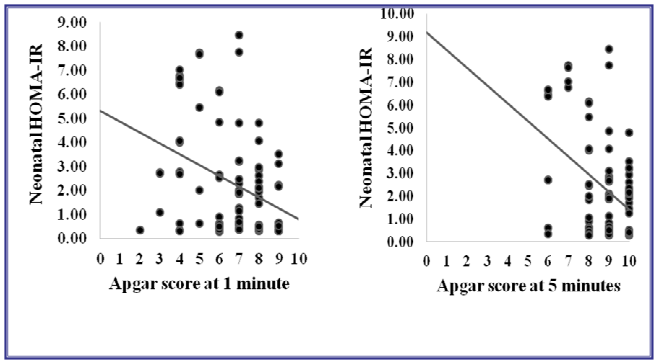

Figure (3) Correlation of Apgar score at 1 minute and 5 minutes to neonatal serum insulin level (in µU/ml).

Discussion:

Although many studies were conducted to evaluate the Apgar score association with neonatal mortality and morbidities, results showed great variations. In the current case- control study, we aimed to investigate the relationship between Apgar score at 1 minute and at 5 minutes to different maternal and neonatal parameters.

The age of mothers whose neonates were included in this study ranged from (19- 36) years old, while neonates of mothers aged less than 19 years or more than 36 years old were not included in this study, so there was no statistically significant difference between neonates with Apgar at 1 minute or Apgar at 5 minutes as regards maternal age. In agreement, a population- based cross- sectional Brazilian study, conducted on 11968227 records of neonates delivered at full- term for women aged (12- 49) years, reported the significant association of low Apgar score at 5 minutes with maternal age less than 21 and more than 34 years old (OR 1.09- 1.68; 95% confidence interval).[3] Similarly, a cross- sectional Ethiopian study, that involved 752 charts of mothers, found that Apgar score was less than 7 at 5 minutes, among neonates of women more than 35 years old (AOR 7.507, 95% CI; 3.134- 17.98, p< 0.001).[18]

As regards maternal BMI, it did not affect Apgar score at 1 minute or at 5 minutes in this study. Similarly, an observational cross- sectional Indonesian study, conducted on 111 obese mothers, they recorded that both Apgar scores at 1 and 5 minutes were not associated with maternal obesity (p> 0.05).[10] On the opposite side, in a systematic review and meta- analysis, that included 11 studies, they stated that obesity increased the risk of decreased Apgar score at 1 minute to less than 7 (P < 0.001).[31] The difference in these findings may be attributed to the difference in sample size, as we only included 90 subjects with maternal BMI mean± SD of 28.21± 4.48, after the exclusion of maternal chronic diseases that may be associated with maternal obesity.

In the present study, Apgar score at 1 minute and Apgar score at 5 minutes were significantly lower among LGA group only (means± SD: 5.7± 1.8 and 8.2± 1.4, respectively), in relation to the other two groups of AGA neonates (means± SD: 7.3± 1.3 and 9.3± 0.7, respectively) and SGA neonates (means± SD: 6.8± 1.8 and 8.9± 1.1, respectively) (p= 0.001 for both Apgar score in 1 minute and Apgar score in 5 minutes). Furthermore, it was found that Apgar score at 5 minutes had a negative significant correlation to neonatal birth weight (r= −0.219, p= 0.038).

Similarly, a retrospective population- based cohort Italian study, conducted on 27807 subjects, suggested that LGA neonates had increased risk of lower Apgar score (less than 7), especially if born to obese mothers[17] Also, a case- control Turkish study reported no significant difference between SGA and AGA groups regarding Apgar score in 1 and 5 minutes, however, they did not include LGA group in their study (p= 0.697 for both Apgar at 1 minute and Apgar at 5 minutes).[13]

In this research, cesarean section was associated with lower values in both Apgar score at 1 minute and Apgar score at 5 minutes (p= 0.019 and 0.024, respectively). The same finding was mentioned by other studies.[1][4][23] In fact, it was suggested that low 5- minutes Apgar score and the need for Neonatal Intensive Care Unit (NICU) admission were the most common fetal complications accompanying cesarean section.[1]

