PREVALENCE OF PULMONARY HYPERTENSION IN NEWBORN INFANTS

By

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ABSTRACT

Background: Echocardiography is non-invasive technique that used to image the effects of pulmonary hypertension on the heart and estimate Pulmonary Artery Pressure from continuous wave Doppler measurements. Pulmonary hypertension prevalence of about 1 - 10% of the global population. Severe persistent pulmonary hypertension is about 2-6 / 1000 of all births. Female/Male ratio is about 2/1. The symptoms of pulmonary hypertension include respiratory distress, poor feeding, Cyanosis and others.

Aim: The current study aimed to assess the incidence of pulmonary hypertension in newborn infants in NICU using Echocardiography.

Patients and Methods: The current study is a case control study & aimed to estimate the prevalence of pulmonary Hypertension in newborn infants in the NICU in Al-Hussain University Hospital during the period from May 2016 till April 2017. The newborn infants were subdivided into four groups according to the gestational age. Group (A): 15 apparent healthy babies who were collected from Obestetric and outpatient departments. Group (B): 15 babies who were admitted to NICU due to underlying problem. Group (C): 30 Near-term infants from 32 – 36 GA. Group (D): 30 Preterm infants less than 32 GA. Including all babies from both sexes, aged 0-14 days, any gestational age and evaluated with Echocardiography. Babies with congenital anomalies, weight less than 1000gm and GA less than 30Weeks were excluded.

Results: The demographic data showed no differences between all groups regarding age and sex. Many risk factors were observed during the study as respiratory distress syndrome (16.7%), premature rupture of membrane (10%), maternal diabetes (5.6%) and meconium aspiration syndrome (8.9%). Pulmonary hypertension $^{(P++)}$ occurred commonly in females (60%), with RDS (33.3%) and with cesarean section (80%). All cases with P^{++} were in need to oxygen supplementation (100%) with O2 saturation ranging from 93-100% and the blood gases analysis tended to be metabolically acidosis. Finally we found the prevalence of pulmonary hypertension in our study were 5.6% of all cases with mean systolic artery pressure 51.80±10.73 mmHg and the mortality rate reached up to 20%.

Keywords: Arterial blood gases – Electrocardiogram - Congenital diaphragmatic hernia - Respiratory distress syndrome - morphogenic protein.

INTRODUCTION

Pulmonary hypertension (PH) is a hemodynamic and pathophysiologic condition defined as an increase in mean pulmonary artery pressure (MPAP) **(1).**

In particular, PAH is characterized by the presence of precapillary PH due to relative blood flow obstruction proximal to the lung capillary bed and increased pulmonary vascular resistance (PVR). This results in right ventricular (RV) pressure overload, ultimately leading to right-heart failure and death. PAH can be idiopathic, heritable, drug or toxin induced, or associated with other medical conditions, such as congenital heart disease (CHD), connective tissue disease, human immunodeficiency virus infection, portal hypertension and chronic hemolytic anemia **(2).**

Persistent pulmonary hypertension of the newborn (PPHN) is an abnormal early adaptation to the perinatal circulation transition. Failure of the normal postnatal decline in pulmonary vascular resistance (PVR) leads to right-to-left intra- or extra-cardiac shunting, (which impairs systemic oxygenation) and right ventricular failure. PPHN affects 2 to 6 per 1000 live births. Mortality rate is still high (up to 48%) and adverse neurological sequelae in survivors are common (up to 46%) **(3)**.

