Impact of cardiopulmonary resuscitation on extremely low birth weight infants

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**Objectives**
To examine whether extremely low birth weight (ELBW) infants who undergo Cardiopulmonary Resuscitation (CPR) in the delivery room present poorer survival and greater short-term neurological and general morbidity than those who do not.

**Methods**
In a retrospective cohort of 150 ELBW infants born at our hospital between 2000 and 2004, those who needed CPR and those who did not were compared for mortality and short-term general and neurological morbidity. Infants with major birth defects, suspicion of genetic disease and those without a proactive perinatal attitude in the delivery room were excluded. CPR was defined as the administration of chest compressions and/or epinephrine in the delivery room.

**Results**
150 infants were included, with gestational ages of 23-27 weeks (mean 25.6 ± 1.2), birth weight of 425-995 grams (mean 745.2 ± 132). Delivery room CPR was given to 32 infants (21.4 %). No differences in perinatal characteristics were found except for lower pH and Apgar score and a higher SNAPPE score in infants who underwent CPR. Survival at discharge was similar (62.5 % vs 76.3 % for those without CPR). Infants who received CPR needed more surfactant, oxygen and higher median airway pressure than infants who did not. Air leaks and coagulopathy were more frequent in CPR infants (p < 0.01). Prevalence of bronchopulmonary dysplasia, necrotizing enterocolitis and retinopathy was similar in the two groups. No statistical differences between ELBW infants who needed CPR and those who did not were found in prevalence of intraventricular haemorrhage (IVH) (62.5 % vs 52.5 %), IVH III (31.2 % vs 17.7 %), periventricular haemorrhagic infarction (PHI) (18.7 % vs 11 %) or cystic periventricular leucomalacia (PVL) (15.6 % vs 11 %). However, in a combined analysis of neurological morbidity (IVH III and/or PVL and/or PHI), significant differences between the two groups were found (46.7 % vs 21.6 %; p = 0.01).

**Conclusion**
This study does not support poorer survival or significant non-neurological morbidity during the neonatal period in ELBW infants who receive CPR. Although the prevalence of individual neurological problems was similar in the two groups, CPR was associated with a clear increase in general neurological morbidity, with a three-times greater risk of brain damage.

**Key words:** Prematurity, Cardiopulmonary resuscitation, Brain damage, Intraventricular haemorrhage, Periventricular leucomalacia, Periventricular haemorrhagic infarction.

**Impacto de la reanimación cardiolunopulmonar avanzada en recién nacidos pretérmino de extremado bajo peso**

**Objetivos**
Examinar si los recién nacidos de extremado bajo peso (RNEBP) que reciben reanimación cardiopulmonar avanzada (RCPA) en la sala de partos presentan peor supervi-
Palabras clave: Conclusión

Resultados

En una cohorte retrospectiva de 150 RNEBP, nacidos en nuestro hospital entre los años 2000 y 2004, se comparó mortalidad y morbilidad global y neurológica a corto plazo entre aquellos que precisaron RCPA y los que no. Se excluyeron los nacidos con malformaciones y aquellos con limitación del esfuerzo terapéutico en la sala de partos.

En un análisis de los nacidos de RNEBP, se comparó mortalidad y morbilidad global y neurológica a corto plazo entre aquellos que precisaron RCPA y los que no. Se excluyeron los nacidos con malformaciones y aquellos con limitación del esfuerzo terapéutico en la sala de partos.

Métodos

Análisis de los nacidos de RNEBP, nacidos en nuestro hospital entre los años 2000 y 2004, se comparó mortalidad y morbilidad global y neurológica a corto plazo entre aquellos que precisaron RCPA y los que no. Se excluyeron los nacidos con malformaciones y aquellos con limitación del esfuerzo terapéutico en la sala de partos.

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Material y métodos

INTRODUCCIÓN

La RCPA en RNEBP no parece implicar un aumento de la mortalidad neonatal ni de la morbilidad significativa neurológica. Aunque la prevalencia individual de problemas neurológicos fue similar entre ambos grupos, la RCPA condujo a un claro aumento de la morbilidad global neurológica, incrementando tres veces el riesgo de lesión del SNC.