The current study revealed that neonatal sex did not affect the Apgar score measured at 1 or 5 minutes. This was similar to findings of studies conducted by other studies.[7][25]

As regards Insulin resistance among neonates of this study, it was recorded that Apgar scores at 1 and 5 minutes were significantly lower among neonates suffering from insulin resistance (p=0.019 and 0.005, respectively). Although there was no significant relationship between blood glucose levels and Apgar scores at 1 and 5 minutes, a negative correlation to serum insulin level (r= −389, p=0.000 and r= −0.453, p= 0.000, for Apgar scores at 1 and 5 minutes, respectively) and a similar negative correlation to HOMA- IR values (r= −0.354, p=0.001 and r= −0.422, p= 0.000, for Apgar scores at 1 and 5 minutes, respectively). It is to be mentioned that this study was the first to correlate between Apgar scores at 1 and 5 minutes to Insulin resistance detected in neonates of healthy non- diabetic mothers.

Several recent studies, compared the neonates of diabetic mothers who had insulin resistance to neonates of healthy mothers as regards neonatal Apgar scores at 1 and 5 minutes. A Turkish study, revealed a significant association between lower neonatal Apgar scores at 1 and 5 minutes among neonates of mothers with gestational diabetes, with a negative correlation to insulin resistance (r= −0.32, p=0.01 and r= −0.3, p=0.03, respectively).[19] Similar results recorded by other studies.[11][12] On the other side, several studies found no significant association between neonatal Apgar score and insulin resistant diabetic mothers as discussed by another study.[25]

In the current study, serum irisin level among the 3 groups of the study was not significantly correlated to Apgar score at 1 or 5 minutes among the subjects of the three groups (p= 0.157, r= 0.265 for Apgar 1 minute and p= 0.392, r= 0.185 for Apgar 5 minutes). In agreement, a case-control Iraqi study, conducted on 96 subjects; 32 in each group of SGA, AGA and LGA neonates, found no statistically significant difference between the serum irisin levels among the three groups of SGA, AGA and LGA neonates and the Apgar score at 1 and 5 minutes (p= 0.42 and 0.162, respectively).[2]

Limitation of the study: the limited number of subjects included in this

Maternal And Fetal Variables			
Birth Order		Serum Glucose	
Mean± SD	1.89± 0.965	Mean± SD	67.11± 14.241
Min- Max	1- 7	Min- Max	44- 108
Neonatal Weight		Serum Insulin	
Mean± SD	2.827± 0.7643	Mean± SD	14.630± 14.3782
Min- Max	1.3- 4.1	Min- Max	1.6- 50.4
Neonatal Height		Homa- Ir	
Mean± SD	47.137± 2.9165	Mean± SD	2.3269± 2.24262
Min- Max	38.0- 51.1	Min- Max	0.27- 8.46
Neonatal Head Circumference		Serum Irisin	
Mean± SD	34.332± 2.0411	Mean± SD	8.056± 6.4907
Min- Max	27- 37.5	Min- Max	0.6- 19.8

Apgar score at 1 minute and Apgar score at 5 minutes were significantly lower in LGA, with mean± SD of 5.7± 1.8 and 8.2± 1.4 for Apgar score at 1 minute and Apgar at 5 minutes, respectively, versus 7.3± 1.3 and 9.3± 0.7, respectively, among AGA neonates and means± SD of 6.8± 1.8 and 8.9± 1.1, respectively among SGA neonates table (3).

Table (2) Correlation of Apgar scores at 1 and 5 minutes to neonatal maternal demographic and birth order:

Variables		Apgar At 1 Minute	Apgar At 5 Minutes
Maternal Age	r	0.098	0.013
	P- Value	0.358	0.908
Maternal BMI	r	0.153	0.197
	P- Value	0.152	0.063
Birth Order	r	0.128	0.173
	P- Value	0.231	0.103

Pearson Significant Correlation Test.

