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The Impact of Intensive Care on Pregnant Mothers and Their Newborns

Abstract

This investigation aimed to identify the clinical features and results for both mothers and newborns of obstetrics admitted to the intensive care unit (ICU). This retrospective study analyzed expectant patients admitted to the ICU at Imam Khomeini Hospital in Ahvaz from March 2020 to March 2021. The medical records of these women were evaluated to determine their clinical features and results.

During the research period, 30 expectant patients were admitted to the ICU. Most of these mothers were under 35 years old (80%), with 11 being nulliparous (36.67%) and 2 (6.66 %) were multiple pregnancies. Of these women, 56.66% (n=17) had an underlying disease, 46.15% (n=12) had abnormal echocardiography results, and 80% (n=24) were delivered via cesarean section (CS). Admission reasons were divided between obstetric (n=13, 43.33%) and non-obstetric (n=17, 56.67%), with the most frequent causes being pulmonary thromboembolism (20%), pregnancy-induced hypertension disorders (16.67%), sickle cell anemia (SCA) (16.67%), platelet reduction (10%), and gestational diabetes mellitus (GDM) (10%). The average length of stay in the ICU was 3.03±1.5 days. Of the newborns, 56.66% (n=17) were premature, with an average birth weight of 2297.33±937.98 grams. While there were no maternal deaths in the ICU, perinatal mortality was reported at 20% (n=6).

This research discovered that the leading causes of ICU admission were pulmonary thromboembolism, hypertension disorders during pregnancy, and SCA. Furthermore, frequent traits among admitted patients included being under 35 years old, nulliparity, having underlying diseases, and delivery via CS.

Keywords: *Pregnancy, Pregnancy Complications, Intensive Care Units, Infant, Newborn*

Mahin Najafian[1], Shekoufeh Morshedi[*2], Mojgan Barati[3], Razieh Mihammad Jafari[4]

1. Associate Professor of Obstetrics and Gynecology, Department of Obstetrics and Gynecology, School of Medicine, Fertility Infertility and Perinatology Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran. Najafian-ma@ajums.ac.ir

2. Resident of Obstetrics and Gynecology, Department of Obstetrics and Gynecology, School of Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran. Morshedi.shokofeh@gmail.com

3. Associate Professor of Obstetrics and Gynecology, Department of Obstetrics and Gynecology, School of Medicine, Fertility Infertility and Perinatology Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran. Barati-m@ajums.ac.ir

4. Associate Professor of Obstetrics and Gynecology, Department of Obstetrics and Gynecology, School of Medicine, Fertility Infertility and Perinatology Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran. Mohamadjafari-r@ajums.ac.ir

**Corresponding author: Dr.Shekoufeh.Morshedi*

Introduction

Pregnancy is typically a natural process for most women, with most pregnancies concluding without significant complications. Improvements in global medical care and increased access to healthcare systems have substantially decreased maternal mortality worldwide (1). However, some pregnancies and childbirths may be accompanied by complications necessitating admission to the intensive care unit (ICU) (2). The physiological alterations that transpire during gestation, maladies associated with pregnancy, and limitations in conducting specific interventions due to the necessity of considering the fetus's welfare can render the management of critically ill pregnant patients challenging (3).

Severe maternal morbidity, an indicator of the quality of clinical care (4, 5) and maternal health quality (6), can be objectively measured by the admission of pregnant women to the ICU. The ICU admission rate of pregnant mothers varies widely across countries and centers, ranging from 0.4% to 16% and from 0.7 to 13.5 per 1,000 births (6-10). Developed countries with organized healthcare systems have the lowest hospitalization and mortality rates (7). Most ICU admissions (63-92%) occur postpartum (10, 11).

Two categories of indications for ICU admission exist; obstetric causes (associated with pregnancy and childbirth) and non-obstetric causes (independent of pregnancy and childbirth). The ICU hospitalization of pregnant women is most often due to pregnancy-induced hypertension disorders, hemorrhage, sepsis, and thromboembolic events (1, 4, 10).

Maternal admissions to the ICU have increased dramatically as a result of the rise in high-risk pregnancies. As a result, there is a greater need for supplies, machinery, and medical knowledge (12). Examining maternal morbidity and the criteria for ICU admission is crucial. It enables us to comprehend the traits of hospitalized mothers and devise interventions for the perpetual enhancement of women's and childbirth care. Therefore, this study aimed to scrutinize the

clinical characteristics of pregnant patients in the ICU and their maternal and neonatal outcomes to obtain comprehensive information on their admission status and prognosis in the studied community.

