Bubble Nasal CPAP in the Management of Respiratory Distress Syndrome (One Year Experience in Low Resources Unit)

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Abstract

Background: Respiratory Distress Syndrome is a clinical manifestation due to a deficiency or dysfunction of pulmonary surfactant. The use of CPAP for RDS Produces more regular breathing pattern, establishes and maintains functional residual capacity, decreases upper airway resistance, results in progressive alveolar recruitment, inflates collapsed alveoli and reduces intrapulmonary shunting, decreases upper airway collapsibility and reduces obstructive apneas, promotes the release of and conservation of surfactant on the alveolar surface.

Objective: To evaluate the effectiveness of using bubble CPAP in the management of respiratory distress syndrome and to identify the risk factors associated with its failure.

Patients and methods: 63 newborns who have been diagnosed as RDS were started on Bubble CPAP with bi-nasal prongs. Bubble CPAP was considered to be successful if the respiratory distress improved and the baby could be successfully weaned off from CPAP. Based on radiological findings, the severity of RDS was graded as mild, moderate and severe.

Results: The mean gestational age was 30.67 ± 2.16 weeks and mean birth weight was 1525.34 ± 441.49 grams. The median age of starting CPAP was 2 hours of life. The median duration of CPAP was 36 hours. 42 (66.67%) newborns were survived and weaned successfully from CPAP and 21 (33.33%) failed to weaned successfully from CPAP and turn to mechanical ventilation. extreme low birth weight, lower gestational age, multiple pregnancies, radiological signs of severe RDS, and delay in the application of CPAP, and long duration of CPAP treatment were associated with poor neonatal out come and failure of CPAP (p value <0.05). Sepsis, apnea and shock are the main immediate complications of RDS patients which may adversely affect the CPAP success.

Conclusion

1. One year experience of the medical and nursing staff with the using of BCPAP had risen its effectiveness from (44.42%) in Umran, *et al*. to (66.66%) in our study within the same center; however, it is still less than that founded by a lot of other researches.
2. Preterm neonate who are; "extreme low birth weight, lower gestational age, multiple pregnancies (twin or triple), whiteout on the chest X-ray, delay in the application of CPAP, prolong duration of CPAP treatment" have increased risk for CPAP failure.
3. Sepsis, apnea and shock are the main immediate complications of RDS patients which may adversely affect the CPAP success.

Keywords: CPAP, nasal CPAP, respiratory distress syndrome, RDS, premature newborn

الخلاصة

اهداف البحث : لتقييم مدى فعالية جهاز الضغط الايجابي المستمر للهواء في المجاري التنفسية في علاج متلازمة عسر التنفس وتشخيص العوامل التي تزيد من احتمالية فشل هذا الجهاز.

العينة : اجريت الدراسة على الخديجين من حديثي الولادة (٢٨-٣٦ اسبوع) والذين تم ادخالهم الى ردمة الخدج المعقم في مستشفى الزهراء (ع) التعليمي في مدينة النجف الاشرف للفترة من آذار ولغاية ايلول من العام ٢٠١١ وكانوا يعانون من اعراض عسر التنفس وعلامات متلازمة عسر التنفس في صورة الاشعة السينية.

التداخل : جهاز الضغط الايجابي المستمر للهواء في المجاري التنفسية باستعمال مجرى الانف.

النتائج : تم ادخال ٦٣ خديج في الدراسة. ٢١ (% ٣٣,٣٣) منهم سجل فشل في الاستجابة للجهاز. العوامل التي لوحظت ذات تاثير في فشل الجهاز هي : الانخفاض الشديد لوزن الخديج وقلة عمر الخديج الرحمي والولادات المتعددة وعلامات متلازمة عسر التنفس الشديده في صورة الاشعة السينية والتاخير في وضع الجهاز وطول مدة بقاء الخديج تحت تاثير الجهاز. المتغيرات الاخرى والمتعلقة بالام والطفل لم نجد لها تاثير على نجاح او فشل عمل الجهاز.المضاعفات التي حصلت اثناء فترة علاج متلازمة عسر التنفس وادت الى فشل عمل جهاز الضغط الايجابي المستمر للهواء في المجاري التنفسية هي : تسمم الدم الجرثومي وتوقف التنفس والصدمة.