Treatment of PPHN includes support of oxygenation and ventilation, fluids and medications to maintain good cardiac output, and sedation. Surfactant may be given to improve lung function. Infants may require inhaled nitric oxide. In extreme cases, the infant may require extracorporeal membrane oxygenation. Persistent pulmonary hypertension puts the infant at risk for low blood oxygen levels, increased requirements for support, and long-term neurodevelopmental impairment such as developmental delays, motor delays, and hearing loss **(4).**

Transthoracic echocardiography is an excellent noninvasive screening test for patients with symptoms or risk factors for PH, by providing direct and/or indirect signs of elevated pulmonary artery pressure (PAP). It may also provide key information on both the etiology and the prognosis of PH Echocardiography is a pivotal screening test in symptomatic patients at risk for PAH. As an imaging modality, it has the advantage of being widely available, cost effective, and safe. It also plays an important role in assessing outcomes, monitoring the efficacy of specific therapeutic interventions for PH, and detect-

ing the preclinical stages of disease. Newer ultrasound techniques may provide key additional information in the assessment of right-heart structure and function [1].

AIM OF THE WORK

The current study aimed to assess the prevalence of pulmonary hypertension in newborn infants in NICU using Echocardiography.

SUBJECTS AND METHODS

The study design:

This is a clinical control case study done among 90 neonates recruited from the neonatal intensive care unit of (Department of pediatrics, Faculty of medicine, Al-Hussein university Hospital).

Duration of the study:

The study was conducted in the period from May 2016 till April 2017.

Setting of the study:

This case control trial was conducted at NICU, Al-Hussain University Hospital, Cairo, Egypt.

Inclusion criteria:

All newborn infants admitted to neonatal unit of Al-Hussain University Hospital, Any sex, Age: from 0 to 14 days and Evaluation for pulmonary hypertension with Echocardiography.

Exclusion criteria:

Major congenital anomalies, Congenital Heart Disease and birth weight less than 1000gm.

Study Population:

During the study period 90 neonates were randomized and divided into four groups:

Group (A): 15 apparent healthy babies who were collected from Obestetric and outpatient departments.

Group (B): 15 babies who were admitted to NICU due to underlying problem.

Group (C): 30 Near-term infants from 32 – 36 GA.

Group (D): 30 Preterm infants less than 32 GA.

Ethical aspect:

1. Patient consent was obtained before the study.
2. Approval of ethical committee was obtained.
3. No conflict of interest regarding the research and fund from any sources.

Methods:

All newborn babies underwent the following assessment:

i) Clinical History:

Maternal History: (1st day of last menstrual period, Diseases (Hypertension, DM, Infection and SLE) and Complications (PROM and bleeding)).

Natal History (Name, Sex, Gestational age, Age, Type of delivery, MAS & Asphyxia)

Postnatal History (Postnatal hypoxia, Cyanosis & RDS).

Family History (Similar condition and CHD in other sibling).

ii) General assessment:

GA assessment, Anthropometry (Weight, length and HC) & Vital Signs (BP, Color {cyanosis}, Temperature, HR and RR)

iii) Systemic examination: (GIT, Chest, Neurological,…..etc)

iv) Cardiac examination: (Heart sounds, murmur, perfusion, peripheral pulsation and blood pressure).

v) Investigations:

Pulse oximeter, Arterial blood gases, Chest X ray & Hematology (CBC, CRP, Blood glucose…etc)=

vi) Echocardiographic assessment:

Statistical Analysis

The data were coded, interred and processed in computer using statistical package for social science (SPSS) version (20). The results were represented in tabular and diagrammatic forms then interpreted. Mean, slandered deviation, range and percentage were used as descriptive statistics.

RESULTS

Table (1): The incidence of PH*.

HTN	No.	%
Negative (<30mmHg)	85	94.4%
Positive (>30mmHg)	5	5.6%
Total	90	100.00%

*Mean Pulmonary artery pressure more than 30 mmHg.

The table showed the incidence of PH in the study (5.6%).