Materials and Methods:

This retrospective cohort study analyzed the medical records of pregnant mothers in the ICU of Imam Khomeini Hospital, Ahvaz, Iran, in 2020. The Research Council granted permission, and the Ethics Committee of Ahvaz Jundishapur University of Medical Sciences approved the study (Ethics Code: IR.AJUMS.HGOLESTAN.REC.1400.083). The Helsinki Declaration on Ethics in Research and principles of patient confidentiality were upheld throughout the research.

Data was gathered by reviewing the medical records of pregnant mothers aged 18-50 years, at any gestational stage, admitted to the ICU of Imam Khomeini Hospital, Ahvaz, in 2020. These records were available in the hospital archive. If data was missing, attempts were made to locate it in file banks. Direct contact with the patient was made to complete the information. If unsuccessful, the patient was excluded from the study.

The research gathered information on the patient's demographics, obstetric/medical history, type of pregnancy at the time, diagnosis and length of ICU admission, laboratory results, interventions, delivery method, gestational age at delivery, and outcomes for the mother and unborn child. Fetal biometry sonography, fetal weight percentile, biophysical sonography (BPP), amniotic fluid assessment index (AFI), color Doppler sonography, and fetal heart rate (NST) results were examined if available. Patients were categorized into two groups based on their diagnosis and hospitalization reasons: obstetric conditions (pregnancy/childbirth-related) and non-obstetric conditions (unrelated to pregnancy/childbirth).

Statistical analysis:

Statistical analysis was performed using SPSS software (SPSS Inc., Chicago, IL, U.S.A.) version 22. Data were described using mean, standard deviation, frequency, and percentage. The Shapiro-Wilk test assessed data normality. ANOVA compared variable means between groups, while the chi-square test compared qualitative variables between groups. A significance level of 0.05 was used in the tests.

Results:

This study examined the files of 30 pregnant mothers admitted to the ICU of Imam Khomeini Hospital, Ahvaz, in 2020. The average age was 27.90 ± 6.7 years (range 19-38) (Table 1). Most mothers were nulliparous (n=11; 36.67%), and most deliveries were cesarean (80%). No history of alcohol or tobacco use and maternal deaths in the ICU were reported.

Of the 30 patients, 11 (43.33%) were admitted to the ICU for pregnancy/childbirth-related reasons and 17 (56.67%) for non-obstetric reasons (Table 2). The most common cause of ICU admission was pulmonary thromboembolism (PTE) (n=6; 20%). Gestational hypertension (GHTN) and SCA each accounted for 5 cases (16.67%), while thrombocytopenia and GDM each had 3 cases (10%). The average ICU stay was 3.03 ± 1.5 days (range 1-8). Most patients stayed for three days (n=10) or two days (n=9).

Echocardiography and sonography were the most common paraclinical interventions (Table 3). Fetal biometry sonography and AFI consultation were performed for 66.66% (n=20), while color Doppler sonography was performed for 50% (n=15) of patients. Cardiology consultation was performed for 26 patients (86.66%), hematology consultation for 12 (40%), and gastroenterology consultation for 10 (33.34%). Fetal sonography evaluation revealed that 16.66% (n=5) of patients had a fetal weight percentile less than 3, 33.33% (n=5) had increased left uterine artery PI, 26.67% (n=4) had increased right uterine artery PI, and 20% (n=3) had increased right and left umbilical artery PI. Of the 15 color Doppler sonographies, 33.33% (n=5) of Intrauterine growth restriction (IUGR) fetuses were observed. One patient (3.85%) with non-reactive NST was reported (Table 3). Most newborns (56.66%) were preterm (Table 4). Six neonatal deaths occurred (20%), all due to preterm delivery.

No significant relationship was found between maternal age and maternal BMI (p-value=0.086), abnormal IUGR Doppler sonography (p-value=0.861), neonatal Apgar score (p-value=0.630), or neonatal death (p-value=0.295) in mothers admitted to the ICU. However, a significant relationship was observed between maternal age and neonatal birth weight (p-value=0.023). Neonates born to younger mothers had significantly lower birth weights than older mothers (Table 5). A significant relationship was also found between delivery mode and neonatal Apgar score (p-value=0.017). Neonates with better Apgar scores were mainly delivered via CS (Table 6). Additionally, neonates with abnormal IUGR Doppler sonography had significantly lower birth weights than those with normal Doppler sonography (p-value=0.035) (Table 5).

