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Survey of neonatal resuscitation practices showed post training improvements but need to reinforce preterm management, monitoring and adrenaline use.

Short: Neonatal resuscitation practices in Spain

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ABSTRACT

Aim

Neonatal resuscitation surveys have showed practice variations between countries, centres and levels of care. We evaluated delivery room practices after a nationwide neonatal resuscitation training programme focused on non-tertiary centres.

Methods

A 2012 survey sent to all Spanish hospitals handling deliveries covered staff availability and training, equipment and practices in the delivery room and during transfers to

neonatal intensive care units. The results from 98 centres that had completed a previous survey in 2007 were analysed by levels of care. Pearson's chi-square test was used to compare the proportions.

Results

The following had significantly improved in 2012 compared to 2007: the availability of T-piece resuscitators (71.4% versus 41.8%), plastic wraps (69.4% versus 31.6%), gas blenders (79.6% versus 40.8%), pulse oximetry (92.9% versus 61.2%), use of continuous positive airway pressure (82.7% versus 43.9%) (all $p < 0.01$), the availability of instructors (55.6% versus 83.3%, $p < 0.05$) and neonatal resuscitation courses (40.8% versus 79.6%, $p < 0.05$) in non-tertiary centres. In 2012, the use of exhaled carbon dioxide detectors was $< 7\%$ and endotracheal administration of adrenaline was $> 90\%$.

Conclusion

Neonatal resuscitation equipment and practices improved over time, but several aspects needed to be reinforced in training programmes, namely preterm infants' management, monitoring and adrenaline administration.

KEY WORDS: Neonatal resuscitation, training, delivery room, survey, preterm infant.

KEY NOTES

- Neonatal resuscitation surveys have showed wide variation in international and national practice.
- This nationwide survey showed an improvement in training opportunities and neonatal delivery room practices in tertiary and non-tertiary hospitals in Spain from 2007 to 2012, following a nationwide training strategy that focused on non-tertiary centres.
- However, it also identified areas that needed to be reinforced in training programmes, namely preterm infants' management, monitoring and adrenaline administration.

INTRODUCTION

Effective basic neonatal resuscitation is essential to decrease neonatal mortality worldwide and it is estimated to reduce asphyxia and preterm birth related mortality by 30% and 10% respectively (1).

The International Liaison Committee on Neonatal Resuscitation (ILCOR) releases a consensus of science and treatment recommendations every five years (2). Resuscitation councils in different countries review those recommendations and publish clinical practice guidelines according to their own health organisation, resources and needs (3–5).

In Spain, the Neonatal Resuscitation Group (NRG) of the Spanish Society of Neonatology is responsible for revising, updating and delivering the national neonatal resuscitation guidelines and training programme (6). In 2009, the NRG published equipment and practices in Spain (7), which reported important gaps between knowledge and practice. Although the relevant resuscitation equipment and access to guidelines were not significantly different between the levels of care, some significant differences were observed regarding their translation into clinical practice.

The ILCOR 2010 publication (8) highlighted the importance of education and training. In view of our first survey results, the NRG focussed on increasing the number of instructors and training courses in non-tertiary centres.

The aim of this survey was to evaluate the progress in implementing recommended equipment and practices in the delivery room over time. We also aimed to identify topics that still need to be addressed after the release of the 2015 ILCOR guidelines.

MATERIALS AND METHODS

In the last three months of 2012, the NRG sent a questionnaire by e-mail to all of the 180 hospitals that provided neonatal care in Spain (Appendix S1). This questionnaire included more data than the one used in 2007, to reflect the 2010 ILCOR guidelines changes, like the use of supplementary oxygen, medication and fluid administration, therapeutic hypothermia, discontinuation of resuscitation and educational techniques (8). They were sent to the paediatricians and neonatologists in charge of neonatal care. A maximum of two reminders were sent to non-responders. The survey covered the demographics of the participating centres, limits of viability, equipment availability, staff availability and training, clinical practices during resuscitation and post-resuscitation management.

A total of 155 hospitals responded to the 2012 survey (9), including 98 who had responded to the previous survey in 2007. In order to evaluate the changes in clinical practice over those five years, the results from the 98 hospitals that participated in both surveys were used for comparison. These 98 centres had no statistically different practices than the rest of the 57 centres surveyed in 2012. Descriptive statistics were used to analyse the results. Differences in proportions were tested using Pearson's chi-

square test with the level of significance set at <0.05 . Results were analysed by levels of care, namely non-tertiary versus tertiary centres.

RESULTS

A total of 180 questionnaires were sent in 2012 and 155 (86.1%) were fully completed. Of those, the 98 that had also completed the survey in 2007 were used for the comparative analysis. Respondents were evenly distributed throughout the country.