PALABRAS CLAVE:

- Pretermiñidad
- Reanimañón cardíopulmonar
- Lesión cerebral
- Hemorragia intraventricular
- Leucomalacia periventricular
- Infarto periventricular hemorrágico
- Mortalidad neonatal
- Morbilidad
- Neurológica
- Cardiopulmonar
- Cardiorespiratoria

INTRODUCCIÓN

In recent years there has been a marked increase in the number of extremely low birth weight (ELBW) infants, weighing under 1,000 grams and with a gestational age under 28 weeks. The guidelines for cardiopulmonary resuscitation of neonates do not stipulate any specific recommendations that take weight or gestational age into account. Therefore, in the population of ELBW infants, the same indications for the start of profound or advanced cardiopulmonary resuscitation are used as in all other neonates, i.e. cardiac massage and/or adrenalin administration are seen as risk factors for poor survival and severe intraventricular haemorrhage.

The vulnerability of the ELBW infant means that CPR may involve greater mortality and high short-term morbidity. In general, in ELBW infants, cardiac massage and/or adrenalin administration are seen as risk factors for poor survival and severe intraventricular haemorrhage.

Nevertheless, since data in the literature on morbidity and mortality in relation to advanced resuscitation in this population group are scarce, the risk/benefit relationship of CPR in this age group is not well established. The study of short- and long-term neurological morbidity associated with CPR in ELBW infants is important not only to optimize indications, guidelines and limits of CPR in these neonates, but to establish whether the CPR at birth leads to a specific group of ELBW infants at high neurological risk.

The aim of this study was to examine whether the ELBW infants, under 28 weeks gestational age and weighing under 1,000 grams at birth, who need CPR in the delivery room, have worse survival and greater neurological and general short-term morbidity during the neonatal period.

MATERIAL AND METHODS

Design

A retrospective cohorts study, conducted by exhaustive review of medical records.

Subjects

We included all neonates weighing under 1,000 grams at birth and under 28 weeks gestational age (estimated by amenorrhea) born at our hospital between September 2000 and September 2004. Neonates with major congenital defects and those without a proactive perinatal attitude in the delivery room were excluded.

Setting

The study was conducted in a university hospital which attends the annual birth of 10,500 infants, 1.4% of them premature under 28 weeks gestational age and over 1,500 grams. In the period of time covered by the study, the standard practice of CPR in ELBW infants remained unchanged at the hospital. The resuscitation of this group of neonates was performed by a staff neonatologist, one or two doctors in training and a specialized nurse in neonatal resuscitation.

Main objective

To examine whether ELBW infants, under 28 weeks gestational age and weighing under 1,000 grams at birth, who needed CPR in the delivery room, had worse survival and greater short-term neurological and general morbidity during the neonatal period. Primary end-points

er drugs. The frequency of advanced cardiopulmonary resuscitation in this ELBW group varies between 6 and 12.5%, according to the literature.

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However, since data in the literature on morbidity and mortality in relation to advanced resuscitation in this population group are scarce, the risk/benefit relationship of CPR in this age group is not well established. The study of short- and long-term neurological morbidity associated with CPR in ELBW infants is important not only to optimize indications, guidelines and limits of CPR in these neonates, but to establish whether the CPR at birth leads to a specific group of ELBW infants at high neurological risk.

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Sánchez-Torres AM et al. Impact of cardiopulmonary resuscitation on extremely low birth weight infants
were established as survival at discharge and initial neurological damage (severe intraventricular haemor-
rhage; haemorrhagic periventricular infarction and cystic
periventricular leucomalacia). In addition, a combined in-
dex of neurological morbidity, in which the three disor-
ders mentioned were included, was established. Other
secondary points examined were haemodynamic insta-
bility, the need for exogenous pulmonary surfactant, the
need for mechanical ventilation, the persistence of duc-
tus arteriosus with clinical repercussions, air leaks, coag-
ulopathy; early sepsis and necrotizing enterocolitis. Fur-
ther secondary points examined were the hospital stay,
time on oxygen therapy, bronchopulmonary dysplasia,
total duration of mechanical ventilation, inotropic sup-
port, prevalence retinopathy of prematurity needing
lasertherapy, age at which enteral nutrition began and
when exclusive enteral nutrition was reached, and
weight and head perimeter on discharge.

The population included in the study was divided into
two groups: 1) Those who needed CPR in the delivery
room; 2) those who did not require it, this group was
used as the control one.

