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Spontaneous breathing trial evaluation in preterm newborns extubation

Avaliação do teste de respiração espontânea na extubação de neonatos pré-termo

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ABSTRACT

Objective: Neonates mechanic ventilation weaning has become a major clinical challenge, and constitutes a large portion of neonatal intensive care units workload. The spontaneous breathing trial (SBT), performed immediately before extubation, can provide useful information on the patient's spontaneous breathing ability. This study aimed to assess the SBT effectiveness for extubation success prediction in mechanically ventilated preterm infants.

Methods: After Ethics Committee approval, an observational, longitudinal, prospective study was conducted. A sample of 60 preterm infants compliant with the weaning criteria was categorized in two groups: 'SBT' group (n=30), with the patients who underwent 30 minutes spontaneous breathing trial (SBT) with continuous positive pressure airway (CPAP), and the control group (n=30) where the extubation was performed without spontaneous breathing trial.

The heart rate (HR), respiratory rate (RR), pulse oxymetry oxygen saturation (SpO_2) and the Silverman-Andersen score were recorded before and 10, 20 and 30 minutes after the spontaneous breathing trial. Were also assessed for both groups, and versus extubation success or failure, the weight, gestational age, Apgar score, mean airway pressure, inspired oxygen concentration, and tracheal tube time. The Chi-square test was used for categorical variables and the Mann-Whitney test for non-normal distribution. Extubation success was defined as a 48 hours period with no reintubation requirement.

Results: No significant differences were identified between the groups for the analyzed variables, except for the mean airway pressure. A significant association was shown between spontaneous breathing trial and successful extubation.

Conclusion: The significant association between SBT and extubation success may contribute for prediction of successful weaning in preterm infants.

Keywords: Infant, premature; Respiration, artificial; Intensive care, neonatal

INTRODUCTION

The worldwide literature progressively reports lower weight and gestational age preterm newborns survival. This deserves healthcare professionals attention.(1) This can be attributed to new neonatal intensive care techniques, still needing to be improved in our country, making this issue a current focus of interest and concern.(2,3)

The preterm newborn respiratory system development faces important changes due to the missed critical intrauterine development phase. The exposure of the immature lung to the postnatal or intensive care environments renders it susceptible to injuries due to its incomplete anatomical differentiation,[2] explaining why about 70% of the preterm newborns require mechanic ventilation (MV) during their clinical course.[3-5]

MV is one of the main resources for these patients' life support. Nevertheless its universally accepted benefits, there are associated risks, as it may contribute to the start or worsening of lung and distant organs injuries, and is one of the responsible for increased morbidity and mortality factors .[6-9] The ventilatory support weaning process takes about 40% of the total mechanic ventilation time. Thus, the determination or prediction of the appropriate extubation time, and its success, is of paramount importance.[10,11]

MV patients weaning is one of the critical ventilatory support phases, and is related to complications and mortality.[12-14] If the extubation failure could be accurately predicted, the extubation could be better scheduled, and the reintubation trauma prevented.[15,16]

During the last decade, the studies have focused on strategies for shortening the MV duration, including the early identification of candidates to spontaneously breathe using the spontaneous breathing trial (SBT), and methods to predict extubation success or failure.[14,16]

The search for physiological accurate and reproducible indicators, able to predict the extubation success, has so far not reached satisfactory results, as no reported indicator was consistently able to predict success in neonates.[15-18]

The SBT is a simple technique performed immediately before the extubation and may provide useful information on the patient's spontaneous breathing ability.[10,19] This test is already common and well founded in adult and pediatric intensive care units (ICUs), however, few studies were developed to validate its neonatal use.[20,21]

This study mainly aimed to check if SBT is a good success predictor in preterm newborns extubation, analyzing the respiratory rate (RR), heart rate (HR), pulse oxygen saturation (SpO_2) and the Silverman-Andersen score (SAS).

METHODS

An observational, longitudinal, prospective study was conducted in 60 male and female preterm newborns under invasive mechanic ventilation for 24 hours or more in the Instituto de Medicina Integral Prof. Fernando Figueira's Neonatal Intensive Care Unit (NICU). The study was conducted from March 2008 to October 2009.

This study was approved by the Institution's Ethics Committee, under the registration number 1126-08. Newborns whose parents or legally accepted representatives signed the informed consent form and who complied with the inclusion criteria were included.

The inclusion criteria were: a) gestational age below 37 weeks; b) body weight < 1,500 g; c) mechanic ventilation for at least 24 hours; d) first extubation; and e) appropriate gas exchange as indicated by partial arterial oxygen pressure (PaO_2) above 60 mmHg, inspired oxygen fraction equal or less 0.50, acceptable partial carbonic gas pressure ($PaCO_2$) levels, pH >7.2 and < 7.4, mean airway pressure (MAP) below 12 cmH_2O and eligible for extubation according to the medical team.