Discussion:

The current investigation assessed 30 pregnant mothers requiring ICU management during a one-year interval. The predominant indications for ICU admission were pulmonary thromboembolism, GHTN syndromes, SCA with thrombocytopenia, and GDM. Non-obstetric determinants accounted for 56.67% of ICU admissions. This diverges from prior studies that documented lesser frequencies of non-obstetric ICU admissions in most instances, including 7.4% in

Finland (13), 13% in Portugal (14), 20.47% in India (5), and either 30% or 42.1% in China(11, 15).

Obstetric etiologies such as hypertensive disorders of pregnancy and hemorrhage have been the predominant determinants of maternal ICU admission in numerous investigations (7, 8, 12, 13, 16-18). However, in this investigation, only 16.67% of ICU admissions were due to hypertensive disorders of pregnancy, and a mere 3.33% were due to hemorrhage. Moreover, cardiac diseases (5, 11, 12, 17, 19, 20) and sepsis (14, 15, 21-23) have been the leading non-obstetric etiologies for ICU admission in many investigations. However, in this investigation, pulmonary thromboembolism (20%) and SCA (16.67%) were the most prevalent non-obstetric determinants of ICU admission. The low frequency of cardiac disease may be attributed to admission to the cardiac care unit (CCU). Different investigations have reported diverse etiologies with varying frequencies for ICU admission.

For instance, in Ardabil, Iran, Mostafazadeh et al. reported that pre-eclampsia (52.6%), hemorrhage (26.3%), obesity (10.5%), and coagulation disorder (10.5%) were the predominant determinants of admission (18). In China, Zhang et al. reported that the leading etiologies of admission were hemorrhage (24.1%), hypertensive disorders of pregnancy (18.8%), cardiac diseases (12%), acute fatty liver of pregnancy (8.3%), respiratory problems (7.5%) and amniotic fluid embolism (3.8%) (11). In Pakistan, Ismail et al. reported that the most prevalent etiologies of maternal ICU admission were hemorrhagic/hematologic causes (54.2%), cardiovascular reasons (36.1%), sepsis (13.9%) and acute liver problems (8.3%) (23). The discrepancies in the results regarding the etiologies of ICU admission may be attributable to the study population's baseline characteristics and the geographic region, development level, and diagnostic-therapeutic facilities in different areas. Moreover, it is conceivable that the variation in ICU admission cases in different investigations is due to the variation in referrals and not a reflection of maternal morbidity.

In this investigation, it was ascertained that the average ICU admission duration was 3.03 days. However, this duration is subject to variation, contingent upon the underlying cause of admission and its associated severity. Previous research has reported a range of 1 to 8 days for ICU stays across multiple investigations (12, 14, 19, 22, 23).

No maternal deaths among pregnant women admitted to the ICU were recorded in this investigation. The lack of maternal mortality in the ICU during this study may be attributed to its brief duration and single-center design. In various studies, mortality rates for pregnant women admitted to the ICU have been reported to range from 0.3 to 30% (11-15, 18, 19). Notably, higher mortality rates have been observed in African countries such as Ghana (22) and regions with suboptimal healthcare systems, including India (24) and Pakistan (23). Maternal morbidity and mortality in ICU are associated with risk factors such as severe hemorrhage (1), underlying cardiac disease (25), maternal infection and sepsis (26), and age over 35 years (12, 13, 22).

Consequently, the lack of maternal death in the ICU in this investigation may be attributable to the low frequency of pre-existing cardiac disease, hemorrhage, and absence of infection and sepsis cases. Furthermore, the low age of the study gravidas may be a determinant. Notably, the preponderance of ICU admissions, exceeding 80%, in most studies were correlated with the postpartum period (10, 11, 15, 23, 24). This may explain the augmented mortality rate relative to our investigation, which solely scrutinized maternal outcomes until delivery. Furthermore, the escalated mortality rate observed in certain studies could be ascribed to factors such as suboptimal socio-economic conditions, deficient levels of education, restricted access to healthcare services, and inadequate or absent consultations with obstetricians during gestation (23, 27), in conjunction with variations in patient demographics. Consequently, maternal mortality is a barometer of women's comprehensive health status, their accessibility to healthcare, and the capacity of the healthcare system to accommodate their requirements (5, 23).