Characteristics of the participating centres

Between 2007 and 2012, there were no differences regarding the care level of the participating hospitals, the number of deliveries per year or the number of very preterm infant admissions per year (Table 1) (10).

Gestational age thresholds for resuscitation

Figure 1 shows the gestational age thresholds for neonatal resuscitation in relation to levels of care. Many non-tertiary centres offered resuscitation from 24 weeks of gestation and some also provided this at 23 weeks. This didn't change over time. In tertiary centres, there was a significant increase in 2012 in providing neonatal resuscitation at 23 weeks of gestation ($p < 0.05$).

Composition and training of the resuscitation team

The composition of the resuscitation teams is shown in Table 2. Paediatric neonatologists were more involved in 2012 than 2007 (33.3% versus 61.1%, $p < 0.05$) and the involvement of anaesthesiologists decreased (83.3% versus 55.6%, $p < 0.05$) in non-tertiary centres. The availability of instructors and neonatal resuscitation courses significantly increased over time in those centres ($p < 0.05$). In 2007, the availability of courses was significantly lower in non-tertiary than in tertiary centres (63.9% versus 81.7%, $p < 0.01$). This difference no longer existed in 2012.

Between 2007 and 2012, the number of courses tripled to 189. Of those, 90 were held in tertiary centres and 99 in non-tertiary hospitals. A total of 3,536 healthcare providers successfully completed the courses and 242 new instructors were certified.

In 2012, 15 (24.2%) tertiary centres and seven (19.4%) non-tertiary centres reported that they had access to simulation courses and four tertiary hospitals (6.5%) used video recording in the delivery room for training and research purposes. These data were not available in 2007.

Equipment in the resuscitation area

Equipment in the resuscitation area is shown in Table 3. In all levels of care the availability of gas blenders, pulse oximeters, manual ventilators (T-piece resuscitators) and plastic wraps significantly increased. The availability of self-inflating bags and positive end expiratory pressure (PEEP) valves also increased ($p<0.01$). The availability of carbon dioxide sensors was very low in both surveys, at less than 10%.

Practices during neonatal resuscitation

The main changes in clinical practice during neonatal resuscitation are shown in Table 4.

The use of devices for heat loss prevention, such as polyethylene bags or wraps, significantly increased over time, regardless of level of care ($p<0.001$), but achieving an environmental temperature of 26°C decreased ($p<0.05$). Overall, 42.9% of centres checked the preterm infant's temperature in the delivery room, before admission. Cooling strategies for hypoxic-ischaemic encephalopathy (HIE) was only surveyed in 2012 and this showed that most centres started cooling in the delivery room: 72.2% of non-tertiary centres and 90.3% of tertiary centres ($p<0.05$). We also found that 61 centres (62.2%) reported that they checked the infant's temperature in the delivery room if at they were at risk of risk of HIE.

Oxygen administration and oxygen saturation (SpO_2) monitoring was only surveyed in 2012. Most centres - 90.3% of tertiary and 91.7% of non-tertiary centres started resuscitation in air for term babies. And the majority - 85.2% of tertiary and 80.6% of non-tertiary centres - used 30-50% oxygen for preterm babies under 32 weeks' gestation. The use of oxygen blenders, pulse oximetry and oxygen administration guided by pulse oximetry significantly increased over time, while assessing oxygenation by observing skin colour significantly decreased, regardless of the level of care.

The use of respiratory devices changed over time: the use of self-inflating bags decreased, whereas controlled positive inspiratory pressure (PIP) and (PEEP) via T-piece significantly increased, especially in preterm infants, regardless of level of care. The use of continuous positive airway pressure (CPAP) for preterm infants also increased, mainly via a T-piece and a face mask, in 72.7% of non-tertiary centres and 78% of tertiary centres in 2012. The pressure settings are displayed in Figure 2. In 2007, PIP use was significantly higher in tertiary centers ($p=0.03$), but this difference no longer existed in 2012. In tertiary centres, PEEP became more consistent over time ($p=0.01$). In 2012, 11 tertiary and one non-tertiary centre (12.2%) used sustained inflation. Exhaled carbon dioxide detectors were used in less than 4% of centres.

For NICU transfers, a transport ventilator was the device of choice to deliver CPAP and PIP/PEEP in all levels of care, in 77.8% of non-tertiary and 69.4% of tertiary centres in 2012. The use of self-inflating bags significantly decreased over time in non-tertiary (58.3% versus 27.8%, $p<0.01$) and tertiary centres (41.9% versus 22.6%, $p<0.05$). The use of gas blenders during transport to the NICU increased in non-tertiary centres (53.3% versus 80.6%, $p<0.05$), but not in tertiary centres (79% versus 90.3%, ns).