الاستنتاج : سنة واحدة من الخبرة في استخدام جهاز الضغط الايجابي المستمر للهواء في المجاري التنفسية ادى الى رفع فعالية الجهاز. الخديجين الذين يعانون من : الانخفاض الشديد لوزن الخديج وقلة عمر الخديج الرحمي والولادات المتعددة وعلامات متلازمة عسر التنفس الشديدة في صورة الاشعه السينية والتاخير في وضع الجهاز وطول مدة بقاء الخديج تحت تاثير الجهاز ، لديهم نسبه اكبر من احتمالية عدم استجابتهم للعلاج بالجهاز. تسمم الدم الجرثومي وتوقف التنفس والصدمة يعتبرون من اهم مضاعفات متلازمة عسر التنفس والتي تؤثر بصورة سلبية على نجاح العلاج بجهاز الضغط الايجابي المستمر للهواء في المجاري التنفسية.

Introduction

Respiratory distress syndrome is one of the commonest problems of newborns over the world with an incidence of 3 to 7% of all live births [1]. Autopsy studies reveal that 32-52% of all perinatal deaths are due to respiratory disorders]2]. RDS occurs primarily in premature infants; its incidence is inversely related to gestational age and birth weight. It occurs in 60–80% of infants less than 28 weeks of gestational age, in 15–30% of those between 32 and 36 weeks, in about 5% beyond 37 weeks, and rarely at term[3].

Respiratory Distress Syndrome (RDS) is a clinical manifestation due to a deficiency or dysfunction of pulmonary surfactant [4]. Pulmonary surfactant lines the surface of the alveoli in the lung, thereby reducing surface tension and preventing alveolar collapse. Surfactant deficiency results in progressive atelectasis of the lung, decreased pulmonary compliance, increased work of breathing, respiratory failure and lung injury [3].

RDS severity ranges widely from the need for low supplemental oxygen only to severe lethal respiratory failure, even with surfactant therapy and mechanical ventilation [5].

NCPAP may lead to reduced oxygen requirements, intubation rates, duration of mechanical ventilation, and BPD[6,7]. NCPAP has been administered to VLBW infants through nasal prongs via a constant-pressure closed circuit (conventional CPAP [CCPAP]). Recently, a form of NCPAP, referred to as bubble CPAP (BCPAP), has gained popularity because it is thought to promote airway opening events as a result of stochastic resonance [8].

The use of CPAP for RDS Produces more regular breathing pattern[8], establishes and maintains functional residual capacity, decreases upper airway resistance [9],
results in progressive alveolar recruitment, inflates collapsed alveoli [10] and reduces intrapulmonary shunting[11], decreases upper airway collapsibility and reduces obstructive apneas, promotes the release of and conservation of surfactant on the alveolar surface [12], Increased lung growth (volume and weight) [13].

Patients and Methods

63 newborns have been included in this study who have been diagnosed as RDS with the following criteria: - Premature neonate (GA 28-36 weak), Signs of respiratory distress, Transcutaneous PO_2 < 85% on room

air, Radiological findings of ground glass appearance of the lungs and/ or air bronchograms.

Newborns with transient tachypnea of newborn, congenital pneumonia and malformations, meconium aspiration syndrome, pulmonary hypoplasia, diaphragmatic hernia, congenital heart disease, birth asphyxia, babies requiring intubation at birth, those with major malformation were excluded.

Eligible babies were started on Bubble CPAP with bi-nasal prongs (Fisher and Paykel Healthcare, New Zealand). PEEP was started at 5 cm of water and adjusted to minimize chest retractions. FiO_2 was adjusted to maintain SpO_2 between 85% and 95%. Flow was titrated to the minimum to produce continuous bubbling in the bubble chamber.

Bubble CPAP was considered to be successful if the respiratory distress improved and the baby could be successfully weaned off from CPAP. The criteria for weaning was absence of respiratory distress (minimal or no retractions and respiratory rate between 30 and 60 per minute), SpO_2 >90% on FiO_2 <30% and PEEP <5 cm of water.

Data collection of maternal variables included were multiple births, pregnancy induced hypertension, diabetes, premature rupture of membrane, cesarean section, vaginal delivery and antenatal steroids.

Infant variables evaluated were birth weight, gestational age (calculated based on mother's last menstrual period and\or early pregnancy ultrasound scan or New Ballard score), Apgar score at 1 & 5 minute, delivery room management (oxygen, bag and mask, intubation), chest X-ray and age at which CPAP had been applied.