The exclusion criteria were: a) neurological or cardiac malformations; b) genetic syndromes patients; and c) hemodynamically unstable (PaO_2 < 60 mmHg, $PaCO_2$ > 50 mmHg, SpO_2 < 85%, HR < 100 bpm, signs of increased respiratory load as: nose wing beat, accessory muscles use, tirage and paradoxical breathing, inappropriate tissue perfusion).

This was a for convenience sample, that considered all study period MV compliant with the inclusion criteria patients. After the study period, approximately 30 patients per group were achieved. As this sample was close to 30 patients, we chose to have two 30 patients' groups.

The following data were collected for all included newborns: gender, gestational age, diagnosis hypothesis, birth weight, current weight, Apgar scores, time of tracheal intubation, drugs used before and after extubation. Data collection sheets were used to record the information.

All patients were mechanically ventilated using the INTER 3® - Intermed (São Paulo, SP) ventilator, and were categorized in two groups: SBT group (n=30) and control group (n=30). The SBT group consisted of newborns elected for extubation by the medical team, for whom routine physiotherapy was applied followed by spontaneous breathing trial. In the control group were included the neonates complying with weaning criteria and extubated without SBT.

The SBT was performed under continued positive airway pressure (CPAP) with 5 cmH_2O end-expiratory pressure (PEEP), inspiratory flow 10 L/min for 30 minutes. Before and after the 10th, 20th and 30th test minutes, were collected: RR (by chest movements observation for 1 minute), respiratory effort signs, SAS, HR, SpO_2, both using the pulse oxymetry (Ohmeda®).

The mean airways pressure and the inspired oxygen fraction were directly collected from the mechanic ventilator monitor before the SBT.

At the 30 minutes period end, the newborns were extubated and placed on CPAP, intermittent mandatory ventilation (IMV) or just a halo (oxygen helmet), as needed, according to the unit's routine protocol.

Test failure was determined on the newborns with: HR<100 bpm, SpO_2 <85% and signs of increased respiratory load, with SAS > 5. In this case, the SBT was discontinued, and the patient returned to the pre-test ventilation mode, until the normal parameters were restored and the newborns extubated. Extubation success was defined as 48 hours or more with no reintubation required. Equally, the newborns needing VNI for the same time, were included in the extubation success group.

The statistical analysis was conducted using the SPSS 13.0 for Windows and Excel 2003 softwares. The Mann-Whitney test was used to analyze the variables for either extubation success or failure in both groups. The Chi-square test was used to look for statistically significant associations between either extubation success or failure between the groups. The *t* Student pairwise test was used for before and during SBT variables comparison. A difference was considered significant for p values < 0.05.

RESULTS

During the study, 60 newborns weighting less than 1,500 g were evaluated and categorized in 2 groups, being SBT group with 30 patients (50%) and the control group with 30 patients (50%). This was a convenience sample. The sample demographics and the variables birth weight, current weight, first minute and fifth minute Apgar scores, mean airway pressure, inspired oxygen fraction, time with tracheal tube and gestational age are shown on table 1, where the groups homogeneity is shown except for the mean airways pressure. Regarding the gender, 32 (54.1%) were male, and 28 (45.9%) female.

Table 2 shows a comparison of extubation success and failure versus the analyzed variables, with a significant difference seen for current weight and FiO_2, i.e., lower weight and higher FiO_2 for the control group.

SBT patients were extubated and underwent CPAP, IMV or oxygen helmet (according to the service routine); 10 patients (33.3%) required reintubation, and 20 (66.7%) required no invasive or non-invasive ventilatory support for at least 48 hours and were deemed extubation success.

For all SBT newborns, no significant changes were seen on HR, SpO_2, RR and SAS values before and in the test 10^{th}, 20^{th} and 30^{th} minutes.

Table 3 shows the extubation success and failure association for the studied groups, with a significant difference for the SBT group success identified (66.7%) versus the control group (36.7%).

The newborns diagnostic hypothesis were: 100% of the SBT group patients were diagnosed respiratory distress syndrome (RDS), and 30% had associated mild or moderate hypoxia. In the control group, 93.3% had RDS, 6.66% perinatal infection, and 33.3% had mild to moderate hypoxia.