Operating Definitions

Gestational age was based on the obstetric estimation
of the last menstrual period and/or the earliest ultra-
sound examination. We defined CPR as resuscitation in
which chest compressions and/or epinephrine were ad-
ministered. Intubation of ELBW infants in our hospital is
decided in each individual case, depending on the pres-
ence of respiratory distress and on cardiopulmonary sta-
tus. Surfactant was administer with an early therapy crite-
orton on entry into the neonatal intensive care unit, but
never prophylactic in the delivery room. Early neurologi-
cal morbidity was diagnosed on the basis of the ultra-
sonomographic findings. Intraventricular haemorrhage (IVH)
was appraised with the Volpe classification11, 12, and
periventricular leucomalacia (PVL) by the modified classi-
fication de Vries and colleagues13, taking as grade 1 the
presence of persistent periventricular hyperechogenici-
ty > 15 days, grade 2, cystic evolution located in the out-
side angle of the lateral ventricle; grade 3, cystic evolution
that extends to the fronto-parietal and/or occipital
periventricular regions; and grade 4, cystic evolution that
extends to the cortico-subcortical region. Haemorrhagic
periventricular infarction (HPI) was diagnosed on ob-
servation of a hyperechogenic, globulous image, half
moon-shaped or triangular, generally unilateral, with an
extension from the outside angle of the lateral ventricle
up to the cortico-subcortical region14. The Score for
Neonatal Acute Physiology Perinatal Extension (SNAPPE)
was designed as a scale to reflect the gravity of the status
of the neonate during the first 24 hours of life and has
been proved as very useful in establishing the risk of
death, the development of chronic pulmonary disease
and the duration of hospital stay15, 16. We assessed the
gravity of the patients in their first twelve hours of life by
means of their SNAPPE-II score.

The background of chorioamnionitis was considered
when the mother had at least two of the following crite-
ria: temperature > 38 °C, neutrophil leukocytosis and/or
high acute phase reactants, or when it was shown in the
pathological analysis of the placenta.

The diagnosis of intranatal growth retardation was
established when the weight development of the child
at birth was below percentile 3 for his/her gestational
age17.

Cardiac echography was used to test for ducatus arte-
riosis in those infants with clinical suspicion. Haemody-
namic instability was classified by the number of inotrop-
ic drugs necessary and/or the need for corticotherapy. We
consider the presence of coagulopathy on transfusion of
frozen fresh plasma and/or platelets being needed in the
first twelve hours of life. Necrotizing enterocolitis was
measured according to the modified Bell scale18. We de-
efined bronchopulmonary dysplasia as the need for sup-
plementary oxygen therapy at 36 weeks of corrected ges-
tational age. A day with supplementary oxygen was
defined as one on which oxygen was needed at a con-
centration over 21 % for over twelve hours17. Retinopa-
thy was measured according to the international scale19.

Statistical analysis
The categoric or qualitative data were expressed as ab-
solute frequencies and as percentages, and quantitative
data, through the mean, the median and standard devia-
tion. Categorical variables were compared through the
Chi-squared test or the Fisher exact test. To compare two
groups of quantitative data, the Student’s t and the U
Mann-Whitney tests were used, depending on whether
the data were normally distributed or not. A value was
considered significant when p was < 0.05. Data were
analysed with the SPSS 10.0 (SPSS Inc.) statistical pro-
gramme.

The study was approved by the Clinical Research Ethics
Committee of La Paz University Children’s Hospital, Madrid.

RESULTS
The population included in the study consisted of
150 infants with gestational ages between 23 and
27 weeks (mean 25.6 ± 1.2), with birth weight between
425 and 995 grams (mean 745.2 ± 132). CPR was given to
32 infants (21.4%). The perinatal characteristics of the two
groups were comparable (table 1). Apgar score at one
minute and 5 minutes and cord pH were significantly
lower in the group that received CPR. Only 9.37 % had a
zero Apgar score in the first minute of life. 59.4 % of the
infants with CPR had an Apgar < 5 and 90.6 % had an Ap-
gar < 5 in the first minute of life versus 11.8 % and 50.8 %

of the infants who did not need CPR. Similarly, the infants in the CPR group had higher scores on the SNAPPE-II scale of gravity in the first twelve hours of life (table 2). We found no differences in the obstetric backgrounds recorded and the incidence of chorioamnionitis was similar in both groups (table 2). During the first week of life we found no differences in the type and duration of respiratory support, haemodynamic instability, persistent ductus arteriosus with clinical repercussions or early sepsis. However air leaks and coagulopathy were more common in the group of children with CPR. The children who received CPR needed higher doses of exogenous pulmonary surfactant, higher oxygen inspired fraction and higher median airway pressure during the first 72 hours of life (table 2). The presence of stage II-III necrotizing enterocolitis was similar in both groups (table 2).