In the current study, 80% of the hospitalised women were 35 years of age or younger, a sizable percentage were nulliparous (36.67%), and a significant percentage (56.66%) had pre-existing conditions. 80% of deliveries were caesarean sections, and 56.66% of deliveries were preterm. Other studies have found that moms admitted to the ICU frequently had the following characteristics: young age (under 35 years), nulliparity, CS, and preterm birth of neonates (11-15, 19, 22, 24). Conversely, in some studies, such as those by Gupta et al. (5) and Miglani et al. (24), it was reported that the majority of pregnant mothers admitted to the ICU were twin pregnancies (84% and 68%, respectively). In Pattnaik's study, half of the cases admitted to the ICU were twin pregnancies (17). However, in the current study, there were only 2 cases (6.66%) of twin pregnant mothers. In numerous other studies, cases of twin pregnancy admitted to the ICU were low (less than 10%) (12-14).

Cardiology consultation and echocardiography were this study's most prevalent therapeutic interventions, performed in 86.66% of cases. Fetal biometry sonography and AFI were done in 66.66% of cases, while color Doppler sonography for IUGR was conducted in 50% of cases. Other interventions included CT angiography of the lung (20%), abdominal and pelvic sonography (13.33%), and hematology consultation (40%). Furthermore, the findings indicated that abnormal echocardiography was present in 45.15% of patients and elevated PAP in 34.61%. Pregnancy induces significant hemodynamic alterations such as augmented cardiac output

(30-50%) and diminished peripheral vascular resistance (28), which increase the likelihood of cardiac disorders, especially in women with pre-existing cardiac disease (29) or pre-eclampsia (30). Hence, given the substantial percentage of abnormal echocardiography in these patients, echocardiographic evaluation is suggested as a non-invasive and accessible modality for risk assessment, monitoring structural and functional cardiac status, and detecting anomalies in pregnancy and subclinical changes(28, 29).

Blood and blood product transfusion (83.5%), central venous catheterization (41%), mechanical ventilation (38.6%), abdominal sonography (18.9%), and echocardiography (9.5%) were the most prevalent therapeutic and paraclinical interventions in ICU in the study by Gupta et al. (5). In the study by Oliveira et al., blood transfusion (57%), mechanical ventilation (53%) and use of vasopressors (22.6%) were the most common interventions (14). Arterial access (66%) and mechanical ventilation (58%) were the most frequent interventions in the study by Leung et al. (15). In the study by Zhang et al., the most frequent interventions were mechanical ventilation (65.4%), intravenous antibiotic injection (96.2%), need for central venous catheter (51.9%), blood and blood product transfusion (41.4%), plasmapheresis receipt (8.3%) (11). The difference in therapeutic interventions performed is attributable to patient characteristics, status, and facility access. Since maternal and neonatal health is a significant indicator for human and social development, prompt detection and effective treatment of high-risk obstetric patients in a specialized ICU with superior facilities can avert severe maternal complications and enhance maternal care(5).

The findings of this study showed that 33.33% of fetuses had IUGR. Furthermore, the mean gestational age of neonates at birth was 33.97±4.9 weeks, and the mean birth weight of neonates was 2297.33±937.98 grams. Additionally, 20% (n=6) of neonatal deaths occurred due to preterm delivery. These results indicate that maternal hospitalization in the ICU is essential for maternal care and treatment and for the condition of these mothers' neonates, which is jeopardized and needs precise monitoring. Our study did not determine the number of neonates hospitalized in the Neonatal intensive care unit (NICU), but preterm and low birth weight neonates usually require hospitalization in the NICU. Therefore, mother-neonate separation due to neonatal death or hospitalization in the NICU is often unavoidable. Similar results have been reported in other studies, and a high percentage of neonates born to mothers hospitalized in the ICU were preterm and needed hospitalization in the NICU (31, 32). In the study by Seppänen et al., low birth weight (<2500 grams) and preterm birth of neonates were frequent in mothers hospitalized in ICU, and most of the neonates born (56.1%) required treatment in NICU and 4.6% of them died within a week (13). Perinatal mortality in pregnant mothers hospitalized in ICU was reported as 10.9% in the study by Zhang et al. (11) and 8% by Leung et al. (15). These findings are consistent with those of the current investigation.