The main reintubation causes, for both groups,

Table 1- Demographics

Variables	Group		P value
	SBT	Control	
	Mean ± SD	Mean ± SD	
Birth weight	1039.7 ± 277.3	1006.6 ± 242.9	0.622*
Current weight	978.8 ± 217.5	952.3 ± 228.1	0.643*
Apgar 1st minute	5.4 ± 2.5	5.2 ± 2.1	0.646*
Gestational age	28.4 ± 2.9	29.7 ± 2.3	0.054*
	Median [Q1 ; Q3]	Median [Q1 ; Q3]	
Apgar 5th minute	8.0 [6.0 ; 9.0]	8.0 [7.0 ; 8.0]	0.876**
MAP	6.0 [5.0 ; 6.3]	6.0 [6.0 ; 7.0]	0.031**
FiO_2 %	30.0 [25.0 ; 40.0]	35.0 [30.0 ; 50.0]	0.076**
OT time (d)	7.0 [4.8 ; 12.5]	6.0 [3.0 ; 18.0]	0.669**

SBT – spontaneous breathing trial; MAP – mean airway pressure; OT – orotracheal tube; FiO2 – inspired oxygen fraction; SD – standard deviation; Q1: 1st Quartile. Q3: 3rd Quartile. (*) t Student test (**) Mann-Whitney test

Table 2 – Variables analyzed for each group newborns versus extubation success or failure

Group	Extubation success		P value
	Yes	No	
	Mean ± SD	Mean ± SD	
SBT			
Birth weight	1078.4 ± 302.912	972.7 ± 223.611	0.323*
Current weigth	1009.5 ± 232.265	925.9 ± 187.681	0.319*
Apgar 1st minute	5.9 ± 2.492	4.6 ± 2.335	0.184*
Apgar 5th minute	7.6 ± 1.674	7.0 ± 1.732	0.334*
MAP	6.1 ± 1.224	5.5 ± 0.820	0.161*
FiO_2 %	32.8 ± 6.852	29.4 ± 7.672	0.217*
Gestational age	28.7 ± 2.728	27.9 ± 3.375	0.500*
	Median [Q1 ; Q3]	Median [Q1 ; Q3]	
OT time (d)	7.0 [3.0 ; 17.0]	7.0 [6.0 ; 9.0]	0.589**
Control			
Birth weight	1033.1 ± 179.334	987.5 ± 283.773	0.615*
Current weight	1046.2 ± 192.150	884.4 ± 232.707	0.050*
Apgar 1st minute	5.2 ± 2.444	5.2 ± 1.917	0.987*
FiO2 %	32.2 ± 10.741	40.0 ± 9.852	0.046*
OT time (d)	10.2 ± 14.249	12.6 ± 9.853	0.586*
Gestational age	30.1 ± 1.679	29.42 ± 2.643	0.445*
	Median [Q1 ; Q3]	Median [Q1 ; Q3]	
Apgar 5th minute	8.0 [6.5 ; 9.0]	8.0 [6.8 ; 8.0]	0.934**
MAP	6.0 [6.0 ; 7.0]	6.0 [6.0 ; 7.0]	0.695**

SBT – spontaneous breathing trial; MAP – mean airway pressure; OT – tracheal tube; FiO2 – inspired oxygen fraction; SD – standard deviation; Q1: 1st Quartile. Q3: 3rd Quartile. (*) t Student test (**) Mann-Whitney test

Table 3 – Extubation success and failure association versus studied groups

Extubation	Group		
	SBT	Control	P value*
	N (%)	N (%)	
Success	20 (66.7)	11 (36.7)	0.038
Failure	10 (33.3)	19 (63.3)	

SBT – spontaneous breathing trial; Results expressed as n(%); (*) Chi-square.

were: bradycardia (27.6%), oxygen saturation drop (24.3%), apnea (21%), cyanosis (14%), bronchoaspiration (3.5%), and respiratory distress (6.8%).

DISCUSSION

Studies have been conducted aimed to identify the best parameter for extubation success or failure prediction, however, specifically in very low weight neonates, few articles are available.[4,5,14]

In this study we analyzed SBT, which is a simple criterion for MV discontinuation success prediction, as the best time for newborns and children extubation decision is both difficult and controversial and requires clinical judgment to balance the early extubation benefits with the deleterious reintubation effect.[22-24]

The variables analyzed for both groups have shown that only MAP was significantly higher in the control group. Indeed, Fontela et al.[25] analyzed pediatric patients' extubation failure risk factors, and suggested that higher MAPs are associated with extubation failure.

When the variables analysis was compared versus the groups' either success or failure, it was identified that the control group newborns had significant extubation success/failure differences for the variables FiO2 and current weight. These data have show increased extubation failure risk for higher FiO_2 and lower current body weight. Hermeto et al.[15] have shown a 23% extubation failure rate in a population with birth weight < 1,250 g and 35% with birth weight < 1,000 g. Additionally, the Dimitriou et al.[4] study has shown that neonates with lower birth weight (among other factors) and pre-extubation higher FiO_2 were associated with extubation failure.