Moving on to late neonatal morbidity, we found no significant differences in the frequency of bronchopulmonary dysplasia (37.5% vs 39%), retinopathy of prematurity needing laser photocoagulation (12.5% vs 13.5%) and days of hospital stay (75.90 vs 81.17 ± 45.05). Weight and head perimeter on discharge were similar in the two groups. No differences were found at the moment of starting enteral nutrition or in the age at which exclusive enteral nutrition was reached. Survival on discharge showed no significant differences, being 62.5% in the children who received CPR vs 76.3% in those who did not. Nor did we find statistical differences on comparing the two groups for mortality in the first three days of life (18.75% vs 8.47%).

The presence of clinical convulsions was the same in both groups. Cerebral ultrasonography was performed on 96.0% of the infants. We found no statistically significant differences for the presence of any degree of IVH. IVH grade III, haemorrhagic periventricular infarct (HPI) or PVL ≥ grade 2 (fig. 1). The presence of PVL grades 3 and 4 did not differ significantly, either: 3.5% in infants needing CPR vs 6.6% in the rest. However, the analysis of the combined index of neurological morbidity (IVH III and/or PVL ≥ grade 2 and/or HPI) did show significant differences for the presence of any degree of IVH, IVH grade III, haemorrhagic periventricular infarct (HPI) or PVL ≥ grade 2 (fig. 1).

**TABLE 1.** Perinatal characteristics of the two groups, expressed as mean and standard deviation for quantitative variables and as a percentage for qualitative variables

<table>
<thead>
<tr>
<th></th>
<th>ELBW infants with CPR</th>
<th>ELBW infants without CPR</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>GA (weeks)</td>
<td>25.5 ± 1.26</td>
<td>25.9 ± 1.35</td>
<td>0.575</td>
</tr>
<tr>
<td>Birth weight (grams)</td>
<td>796.1 ± 134.1</td>
<td>726.6 ± 125.6</td>
<td>0.596</td>
</tr>
<tr>
<td>Sex (female)</td>
<td>54.2%</td>
<td>40.6%</td>
<td>0.231</td>
</tr>
<tr>
<td>IUGR</td>
<td>2.5%</td>
<td>0.3%</td>
<td>0.289</td>
</tr>
<tr>
<td>Multiple pregnancy</td>
<td>21.2%</td>
<td>51.5%</td>
<td>0.245</td>
</tr>
<tr>
<td>In vitro fertilization</td>
<td>20.5%</td>
<td>21.9%</td>
<td>0.800</td>
</tr>
<tr>
<td>Prenatal corticoids</td>
<td>57.6%</td>
<td>55.3%</td>
<td>0.901</td>
</tr>
<tr>
<td>Cerebroventricles</td>
<td>46.5%</td>
<td>56.5%</td>
<td>0.446</td>
</tr>
<tr>
<td>Chorioamnionitis</td>
<td>21.2%</td>
<td>18.8%</td>
<td>0.796</td>
</tr>
</tbody>
</table>

**TABLE 2.** Apgar score, cord pH and SNAPPE-II score (Score for Neonatal Acute Physiology Perinatal Extension), and general short-term neonatal morbidity in the two groups, expressed as mean and standard deviation for quantitative variables and as a percentage for qualitative variables

<table>
<thead>
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<th>ELBW infants with CPR</th>
<th>ELBW infants without CPR</th>
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</thead>
<tbody>
<tr>
<td>Apgar 1 min</td>
<td>7.24 ± 0.30</td>
<td>7.28 ± 0.11</td>
<td>0.017</td>
</tr>
<tr>
<td>Apgar 5 min</td>
<td>4.65 ± 1.76</td>
<td>4.67 ± 1.78</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>SNAPPE score</td>
<td>72.5 ± 22.04</td>
<td>72.9 ± 24.58</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Surfactant (dose)</td>
<td>1.77 ± 0.49</td>
<td>1.50 ± 0.76</td>
<td>0.095</td>
</tr>
<tr>
<td>MAP (cm H2O)</td>
<td>15.20 ± 4.24</td>
<td>9.97 ± 2.79</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Minimum PaO2</td>
<td>9.99 ± 0.21</td>
<td>9.70 ± 0.24</td>
<td>0.005</td>
</tr>
<tr>
<td>≥ 2 vasoactive drugs</td>
<td>54.6%</td>
<td>28%</td>
<td>0.076</td>
</tr>
<tr>
<td>Air leaks</td>
<td>25%</td>
<td>5.9%</td>
<td>0.004</td>
</tr>
<tr>
<td>Coagulopathy</td>
<td>56.5%</td>
<td>20.4%</td>
<td>0.001</td>
</tr>
<tr>
<td>Entococci</td>
<td>12.8%</td>
<td>16.9%</td>
<td>0.135</td>
</tr>
<tr>
<td>Early sepsis</td>
<td>12.5%</td>
<td>6.8%</td>
<td>0.205</td>
</tr>
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</table>