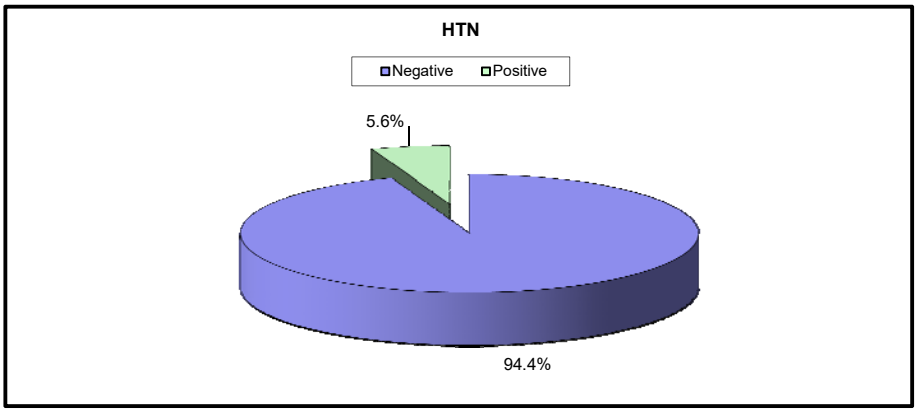

Fig (1): Incidence of PHN.

Table (2): Comparison between the four studied groups regarding demographic data.

		Group A	Group B	Group C	Group D	Test value	P-value	Sig.
		No. = 15	No. = 15	No. = 30	No. = 30			
Age	Mean±SD	6.80 ± 3.95	5.47 ± 2.56	6.53 ± 3.58	6.23 ± 3.51	0.440•	0.725	NS
	Range	2 – 13	2 – 11	2 – 14	2 – 13			
Sex	Female	6 (40.0%)	6 (40.0%)	14 (46.7%)	14 (46.7%)	0.360*	0.948	NS
	Male	9 (60.0%)	9 (60.0%)	16 (53.3%)	16 (53.3%)			
Mode of delivery	NVD	5 (33.3%)	5 (33.3%)	4 (13.3%)	1 (3.3%)	10.080*	0.018	S
	CS	10 (66.7%)	10 (66.7%)	26 (86.7%)	29 (96.7%)			

This table shows no statistically differences between four groups regarding age and sex (P=0.725 and 0.948 respectively) and there was a significant difference in the mode of delivery (P= 0.018).

Table (3): Comparison between the four groups regarding the risk factors.

Risk factor	Group A		Group B		Group C		Group D		Test value*	P-value	Sig.
	No.	%	No.	%	No.	%	No.	%			
No	0	0.0%	9	60.0%	12	40.0%	17	56.7%			
RDS	0	0.0%	1	6.7%	7	23.3%	7	23.3%			
PROM	0	0.0%	0	0.0%	3	10.0%	6	20.0%	15.249	0.054	NS
DM	0	0.0%	2	13.3%	3	10.0%	0	0.0%			
MAS	0	0.0%	3	20.0%	5	16.7%	0	0.0%			

This table shows no statistically differences between the study groups regarding the risk factors (P= 0.054).

Table (4): Correlation between the blood gases analysis and pulmonary hypertension in studied groups.

		Negative HTN	Positive HTN	Test value•	P-value	Sig.
		No. = 85	No. = 5			
PH	Mean±SD	7.35 ± 0.07	7.19 ± 0.02	5.025	0.000	HS
	Range	7.11 – 7.49	7.16 – 7.21			
PCO2	Mean±SD	39.98 ± 8.34	50.20 ± 18.54	-2.373	0.021	S
	Range	25 – 72	34 – 75			
PO2	Mean±SD	71.16 ± 23.21	63.00 ± 32.58	0.736	0.464	NS
	Range	28 – 151	35 – 117			
HCO3	Mean±SD	21.51 ± 3.48	16.30 ± 4.58	3.155	0.002	HS
	Range	14 – 29	12 – 24			

This table shows there was statistically differences between the affected cases with pulmonary hypertension regarding the pH (P= 0.000), PCO2 (P= 0.021) and HCO3 (P= 0.002) and there was no difference in PO2 (P= 0.464).

Table (5): Comparison between the four groups regarding the death rate.