The higher extubation success rates for the SBT group suggests that, although the neonates had favorable clinical features that rendered them eligible for weaning, 19 (63.3%) of the control group newborns had extubation failures. This stresses the relevance of predictive tests identification and use, aiming a better identification of the best time for extubation, thus reducing the MV duration, its deleterious effects, and later reintubation requirements.[14,15,18,26]

The success in the 30 minutes test with CPAP ventilatory mode may reflect the neonate ability to spontaneously breathe with no significant clinical changes, as shown for the maintenance of the clinical parameters (HR, RR, SpO_2 and SAS).

Several studies suggest an ideal time for the test in adults usually performed in 2 hours. However, a study in adults by Esteban et al.[27] has shown that the extubation success rate was similar for patients with either 30 minutes or 120 minutes tests. In the Chavez et al.[12] study, the SBT was performed both in newborns and children, with a 15 minutes proposed time. In this study, the proposed time was considered appropriate for observation of the test accuracy, analyzing both the gas exchange effectiveness and the presence of increased respiratory load, without fatiguing the newborn – it should be considered that population uses very narrow tracheal tubes which could easily cause fatigue if lasting longer.[7,12]

CPAP, due to its airways, chest and lung volume stabilizing effects, has been used as preferred ventilatory strategy for MV weaning support, particularly in very low weight neonates. Recent evidence suggest that CPAP reduces the adverse events rate, as post-extubation atelectasis, apnea episodes, respiratory acidosis and tracheal reintubation requirements.[28]

Bradycardia, oxygen saturation drop, apnea, cyanosis, bronchoaspiration and respiratory distress were the main reintubation causes in both groups. Several studies confirm our results, indicating among the main failure causes apnea and increased respiratory load.[4,16]

Sinha and Donn[29] say that children with no respiratory distress or worsened gas exchange during the test had between 60% to 80% chance to require no artificial airway support.

Kamlin, Davis and Morley[3] say that SBT sensitivity to identify children with successful mechanic ventilation weaning was 83%, thus leading to less extubation failures and increased well succeeded extubations. This study has additional relevance for showing that the SBT group was significantly better, making this test a good predictor for neonates extubation success (61.5%).

Perhaps this test may be suggested as an indicator for extubation success prediction, due to its association with successfully extubated children. Further prospective studies, with larger samples, are necessary to evaluate this test safety and efficacy in very low weight newborns.

Study limitations

The lack of appropriate tools to measure objective volumes, pulmonary capacity and mechanic ventilation data, and the lack of a continued physiotherapy regimen during weekends limiting the sample size, were considered limitations.

CONCLUSION

SBT has been largely studied; however the literature focusing its use in neonates is scarce.

Although this study sample was small, and no sensitivity and specificity data are available for children below 1,500 g body weight, the SBT group extubation success rate was significantly higher versus the control group, and the newborns with higher FiO_2 and lower body weight were associated with increased extubation failure rate.

RESUMO

Objetivo: O teste de respiração espontânea (TRE) antes da extubação fornece informações sobre a capacidade de respirar espontaneamente. O objetivo desse estudo foi verificar se o TRE é preditor de sucesso da extubação.

Métodos: Estudo de perfil observacional, longitudinal e prospectivo. Após eleitos para extubação, 60 recém nascidos pré-termo foram divididos em dois grupos: TRE (n= 30), pressão positiva contínua de vias aéreas durante 30 minutos, e controle (n=30), extubados sem o teste. Foram avaliados antes, aos 10, 20 e 30 minutos do grupo TRE, a freqüência respiratória e cardíaca, saturação de pulso de oxigênio e boletim de Silverman e Andersen. Peso, idade gestacional, Apgar, pressão média de vias aéreas, fração inspirada de oxigênio (FiO_2) e tempo de cânula orotraqueal foram analisadas intra-grupos e quanto ao sucesso e falha na extubação. O Qui-quadrado para associações das variáveis categóricas e Mann-Whitney para distribuição não-normal. O sucesso na extubação foi 48 horas sem necessidade de reintubação.

Resultados: Não houve diferença significante nas variáveis analisadas, exceto pressão média de vias aéreas. As variáveis analisadas durante o TRE (freqüência respiratória e cardíaca, saturação de oxigênio e boletim de Silverman e Andersen) não demonstraram alterações significantes. Comparado sucesso e falha na extubação houve diferença significativa para FiO_2 e peso atual no controle, indicando que a FiO_2 maior e o peso menor indicam falha na extubação. Houve associação significante entre realização do TRE e sucesso na extubação.

Conclusão: Houve associação significante do TRE e o sucesso na extubação, indicando que, no grupo que realizou o teste observou-se maior sucesso na extubação comparado ao controle.

Descritores: Prematuro; Respiração artificial; Terapia intensiva neonatal

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