Table (3) Relation of Apgar scores at 1 and 5 minutes to groups of the study and other qualitative parameters

Variables			Apgar Score at 1 Minute	Apgar Score at 5 Minutes	P value of Apgar at 1 minute	P value of Apgar at 5 minutes
Study Groups	SGA	Mean ± SD	6.8± 1.8 (a)	8.9± 1.1 (a)	0.001*	0.001*
		Min. -Max.	2.0-9.0	6.0-10.0		
	AGA	Mean ± SD	7.3± 1.3 (a)	9.3± 0.7 (a)		
		Min. -Max.	3.0-9.0	8.0-10.0		
	LGA	Mean ± SD	5.7± 1.8 (b)	8.2± 1.4 (b)		
		Min. -Max.	3.0-9.0	6.0-10.0		
Neonatal Sex	Male	Mean ± SD	6.58± 1.86	8.88± 1.16	0.776	0.533
		Min. -Max.	2.0- 9.0	6.0- 10.0		
	Female	Mean ± SD	6.69± 1.77	8.71± 1.28		
		Min. -Max.	3.0- 9.0	6.0- 10.0		
Mode Of Delivery	C. S	Mean ± SD	6.25± 1.83	8.55± 1.33	0.019*	0.024*
		Min. -Max.	2.0- 9.0	6.0- 10.0		
	NVD	Mean ± SD	7.13± 1.53	9.13± 0.95		
		Min. -Max.	4.0- 9.0	6.0- 10.0		
Insulin Resistance	Present	Mean ± SD	5.92± 1.74	8.21± 1.44	0.019*	0.005*
	Absent	Min. -Max.	6.89± 1.71	9.02± 1.05		

*Significant. Homogenous groups had the same symbol (a, b) based on Post hoc Bonferrroni test.

Apgar score at 1 minute and 5 minutes had a significant correlation to cesarean section (CS) delivery, with means± SD of 6.25± 1.83 and 8.55± 1.33, respectively versus 7.13± 1.53 and 9.13± 0.95, respectively in neonates delivered by normal vaginal delivery (p= 0.019, 0.024, for Apgar at 1 minute and Apgar at 5 minutes, respectively). Neonates with insulin resistance had also lower Apgar score at 1 minute and 5 minutes with means± SD of 5.92± 1.74 and 8.21± 1.44, respectively, versus 6.89± 1.71 and 9.02± 1.05, respectively among neonates with no insulin resistance (p=0.019 and 0.005, respectively). Neonatal sex didn't affect Apgar score at 1 minute or Apgar score at 5 minutes table (3).

Table (4) Correlation of Apgar scores at 1 and 5 minutes to neonatal anthropometric measurements

Variables		Apgar At 1 Minute	Apgar At 5 Minutes
Neonatal Weight	r	−0.150	−0.219
	P- Value	0.158	0.038*
Neonatal Length	r	−0.133	−0.184
	P- Value	0.212	0.082
Head Circumference	r	−0.092	−0.171
	P- Value	0.389	0.108

*Significant, Pearson correlation test

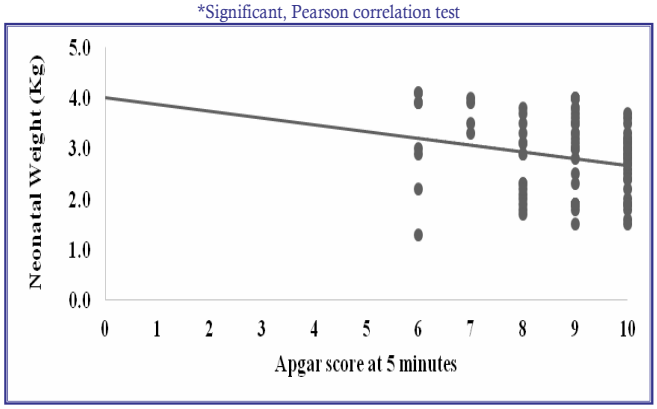

Figure (1) Correlation of Apgar score at 5 minutes to neonatal weight (in Kg).

Only Apgar score at 5 minutes had a significant negative correlation to neonatal weight (r=−0.219, p=0.038), while there was no statistical correlation to neonatal length or neonatal head circumference (table 4). Both Apgar scores at 1 minute and 5 minutes had also a significant negative relation to neonatal serum insulin level (r= −0.389, p= 0.000 for Apgar at 1 minute and r=−0.453, p=0.000 for Apgar at 5 minutes) and HOMA- IR (r= −0.354, p= 0.001 for Apgar at 1 minute and r= −0.422, p= 0.000 for Apgar at 5 minutes) table (5).