According to our research, there is a significant relationship between the mother's age and the weight of the newborn. Compared to older mothers, newborns born to younger mothers had significantly lower birth weights. Furthermore, neonates with higher Apgar scores were predominantly delivered via CS. These findings align with previous research, which has demonstrated that, in critically ill women admitted to the ICU, CS can result in superior maternal and neonatal outcomes compared to vaginal delivery (VD) (22). This study also revealed that birth weight in neonates with abnormal IUGR Doppler sonography was significantly lower than in neonates with normal Doppler sonography. Since IUGR neonates have growth restriction, the relationship between neonatal weight and abnormal IUGR Doppler is reasonable. Finally, it should be noted that there is no standard criterion for admission to ICU in different areas, which hinders the comparison of data and different articles and interpretation of results. However, screening and prevention of common indications and pregnancy education about dangerous signs of pregnancy can reduce maternal complications. Furthermore, more studies are required to understand better broader issues regarding the outcomes of admission to obstetric ICU.

Some of the limitations of this study are the retrospective nature, single-center and small sample size, and potential bias in the data available in medical records. In this study, we could not retrieve information about birth outcomes, such as hospitalization in the NICU. Furthermore, data on neonatal death up to 7 days were available, and long-term neonatal outcomes were not examined. Finally, since this is a single-center study, any extrapolation and generalization of these results should be done cautiously.

Conclusion:

The findings of this study revealed that contrary to most previous studies, non-obstetric indications were the most frequent causes of hospitalization of pregnant mothers in the ICU of the hospital under study. The most frequent causes of hospitalization of pregnant mothers in ICU were PTE, GHTN disorders, SCA, thrombocytopenia, and GDM, respectively. Furthermore, young maternal age, nulliparity, CS, and preterm birth were typical among women hospitalized in the ICU. Therefore, a multidisciplinary team approach is required to manage pregnant women in the ICU, which can significantly improve maternal outcomes.

Ethical statement:

The protocol of this study was approved by the Ethics Committee of Ahvaz Jundishapur University of Medical Sciences (code IR.AJUMS.HGOLESTAN.REC.1400.083), and the information available in the patient's records was confidential throughout the research.

Ethical Issues:

The present article is derived from the specialty residency thesis in obstetrics and gynecology with the research project number FIRC-0015 at the Faculty of Medicine, Jundishapur University of Medical Sciences, Ahvaz.

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Conflicts of Interest:

The authors report that this study has no competing or conflict of interest.

Acknowledgments:

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Table 1. Basic characteristics of pregnant mothers admitted to the ICU

Variable	Group	N (%)
Mother's age (years)	<30	20 (66.67)
	30-35	4 (13.33)
	>35	6 (20)
BMI (Kg/m^2)	18.5-24.5	3 (10)
	25-29.9	14 (46.66)
	≥ 30	13 (43.34)
Underlying disease	High blood pressure	5 (16.66)
	Underlying heart disease	3 (10)
	SCA	5 (16.66)
	Thalassemia	2 (6.66)
	Von Willebrand disease	1 (3.33)
	Hypothyroidism	2 (6.66)
	Asthma	2 (6.66)
	Lupus	1 (3.33)
	Wegener's granulomatosis	1 (3.33)
	Mild liver hemangioma	1 (3.33)
	Pre-gestational diabetes	1 (3.33)
	Breast Cancer	18 (60)
Laboratory findings	Low HB	18 (60)
	Low HC	12 (40)
	Low PLT	6 (20)
	High ALT	13 (43.33)
	High AST	12 (40)
	High LDH	12 (40)
	High Cr	12 (40)
	High BUN	2 (6.66)
	Low K	13 (43.33)
Surgical records	CS	10 (33.33)
	Laparoscopy	1 (3.33)
	Non-gynecological surgery	6 (20)
Parity	P1	9 (30)
	P2	5 (16.67)
	P≥3	5 (16.67)
Gravida	G1	9 (30)
	G2	10 (33.34)
	G3	3 (10)
	G≥4	8 (26.66)
History of abortion	-	9 (30)
History of ectopic pregnancy	-	1 (3.33)
Current pregnancy	Singleton	28 (93.33)
	Twins	2 (6.66)
Type of delivery	VD	6 (20)
	CS	24 (80)