Death	Group A		Group B		Group C		Group D		Test value*	P-value	Sig.
	No.	%	No.	%	No.	%	No.	%			
Alive	15	100%	15	100%	29	96.7%	27	90.0%	3.663	0.300	NS
Dead	0	0.0%	0	0.0%	1	3.3%	3	10.0%			

This table shows no differences between the study groups regarding the death cases (P= 0.300).

Table (6): Correlation between PH^{++} and the Echocardiographic finding.

		Negative HTN	Positive HTN	Test value•	P-value	Sig.
		No. = 85	No. = 5			
PR/EDPAP	Mean±SD	12.07 ± 1.59	14.40 ± 3.36	-2.952	0.004	HS
	Range	10 – 18	12 – 20			
TR/ESPAP	Mean±SD	20.82 ± 3.86	51.80 ± 10.73	-15.247	0.000	HS
	Range	17 – 41	38 – 65			

This table shows a highly significant difference between the affected and unaffected cases with PHN regarding EDPAP and ESPAP (P= 0.004 and 0.000 respectively).

Table (7): relation between PH^{++} and Risk Factors in studied groups.

Risk factor		TR/ESPAP		Test value	P-value	Sig.
		Mean±SD	Range			
Group B	No	23.33 ± 3.97	18 – 28	6.228	0.010	S
	RDS	19.00 ± 0.0	19 – 19			
	PROM	–	–			
	DM	39.00 ± 12.73	30 – 48			
	MAS	21.00 ± 1.73	19 – 22			
Group C	No	23.33 ± 5.94	17 – 38	1.792	0.162	NS
	RDS	21.14 ± 4.22	17 – 28			
	PROM	28.33 ± 11.02	21 – 41			
	DM	20.00 ± 2.00	18 – 22			
	MAS	18.60 ± 1.14	17 – 20			
Group D	No	25.00 ± 14.34	17 – 65	0.533	0.593	NS
	RDS	23.43 ± 11.04	18 – 48			
	PROM	19.00 ± 2.10	17 – 23			
	DM	–	–			
	MAS	–	–			

This table shows significant difference in group B regarding ESPAP (P= 0.010).

Table (8): correlation between PH^{++} and Gestational age in studied groups

Gestational age	TR/ESPAP	
	r	P-value
Group B	-0.233	0.404
Group C	-0.070	0.714
Group D	-0.234	0.212

This table shows no differences between the studied groups.

DISCUSSION

The definition of pulmonary hypertension (PH) is a mean pulmonary artery pressure >25 mmHg at rest and >30mmHg at stress [(5)].

Pulmonary hypertension of the newborn occurs in an estimated 1 or 2 infants per 1000 live births and is associated with substantial morbidity and mortality. Despite treatment, 10 to 20 percent of affected infants will not survive. Newborns with PHN are typically full-term or near-term infants without associated congenital anomalies who present shortly after birth with severe respiratory failure requiring intubation and mechanical ventilation. This disruption of the normal fetal-to-neonatal circulatory transition is characterized by postnatal persistence of elevated pulmonary vascular resistance, resulting in right to left shunting of blood through fetal channels (the patent ductus arteriosus, foramen ovale, or both), diminished pulmonary blood flow, and profound hypoxemia [(6)].

Neonatal respiratory failure affects 2% of all live births, and is responsible for over one third of all neonatal mortality. Pulmonary hypertension (PHN) complicates the course of approximately 10% of infants with respiratory failure, and is a source of considerable mortality and morbidity in this population [(7)].

Persistent pulmonary hypertension (PPHN) is a unique form of pediatric pulmonary hypertension characterized by vascular injury and remodeling that occurs before and just after birth [(7)].

Supportive therapy in patients with PAH traditionally, on an individualized basis. The use of oxygen is recommended only when arterial blood oxygen partial pressure is consistently <60 mmHg. Ambulatory supply of oxygen can be considered when evidence exists of symptomatic benefit and correctable desaturation on stress. Diuretics should be used with caution in children with PAH because of the preload-dependency of the pressure-loaded right ventricle, and the importance of sufficient systemic blood pressure and flow for both right and left ventricular function [(8)].