Based on radiological findings, the severity of RDS was graded as: ***mild*** (mild granularity of lungs), ***moderate*** (generalized granularity of lungs with air bronchogram with preserved cardiac borders) and ***severe*** (white out lungs with loss of cardiac borders).

Data were analyzed by SPSS 17th version using Chi-square test for comparison of proportions and Student't' test to compare means between two groups. P value <0.05 was considered to be significant.

The study was approved by the institute ethics committee and informed consent was obtained from either the father or a guardian.

Results

63 newborn babies enrolled in this study. The mean gestational age was 30.6667 ± 2.16273 (28-36) weeks and mean birth weight was 1525.3968 ± 441.48512 (850 - 2500) grams. The median age of starting CPAP was 2(0.3-6) hours of life. The median duration of CPAP was 36 hours (range 7-120 h).The demographic characteristics of study group shown in table (1).

Table 1 Demographic charecterestics of the study group

Characteristic		number	%
Gender	Male	39	61.9
	female	24	38.1
pregnancies	Multiple	19	30.2
	single	44	69.8
Gestation	≤ 30 wk.	37	58.7
	≥ 30 wk	26	41.3
Birth weight	LBW (1501 – 2500gm)	30	47.6
	VLBW (1001 - 1500 gm)	21	33.3
	ELBW (≤ 1000 gm)	12	19.04
Maternal condition	Maternal diabetes	4	6.3
	Maternal hypertension	19	30.2
	PROM	17	26.9
	normal	23	36.6
Type of delivery	Vaginal Delivery	28	44.4
	Cesarean section	35	55.5
Antenatal steroid	Yes	26	41.2
	No	37	58.7

42 (66.67%) newborns were survived and weaned successfully from CPAP and 21 (33.33%) failed to weaned successfully from CPAP and turn to mechanical ventilation.

The comparison of the clinical features and the management between the successful and failure groups were shown in table (2). It was found that extreme low birth weight, lower gestational age, multiple pregnancies (twin or triple), whiteout on the chest x-ray (radiological signs of severe RDS), and delay in the application of CPAP, and long duration of CPAP treatment associated with poor neonatal out come and failure of CPAP management.

Table 2 Clinical features and management of the successful and failure groups

variable	CPAP success n=42	CPAP failure n=21	P value
Birth weight (gm) (mean ± SD)	1623.81± 443.14	1328.57± 375.02	**.011***
Gestational age (wk.) (mean ± SD)	31.31 ± 2.15	29.38 ±1.56	**.001****
Male (%)	25(59.5)	14(66.6)	.582
Twins\triplet (%)	9(21.4)	10(47.6)	**.033***
No Antenatal steroid (%)	22(52.38)	15(71.42)	.148
Maternal diabetes (%)	2(4.7)	2(9.5)	.465
Maternal hypertension (%)	16(38.09)	3(14.2)	.052
Premature rapture of membrane	14(33.3)	3(14.2)	.108
Cesarean section (%)	23(54.7)	12(57.1)	.858
Chest X-ray severe RDS (%)	7(16.6)	12(57.1)	**.001****
Age at CPAP (hrs.)(mean±SD)	1.76 ± 0.49	2.22 ± 1.11	**.024***
PEEP (cm H_2O)(mean±SD)	4.9 ± 0.6	5.2 ± 0.4	.10
Duration of CPAP (hrs.) (mean±SD)	32.57 ± 20.42	80.00 ± 34.64	**.000*****

The success and failure of CPAP according to the birth weight categories and GA were shown in table (3) which show that lower birth weight and early gestational ages associated

with high failure rate of CPAP management.

Table 3 CPAP management results according to birth weight and GA.

Parameters		Success no. (%)	Failure no. (%)	P value
Birth wt. categories (gm)	≤ 1000	5 (41.6)	7 (58.64)	0.041
	1001-1500	13 (61.9)	8 (38.1)	0.57
	1501 – 2500	24 (80)	6 (20)	0.032
GA (wk)	≤ 30	20 (54.1)	17 (45.9)	0.011
	≥ 30	22 (84.6)	4 (15.4)	0.011

The complications that occurred during the course of the RDS treatment which associated with CPAP failure were sepsis, apnea and shock, table 4.

Table 4 complications during RDS management with CPAP outcome.