Table (5) Correlation of Apgar scores at 1 and 5 minutes to laboratory investigation result

Variables		Apgar At 1 Minute	Apgar At 5 Minutes
Glucose (mg/dl)	r	0.190	−0.139
	P- Value	0.072	0.190
Insulin (µU/ml)	r	−0.389	−0.453
	P- Value	0.000*	0.000*
Homa- Ir	r	−0.354	−0.422
	P- Value	0.001*	0.000*
Irisin (ng/ml)	r	−0.077	−0.135
	P- Value	0.469	0.206

*Significant, Pearson correlation test

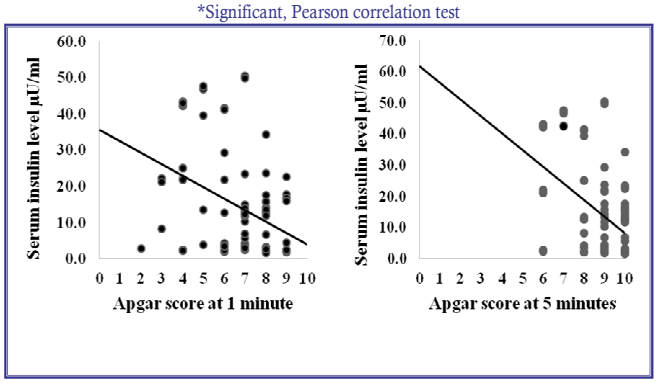

Figure (2) Correlation of Apgar score at 1 minute and 5 minutes to neonatal serum insulin level (in µU/ml).

Introduction:

Apgar score had been used worldwide as an assessment tool for neonatal viability and vitality. It was first described by the US anesthesiologist Virginia Apgar, Columbia University, in 1953, who proposed that this score may be considered as a beneficial and easy method for neonatal assessment. She selected five components that can be examined in the delivery room, which are heart rate, respiratory effort, reflex irritability, muscle tone and skin color. Initially, sh[e u]sed Apgar score at 1 mi[nut]e after delivery, to assess neonates, giving a score from (0 to 2) to each examined sign, and a total score from (0 to 10). She suggested that neonates with a total score from (8- 10) were at good condition, from (3- 7) were at fair condition and those who had a score from (0- 2) were at bad condition.[21][27]

Modern research of Tan and Davis, 2018 reported that Apgar score at 5 min was a better tool predicting neonatal condition than Apgar score performed at 1 min.[27] Another literature of Cnattingius et.al, 2017 discussed that low 5- minutes Apgar score was associated with increased the mortality rate in preterm and full- term neonates.[5] Some studies defined low Apgar score as score less than 7.[20][24] Apgar score at 1 minute is believed in many studies to be a tool indicating increased risk of and mortality and short- term neonatal complications as increased the risk of neonatal respiratory distress and the need for mechanical ventilation and admission to neonatal intensive care units (NICU), while Apgar score at 5 minutes was highly associated with long term neonatal complications as in cerebral palsy, neurological disability, epilepsy and low school performance.[28]

Insulin resistance was detected in several studies among neonates, especially among SGA and LGA neonates and was related significantly to irisin; a newly discovered hormone that was associated in many literatures with morbidities occurring later in adult life as metabolic syndrome.[15][29] Irisin was reported as a potential biomarker for development of obesity, chronic kidney diseases, heart disease, diabetes and stroke.[6][8] Lower irisin levels were associated with elevated hemoglobin A1C, fasting blood sugar, 2 hours post prandial blood glucose level and homeostasis model assessment of insulin resistance (HOMA- IR).[9][16]

Aims:

1. Investigate the correlation between Apgar score and different neonatal parameters.
2. Correlate Apgar score to neonatal glucose level, insulin level, HOMA-IR and irisin level.