The current study aimed to assess the prevalence of pulmonary hypertension in newborn infants in NICU using Echocardiography.

Our plan was to assess three groups of newborn infants that were classified according to the

gestational age to show the risk of prematurity on the incidence of pulmonary hypertension.

All groups were underwent medical history taking, general physical examination and Echocardiographic assessment collecting more information about the risk factors that influence the study.

Echocardigraphic assessment was done with attention to the body temperature, cardiorespiratory monitoring and oxygen supplementation if needed and was done within the first 2weeks of life.

Our study was included 90 newborn infants that were divided into Group A and B (Full term), Group C (32-36 w) and Group D (<32 w).

The demographic data show that there were no differences between the three groups prior to the study, so, the samples are homogenous. As the following:

- The ages of the infants during the study were ranging 2-14 days with (P-value= 0.725).
- The gender ratio in the three groups showed there was no significant difference (P= 0.948).
- The mode of delivery showed a significant difference between the three groups of the study (P= 0.018).

Many risk factors were generally observed in this study such as respiratory distress syndrome (RDS) which occurred in 16.7% of all infants of the study that in agreement with the study of **Lau et al, 2017[9]** which included 352 infants with gestational age between 23^{+5} to 36^{+6} weeks and the rate of RDS was 17.6%.

Premature rupture of membranes were observed in 10% of all infants in the study which in agreement with **Yasmina and Barakat, 2017[10]** study that included 144 infants with PROM from 2400 infants (6%) with range of 5-10%.

Infants who were born to diabetic mothers were 5.6% that are in conduction with the study of **Hanne et al, 2017[11]** study (4.8-8%) and the study of **Hosagasi et al, 2017[12]** that included 207 infants, 12 (5.7%) infant had a diabetic mother.

Also, meconium aspiration was observed in rate 8.9% which in agreement with the study of **Lee et al, 2016[13]** which included 1281 cases, 118 (9.2%) cases of them had a meconium stained amniotic fluid.

23.3% of infants of the study who developed pulmonary hyper-

tension in group C and D (premature) had RDS which is a major risk factor for developing pulmonary hypertension.

Also, the gender is considered a risk factor for pulmonary hypertension, the prevalence of pulmonary hypertension between the males and females are 40% and 60% respectively. This correlated with the finding of the study of **Barst et al. 2012**[14] who found that the female to male ratio was 2/1. And was in disagreement with **Hernandez-Dias et al. 2007**[15] who conducted a study on 377 infants with PPHN and found that a male gender is a risk factor with increased number of affected males 239 (63.4%) when compared to number of affected females 138 (36.6%).

Cesarean section was observed in 75 infants from 90 infants with incidence rate 83.3% which in agreement with the retrospective study of **Jian et al, 2015**[16] that include 232 infants who 86.1% of them were delivered by CS.

In comparison between the affected and the unaffected infants with pulmonary hypertension regarding blood gases analysis, there was a high significant differences (Table 6) in pH, PaCO2 and HCO3 (P= 0.000, 0.021 and 0.002 respectively), such results shows that the infants with pulmonary hypertension tend to have metabolic acidosis.

In general we found the prevalence of pulmonary hypertension in our study was 5.6% of all cases.

The mortality rate in the study (in all groups) was 4.4%, and the rate was increased with decreased gestational age (group A 0%, group B 0%, group C 3.3% and group D 10%), this results in agreement with the study of **Ashna et al, 2011**[17] which included data on 29 countries/ regions from 2004 till 2011 and reported that the neonatal mortality rate 1.6-5.7% and increased with decreased gestational age.

The mortality rate among the infants who affected with pulmonary hypertension was 20% which in conduction with the study of **Athar et al, 2013**[18], that included 79 infants with pulmonary hypertension and the mortality rate was 8% to 16.8% according to gestational age.