Hb: Hemoglobin; PLT: Platelet count; HCT: Hematocrit; AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; LDH: Lactate dehydrogenase; Cr: Creatinine; BUN: Blood urea; K: Potassium; VD: vaginal delivery; CS: Cesarean section; SCA: sickle cell anemia

Table 2. The incidence of admission of pregnant mothers to the ICU

Cause of hospitalization	Type of complication	N (%)
Related to pregnancy and childbirth	Blood pressure disorders of pregnancy	5 (16.67)
	GDM	3 (10)

	Decreased platelets	3 (10)
	Hyperemesis	1 (3.33)
	Vaginal bleeding + von Willebrand disease	1 (3.33)
Unrelated to pregnancy and childbirth	PTE	6 (20)
	SCA	5 (16.67)
	Maternal heart disease - PDA	1 (3.33)
	Lupus	1 (3.33)
	Kidney hydronephrosis	1 (3.33)
	Sharp abdominal trauma and uterine rupture	1 (3.33)
	Fracture of the femur	1 (3.33)
	Snakebite and increased INR	1 (3.33)

PTE: Pulmonary Thromboembolism; PDA: Patent ductus arteriosus; INR: international normalized ratio; SCA: sickle cell anemia; GDM: Gestational Diabetes Mellitus

Table 3. Paraclinical assessments in pregnant mothers admitted to the ICU

Paraclinical measures	Parameter	Result	N (%)
Echocardiography (n=26)	-	Abnormal echocardiography	12 (46.15)
	-	High PAP	9 (34.61)
Biometric ultrasound (n=20)	Weight percentile	<3%	5 (16.66)
		normal	25 (83.34)
	FL	normal	26 (86.67)
		abnormal	4 (13.33)
	BDP	normal	25 (83.34)
		abnormal	5 (16.66)
	AC percentile	<3%	5 (16.66)
		10-50%	17 (56.68)
		50-90%	8 (26.66)
		>90%	0 (0)
Ultrasound index of amniotic fluid evaluation (n=20)	-	Polyhydramnios	1 (5)
	-	Normal AFI	19 (95)
Biophysical ultrasound (n=3)	-	Normal BPP	3 (100)
Color Doppler ultrasound (n=15)	PI left-uterine artery	High PI	5 (33/33)
		Normal PI	10 (66.67)
	PI right-uterine artery	High PI	4 (26.67)
		Normal PI	11 (73.33)
	PI-Umbilical artery	High PI	3 (20)
		Normal PI	12 (80)
	PI-Middle cerebral	High PI	3 (20)
		Normal PI	12 (80)
	IUGR fetus	Yes	5 (33/33)
Fetal ECG (n=26)	-	non-reactive NST	1 (3.85)
	-	reactive NST	25 (96.15)

FL: Femur length; BDP: Biparietal diameter; AC: abdominal circumference; AFI: Amniotic fluid index; BPP: Biophysical profile; PI: Pulsatility index; NST: nonstress test

Table 4. Features of neonates of mothers admitted to the ICU

Variable	Group	Result
Age at birth (weeks), mean±SD	-	33.97±4.9
Birth weight (grams), mean±SD	-	2297.33±937.98
Apgar at birth, N (%)	0-1	3 (10)
	0-2	3 (10)
	<8-9	6 (20)
	8-9	5 (16.66)
	9-10	13 (43.33)
Baby's Death, N (%)	-	6 (20)
The number of full-term and pre-term babies, N (%)	pre-term	17 (56.66)
	full-term	13 (43.33)

Table 5. Establishing the correlation between the neonatal weight and the maternal age and fetal color doppler sonography of the gravid females admitted to the ICU

Variable	Birth weight (grams)	P-value*
Mother's age		
<30 years	1986.00±980.94	0.023
30-35 years	2675.00±350.01	
>35 Years	3083.33±360.09	
Doppler sonography		
Normal	2886.67±898.52	0.035
Abnormal	1708.90±249.34	

*** ANOVA test**

Table 6. Establishing the correlation between the mode of delivery of the female and Apgar score of the neonate in gravid females admitted to the ICU

Apgar at birth	VD (n=6)	CS (n=24)	P-value*
0-1	2 (66.66)	1 (33.33)	0.017
0-2	2 (66.66)	1 (33.33)	
<8-9	1 (16.66)	5 (83.33)	
8-9	0	5 (100)	
9-10	1 (7.70)	12 (92.30)	

VD: vaginal delivery; CS: Cesarean section

*** chi-square test**