Complication	CPAP success		CPAP failure		P value
	N=42	%	N=21	%	
Sepsis	2	4.7	8	38.09	.001**
Pneumothorax	2	4.7	0	0	.310
Apnea	0	0	7	33.33	.000***
Shock	0	0	5	23.8	.001**
mortality	2	4.7	16	76.19	.000***

Discussion

Forty two patient out of 63 (66.66%) whose treated with CPAP were considered successful treatment which is lower than that founded by URS, *et al*. [14] (i.e. 80%) who manage his patient with the same guide line (i.e. without INSURE technique) and the same machine that we use (Fisher and Paykel Healthcare, New Zealand); but with a higher percentage of antenatal steroid (56% versus 41.26% in our study) which may explain such a difference; however, no significances was found for antenatal steroid (P value=0.148) in our study which is not the situation in URS, *et al*. (P value=0.001). Similar cause may be applied to explain the higher percentage of CPAP failure in a case-control study by Boo, *et al* [15] , who conduct analytic study on 97 preterm babies (gestation <37 weeks) with RDS on ventilator CPAP or Bubble CPAP, and found a 38% failed CPAP and required ventilator support , which is higher than that found in our study (33.33%); with only 34% of the infants in their study received antenatal steroids and the authors did not report the usage of surfactant in their study.

KOTI, *et al* [16] conduct a retrospective analytic study on 56 neonate (28-34weaks) ; only 14(25%) patient considered as CPAP failure which is lower than that found in our study i.e. 21out of 63(33.33%) taking in account the differences in birth weight and gestational age of infants enrolled, type of nasal interface, the CPAP device, age of starting CPAP, and use of antenatal steroids and surfactant.

In our study we found that the age of neonate at which CPAP had been applied [median=2(0.3-6) hours of life] is a significant contributor for the CPAP failure (P=0.024) which is

different from that found by KOTI, *et al* (P value=0.58). Similar to our study and that by KOTI, *et al* and Ammari, *et al* [17]; Severe RDS on the chest X-ray was an important predictor of CPAP failure. Although septicemia and apnea predicted CPAP failure in our study too, pneumothorax was seen in 2 babies in the success group which is unlike that founded by Ammari, *et al*. The Birth weight and the gestational age and multiple pregnancies were an important risk factor for CPAP failure in our study which is the same situation founded in URS, *et al*., but not in KOTI, *et al* .In our study, the CPAP success rate increase with the increment of birth weight i.e.(≤1000 gm 41.6%, 1001-1500 gm 61.9% , 1501-2500 gm 80%) which is different from that founded by Ammari, *et al*(CPAP was successful in 76% of infants ≤1250 g birth weight and 50% of infants ≤750 g birth weight). Such differences may be explained by the routine and rapid (5-10 min.) application of CPAP to all spontaneously breathing VLBW neonates by Ammari, *et al*.

In this study, outcome of CPAP did not vary between genders. Sandri, e*t al*.[18] have shown higher need for respiratory assistance in male infants with RDS. In Ammari, *et al* study Mortality in the CPAP-failure group was 18 of 55 (33%), and the mortality in the CPAP-success group was 2 of 174 (1%) which is different from our study 16 of 21(76.19%) in the CPAP-failure group and 2 of 43(4.7%) in the CPAP-success group.

Umran, *et al.*[19] one year ago had conduct a clinical study for evaluation of the effect of BCPAP in NICU of this hospital for the first time. He also include thirty six neonate with respiratory distress. He found a success rate of (44.24%) of BCPAP in the treatment of RDS which is much less than that founded by our study after one year despite the similarities in a lot of variables (e.g. the same way of diagnosis, the same guideline for management, the same BCPAP device and the same medical and paramedical staff). However; this difference may be attributed to the improvement in the experience of medical and paramedical staff.

Recommendations

1. Bubble CPAP to be used as a primary care for treatment of neonate with RDS and to be applied as early as possible to minimize the risk of its failure.
2. Early anticipation of the ineffectiveness of BCPAP for treating RDS in those neonate with extreme low birth weight, low gestational age, X-ray signs of severe RDS and no antenatal steroid. So prepare for intubation and mechanical ventilation.
3. Further prospective controlled trial studies are needed to determine if extremely premature spontaneously breathing infants are better served by initial management with CPAP or mechanical ventilation.
4. Encourage the use of antenatal steroid for pregnant women with potential premature delivery.
5. Use of the other supportive measure for treating of RDS such as TPN and surfactant.
6. More training courses for resident doctor and staff in NICU about using BCPAP.
7. All efforts should be done to avoid sepsis, apnea and shock to improve the CPAP outcome.

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