Echocardiography is the main tool for pulmonary hypertension diagnosis showing a significant differences between the three groups regarding diastolic pulmonary artery pressure (P=0.000), acceleration time (P=0.029), acceleration time/ejection time ratio

(P=0.001), LVEDD (P=0.000), ESD (P=0.000), Ejection fraction (P=0.022) and FS (P= 0.014).

The estimated diastolic pulmonary artery pressure (EDPAP) measurements in the affected infants was highly different than measurements in the unaffected infant (P=0.004) with mean 14.4±3.36 (12-20) and EDPAP in the unaffected infants 12.07±1.59 (10-18).

The mean systolic pulmonary artery pressure in the affected infants was 51.80±10.73 (PHN > 30mmHg) and in the unaffected infants was 20.82±3.86.

CONCLUSION

Pulmonary Hypertension (PH) has a prevalence as in the general population (5.6%). Its mechanisms will be the focus of investigation in the near future. Echocardiography should be considered to be an indispensible non-invasive tool for the evaluation of newborn infants.

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معدل انتشار ارتفاع ضغط الشريان الرئوي بين الأطفال حديثي الولادة

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المقدمة: هو حالة من الفسيولوجيا المرضية التي تؤثر علي الدورة الدموية ويعرف ارتفاع ضغط الشريان الرئوي إذا كان أكثر من 30 مليميتر زئبقي في الأطفال حديثي الولادة.

من الممكن أن يكون ارتفاع ضغط الشريان الرئوي ارتفاعا أوليا أو ثانويا نتيجة لعدة أسباب مثل متلازمة الضائقة التنفسية, خلل التنسج القصبي الرئوي, أمراض النسيج الضام..... وغيرها.

يحدث هذا الارتفاع نتيجة انسداد نسبي لسريان تيار الدم إلي الرئتين وزيادة نسبة مقاومة الأوعية الدموية الرئوية مما يؤدي إلي ضغط زائد علي البطين الأيمن في القلب وبالتالي يحدث فشل في وظائف القلب وتحدث الوفاة والتي قد تصل إلي 48%.

عالميا يحدث ارتفاع ضغط الشريان الرئوي بين الأطفال حديثي الولادة بنسبة من 1 إلي 10%. كما أنه يحدث بين الذكور والإناث بنسبة 1: 2.

ارتفاع ضغط الشريان الرئوي المستمر عند الأطفال حديثي الولادة هو نوع خاص يحدث نتيجة فشل الرئة في التكيف ما بعد الولادة علي تقليل مقاومة الأوعية الدموية والتي تؤدي إلي تحويل مسار الدم من اليمين إلي اليسار داخل أو خارج القلب وفشل في الجانب الأيسر من القلب والذي يع الطفل في حالة من نقص الأكسجين والذي له تأثير علي النمو العصبي للطفل.

أعراض هذا المرض تشمل النهجان, الزرقة, صعوبة التغذية..... وغيرها.

تشخيص هذا المرض يحتاج إلي فحوصات كالتاريخ المرضي (قبل, أثناء وبعد الولادة), فحص عام وفحص باستخدام الموجات الفوق صوتية علي القلب.

يشتمل العلاج علي الإمداد اللازم بغاز الأكسجين والتغذية الوريدية والأدوية مثل مدرات البول والمهدئات وبعض الأطفال تستجيب للعلاج بغاز أكسيد النيتريك, والحالات الشديدة يلزمها الأكسجين خارج الجسم.

تخطيط صدي القلب هو تقنية ممتازة غير إختراقية تستخدم في تشخيص ارتفاع ضغط الشريان الرئوي كما أنها تستخدم كاختبار فحصي للأطفال الذين يظهر عليهم أعراض ارتفاع ضغط الشريان الرئوي أو تعرضوا لعوامل الخطورة وكذلك قد يعطينا معلومات عن السبب وتكهنات عن وضع الطفل مستقبلا. ويتميز هذا النوع من الفحص بأنه متاح, قليل التكلفة وآمن.