**Figure 1.** Short-term neurological morbidity in both groups, expressed as percentages. IVH (Intraventricular haemorrhage), HPI (Haemorrhagic Periventricular Infarction), PVL (Periventricular Leucomalacia). CPR (Cardiopulmonary Resuscitation).
The characteristics of the two groups were similar, not only for weight, gestational age and other perinatal characteristics such as the frequency of multiple delivery and/or HPI and/or PVL, but also for the frequency of characteristics such as the frequency of multiple delivery and/or HPI and/or PVL, but also for the frequency of weight, gestational age and other perinatal characteristics such as the frequency of multiple delivery and/or HPI and/or PVL, but also for the frequency of weight, gestational age and other perinatal characteristics such as the frequency of multiple delivery and/or HPI and/or PVL.

In our population, the frequency of CPR in ELBW infants is associated with greater overall neurological morbidity during the neonatal period.

The low number of ELBW infants with CPR in our study limited statistical power and prevented stratification of the results by weight groups (< 750 g vs 750 to 1000 grams). In addition, the retrospective design of the study suggests that the indications, duration and aggressiveness of CPR may have been heterogeneous. The association between CPR and brain damage is not necessarily causal and sequential, since the need for CPR and way pressure and higher oxygen inspired fraction during the first 72 hours. In addition, they had greater frequency of air leaks and coagulopathy. However, despite this higher early morbidity of the group needing CPR, there were no differences between the two groups in final overall morbidity, whether respiratory, haemodynamic, gastro-intestinal, ocular, or in length of hospital stay. The increased early respiratory morbidity associated with CPR was also seen in an earlier study including 158 neonates (< 1500 g).

In our study, survival was similar in the two groups (62.5% vs 76.3%), result that is consistent with other studies on the question. Although the data available indicate that most ELBW infants with CPR survive, the analysis of this question in large populations reveals that CPR is associated with a greater probability of death in the neonatal period comparing with infants who do not need CPR in all weight categories except the 401-500 gram sub-group. The main concern after CPR in this especially vulnerable group of premature infants is that the CPR intervention might be accompanied by neurological lesion and subsequent long-term neurological morbidity. The frequency of PVL in this study was 21.4%, a prevalence somewhat higher than that reported in other studies. As was to be expected, the Apgar scores at one and at five minutes were markedly lower in the group of infants who needed CPR. Only 9.57% of these had an Apgar score of zero in the first minute of life and 59.6% had a score < 3. The remaining infants in this group had Apgar scores from 3 to 5 inclusive, and it is likely that some of these neonates did not meet the international recommendations for the start of cardiac massage and/or administration of epinephrine during resuscitation. The ELBW infants who needed CPR had greater early neonatal morbidity, with worse physiological stability and greater clinical gravity in the first 12 hours of life expressed by higher scores on the SNAPPE, and more surfactant doses, greater median air-
brain damage may be related through some underlying factor or be indicators of a varied group of factors. Despite these limitations, the results of this study indicate clearly that the history of CPR at birth defines a specific group of ELBW infants at high risk of having brain lesions and, therefore, neurodevelopmental disorders.

Long-term follow-up studies will be needed to find the real impact of CPR on the neurodevelopment of ELBW infants. Unfortunately, we do not have neurodevelopmental results for the patients included in our study. This is a common drawback, as there are very few studies on the long-term evolution of premature babies weighing <1,500 grams who needed CPR and the populations studied are small. This does not allow us to reach clear conclusions, apart from that intact survival is possible and that it happens, probably, with greater frequency than expected1-3.

**CONCLUSION**

In summary, in our scope CPR in ELBW infants clearly signifies increased risk of brain damage, but not of greater non-neurological morbidity during the hospital stay. However, in this study as in others published in recent years, the high mortality and the high percentage of severe lesions or sequelae traditionally associated with CPR in ELBW infants are not shown. Rather, our study provides further evidence that over half the ELBW infants who undergo CPR suffer no significant brain damage, IVH grade III, IPIH or PVL. These data are relevant when weighing benefits and risks of CPR in this group, information that is important when we define our interventions and also at the pre-delivery interview with the parents. However, CPR in ELBW infants must also be noticed as a potential factor of biological risk of adverse neurodevelopment when both short and long-term evolution of these newborns are examined.

**REFERENCES**