Methodology:

This was a control study conducted on 90 neonates, allocated in 3 groups, according to gestational age, birth weight and sex; 30 small for gestational age (SGA), 30 appropriate for gestational age (AGA) and 30 large for gestational age neonates (LGA).

The inclusion criteria were neonates with a gestational age from (30-42) weeks, born in the period 12 months, from January 2020 to January 2021, in Al Fayoum General Hospital, Gynecology and Obstetrics Department. Exclusion criteria were newborns with congenital anomalies, neonatal sepsis, meconium aspiration, neonates of a mother with any chronic disease, history of drug use during pregnancy, gestational diabetes, preeclampsia, eclampsia or intrauterine infections and the use of dextrose solutions or drugs that affect the glucose metabolism during labor.

Data Collection:

1. Maternal demographic profiles, complete history taking, full clinical examination, Apgar score assessment and anthropometric measurements were recorded.
2. Sera of umbilical cord blood were collected from the umbilical vein attached to the placenta at the time of delivery, for laboratory investigations. Serum irisin and insulin levels were measured by ELISA technique.
3. Serum glucose concentrations were measured using Erba Chem 7 biochemistry analyzer.
4. Homeostasis Model assessment for Insulin Resistance (HOMA IR) index was calculated using the formula:[26][29]

$$\frac{\text{Fasting insulin (}\mu\text{U/mL) x Fasting glucose (mg/dl).}}{405}$$

Classification:

1. Classification of subjects into SGA, AGA and LGA groups was according to the World Health Organization (WHO) Fetal Growth Curves.[14]
2. HOMA- IR cut- off value for diagnosing insulin resistance was from 95th percentile according to age.[26]

Statistical Analysis:

The collected data were statistically analyzed using IBM SPSS statistics (Statistical Package for Social Sciences) software version 28.0, IBM Corp., Chicago, USA, 2021. Quantitative data described as mean± SD (standard deviation) as well as minimum and maximum of the range, then compared using independent t- test (two independent groups) and Analysis of Variance (ANOVA) test (three independent groups). Qualitative data described as number and percentage and compared using Chi square test. The level of significance was taken at P value of < 0.050, otherwise was non- significant.

Results:

Among the ninety subjects of this study, the mean± SD of maternal age was 26.12± 3.83 (minimum- maximum: 19- 36 years old), and the mean± SD of maternal body mass index (BMI) was 28.21± 4.48 (min-max: 18.5- 38.7) table (1). Apgar score was not significantly associated with maternal age or maternal BMI or birth order table (2).

Table (1) Descriptive Statistics Of Different Parameters

Maternal And Fetal Variables			
Maternal Age		Apgar At 1 Minute	
Mean± SD	26.12± 3.833	Mean± SD	6.63± 1.764
Min- Max	19- 36	Min- Max	2- 9
Maternal BMI		Apgar At 5 Minutes	
Mean± SD	28.211± 4.4804	Mean± SD	8.80± 1.210
Min- Max	18.5- 38.7	Min- Max	6- 10

Correlation of Apgar score to birth weight in relation to gestational age, insulin resistance and irisin among 90 Egyptian neonates

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Summary

Background: Apgar score is used worldwide as a tool for evaluation of neonatal viability and vitality. Low Apgar score at 1 and 5 minutes of birth has been linked in various studies to increased mortality rates and morbidities among neonates.

Aim: To investigate the correlation between Apgar score and neonatal glucose level, insulin level, HOMA- IR and irisin level.

Methodology: This case- control study was conducted on 90 newborn infants; 30 small for gestational age (SGA), 30 appropriate for gestational age (AGA) and 30 large for gestational age (LGA) neonates.