الهدف من الدراسة: يهدف البحث إلي قياس معدل انتشار حدوث ارتفاع ضغط الشريان الرئوي بين الأطفال حديثي الولادة باستخدام تخطيط صدي القلب.

طريقة الدراسة: تم اختيار الأطفال في مستشفي الحسين الجامعي (جامعة الأزهر) في الفترة من مايو 2016م وحتى أبريل 2017م وتقسيمهم إلي ثلاث مجموعات رئيسية علي حسب العمر الرحمي من كلا الجنسين كالتالي:

- المجموعة (أ): الأطفال كاملي النمو (أكثر من 37 أسبوع) وتم تقسيم المجموعة إلي مجموعتين فرعيتين:
  - مجموعة (أ-1): 15 طفل كامل النمو صحي ظاهريا وتم تجميعهم من قسم الولادة أو العيادة الخارجية.
  - مجموعة (أ-2): 15 طفل كامل النمو تم حجزهم بوحدة الرعاية المركزة للأطفال حديثي الولادة بسبب مشاكل صحية.
- المجموعة (ب): 30 طفل ناقصي النمو (من 32-36 أسبوع).
- المجموعة (ج): 30 طفل ناقصي النمو (أقل من 32 أسبوع).

وتم إقصاء الأطفال ذوي العيوب الخلقية, الوزن أقل من 1000 جرام.

كل الأطفال موضع الدراسة خضعوا لأخذ التاريخ المرضي (الاسم, العمر, النوع, العمر الرحمي, طريقة الولادة والمشاكل الصحية للأم), الفحص العام (الوزن, اللون, وتخطيط صدي القلب (ضغط الشريان الرئوي الانقباضي والانبساطي, وقت التسارع والطرد والنسبة بينهما, ارتجاع الصمام الرئوي, أبعاد البطينين الأيمن والأيسر وجزء الطرد).

النتائج: تم تجميع البيانات وتحليلها إحصائيا وكانت النتائج كالتالي:

- البيانات السكانية تفيد بأنه لا يوجد اختلاف بين المجموعات فيما يخص العمر والنوع.
- تم ملاحظة العديد من عوامل الخطورة العامة مثل متلازمة الضائقة التنفسية, تمزق الأغشية المبكر, الأم المصابة بالسكري و شفط العقي.
- نسبة حدوث ارتفاع ضغط الشريان الرئوي بين الأطفال حديثي الولادة هي 5,7%.
- نسبة حدوث ارتفاع ضغط الشريان الئوي في الإناث أكثر من الذكور.
- الأطفال المصابة بارتفاع ضغط الشريان الرئوي تميل إلي الحما الأيضي.
- نسبة حدوث الوفاة بين الأطفال المصابة بارتفاع ضغط الشريان الرئوي تصل إلي 20%.
- متوسط ضغط الشريان الرئوي في الحالات المصابة هو 51±10,73 مليميتر زئبقي.

الاستنتاجات: نسبة حدوث ارتفاع ضغط الشريان الرئوي بين الأطفال حديثي الولادة في هذه الدراسة هي 5,7% وكانت أكثر بين الإناث وارتبطت بعدة عوامل خطورة مثل الولادة القيصرية ومتلازمة الضائقة التنفسية.

التوصيات:

- تجنب عوامل الخطورة قد يساهم في تقليل نسبة حدوث ارتفاع ضغط الشريان الرئوي أو التقليل من مضاعفاته.
- استخدام تخطيط صدي القلب في الكشف المبكر عن ارتفاع ضغط الشريان الرئوي.
- تخطيط صدي القلب هو أفضل الطرق للبحث عن ارتفاع ضغط الشريان الرئوي والتشخيص والتكهن بالحالة المستقبلية.
- المزيد من الدراسات مطلوبة لنتائج أكثر دقة.