Results: Both Apgar scores at 1 and 5 minutes were significantly correlated with LGA neonates, with mean± SD of 5.7± 1.8 and 8.2± 1.4, respectively, versus 7.3± 1.3 and 9.3± 0.7, respectively, among AGA neonates and means± SD of 6.8± 1.8 and 8.9± 1.1, respectively among SGA neonates (p=0.001 and 0.001, respectively). Also, cesarean section delivery was significantly associated with Apgar score at 1 and 5 minutes, with means± SD of 6.25± 1.83 and 8.55± 1.33, respectively versus 7.13± 1.53 and 9.13± 0.95, respectively in neonates delivered by normal vaginal delivery (p=0.019 and 0.024, respectively). Neonates with insulin resistance, had lower Apgar score at 1 and 5 minutes, with means± SD of 5.92± 1.74 and 8.21± 1.44, respectively, versus 6.89± 1.71 and 9.02± 1.05, respectively among neonates with no insulin resistance (p=0.019 and 0.005, respectively). Both scores were negatively correlated with neonatal serum insulin level (r=-0.389, p=0.000 and r=-0.453, p=0.000, respectively) and neonatal HOMA- IR values (r=-0.354, p=0.001 and r=-0.422, p=0.000 respectively).

Conclusion: LGA neonates should be given special medical and supportive care, especially during resuscitation after birth. The decision for cesarean section should be a last resort. Apgar score can be used in evaluation of neonatal morbidities especially among this group of neonates.

Keywords: Apgar Neonates SGA AGA LGA Insulin resistance Irisin.

العلاقة بين درجة أبجار والوزن عند الولادة بالنسبة لعمر الحمل ومقاومة الأنسولين والإيريسين لدى ٩٠ طفل مصري من حديثي الولادة

الخلفية: يتم استخدام مقياس أبجار في جميع أنحاء العالم كأداة لتقييم حيوية الأطفال حديثي الولادة. كان هناك علاقة بين انخفاض درجة أبجار عند ١ و٥ دقائق من الولادة في دراسات مختلفة بزيادة معدلات الوفيات والأمراض بين حديثي الولادة.

الأهداف: سيتم معرفة ما إذا كانت هناك علاقة ذات مغزى بين درجة أبجار وبين المعايير المختلفة لحديثي الولادة مثل مستوى الجلوكوز عند الأطفال حديثي الولادة ومستوى الأنسولين ومستوى HOMA- IR ومستوى الإيريسين.

المرضى وطرق البحث: أجريت دراسة الحالات المرضية والمجموعة الضابطة على ٩٠ طفلا حديث الولادة: ٣٠ من حديثي الولادة من ذوي الوزن الصغير بالنسبة لعمر الحمل، ٣٠ من حديثي الولادة من ذوي الوزن المتوسط بالنسبة لعمر الحمل و٣٠ من حديثي الولادة من ذوي الوزن الكبير بالنسبة لعمر الحمل. كان عمر الحمل لحديثي الولادة من ٣٠ أسبوع إلى ٤٢ أسبوع، في فترة ١٢ شهرا، من يناير ٢٠٢٠ إلى يناير ٢٠٢١. تم تسجيل تقييم درجة أبغار وقياسات الجسم كالطول والوزن ومحيط الرأس. تم قياس مستويات الإيريسين والأنسولين في دم حديثي الولادة بتقنية ELISA.

النتائج: كانت درجات أبجار عند ١ و٥ دقائق من الولادة أقل بشكل ملحوظ بين حديثي الولادة من ذوي الوزن الكبير بالنسبة لعمر الحمل، والولادة القيصرية وحديثي الولادة الذين يعانون من وجود مقاومة للأنسولين، كما ارتبطت سلبا بمستوى الأنسولين في الدم، ومستوى HOMA- IR لحديثي الولادة. لم تتأثر كلتا درجات أبجار عند ١ دقيقة وعند ٥ دقائق بشكل كبير بعمر الأم أو مؤشر كتلة الجسم للأم أو ترتيب الولادة أو جنس المولود. كذلك، لم يكن هناك ارتباط بين درجات أبجار مع طول الجسم، ومحيط الرأس لحديثي الولادة، ومستويات الجلوكوز أو الإيريسين في دم الحبل السري.

الخلاصة: يجب إعطاء حديثي الولادة ذوي الوزن الكبير بالنسبة لعمر الحمل رعاية طبية خاصة، خاصة أثناء الإنعاش بعد الولادة. اتخاذ قرار الولادة القيصرية يجب أن يكون الملاذ الأخير، كما يمكن استخدام مقياس أبجار في تقييم الأمراض بين الأطفال حديثي الولادة خاصة بين الرضع في هذه المجموعة.

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