Information regarding drug use was only surveyed in 2012. Adrenaline was commonly administered via the endotracheal tube, before vascular access was attempted, regardless of level of care, in 94.4% of non-tertiary and 98.8% of tertiary centres.

DISCUSSION

The aim of this study was to evaluate the results of a proactive formative intervention, using a survey that covered a representative sample of maternity hospitals in Spain. Between 2002 and 2006, 63 neonatal resuscitation courses were held in Spain. After our 2007 survey, a more active training policy was successfully implemented, especially in non-tertiary centres (Table 2). Between 2007 and 2012, the number of courses tripled to 189. This resulted in more than 240 new instructors being trained and more than 3,000 health providers being certified. In our *Training the trainer* courses we focus on the necessary skills to facilitate learning and debriefing, which is in accordance with the 2010 ILCOR recommendations (8). Attendants are selected with regard to their geographical distribution to ensure a successful spread of the national neonatal resuscitation programme. They stay in touch with the NRG, in order to provide feedback and receive updates.

The benefit of training in delivery room resuscitation after nationwide educational interventions has been described in countries like China (11) and Peru, (12), where birth asphyxia mortality rates significantly decreased after these interventions were implemented. In single sites, proactive training policies resulted in better admission temperature, a reduction in the exposure to oxygen during the first minutes of life and a increase in the use of CPAP in preterm respiratory stabilisation (13).

Most of Spanish maternity hospitals have updated their equipment and are more compliant to current international practice guidelines. These improvements have been made in primary and secondary hospitals as well as tertiary hospitals. Such improvements cannot be explained by changes in the baseline characteristics of the participant centres, which have remained the same (Table 1). We speculate that

focusing on *Training the trainer* had a positive impact on delivery room equipment and practices. We believe that this can contribute to better clinical outcomes. However, translating theory into practice is a complex process and may take a long time. Some aspects of this translation are discussed below.

Our survey showed that neonatal resuscitation at 23 weeks of gestation increased over time in tertiary centres and was also offered in non-tertiary centres. This highlights the need to discuss ethics at the limits of viability in our training programme, as mortality and morbidity outcomes vary in our country, making antenatal consultation and decision making very challenging (14).

Since the first publications on heat loss prevention in very preterm infants appeared (15), this has continued to be a challenge, especially keeping the delivery room temperature at a level of at least 26°C (8). This has been shown in this and other international surveys, where this target was achieved in no more than 20-40% of centres. However, the universal use of polyethylene bags is an achievable target, as shown in a UK survey where this strategy was successfully implemented in 99% of centres (16). To achieve nationwide implementation, the benefit and feasibility of this intervention need to be reinforced in neonatal resuscitation courses. Including statistics on admission temperature from a national database in training programmes may help healthcare staff to understand the magnitude of the problem and improve the compliance of this simple, cheap and effective intervention.

Cooling reduces mortality without increasing major disabilities in survivors of HIE (17), but whether to start the cooling process in the delivery room or how to perform it effectively it is not specified in the cooling protocols (17,18) or in the ILCOR guidelines (2,8). Our training programme recommends stabilising the infant first and starting passive cooling after that, if the HIE criteria are met. Most of the centres we surveyed in 2012 started therapeutic hypothermia in the delivery room if there was a high risk of HIE. There is very limited evidence to support such early intervention and this needs further evaluation.

The availability of gas blenders, pulse oximeters and manual ventilators increased over time in tertiary and non-tertiary centres. One of the biggest changes in the neonatal resuscitation recommendations in 2010 was targeting oxygen saturation, guided by pulse oximetry (8), and this was highlighted in 2015 (2). Compliance with the guidelines on initial oxygen concentration settings was high, as was the availability of a pulse oximeter in the delivery room, which was reported by around 92% of centres in 2012. However, in 2012, only 56% of hospitals used a pulse oximeter consistently in all resuscitations. The most common reason for not using it was reported to be the lack of reliability during the first minutes of life. A UK study by Mann et al reported that only

60% of tertiary and 30% of non-tertiary units used pulse oximetry in the delivery room, with several commenting on poor reliability at the start (19). However, studies have showed show signal-extraction pulse oximeters can obtain heart rate and oxygen saturation data in about one minute (20–22) and that the quality of data provided by different new generation pulse oximeters, such as Masimo and Nellcor, is similar at an oxygen saturation of $\geq 70\%$ (23). Accurate knowledge about how a pulse oximeter works and the evidence for best practice in using pulse oximetry in the delivery room (24), together with specific educational programmes (25), are the basis of the optimal use of this technology. This will need to remain a highlight in training programmes.

T-pieces have become the device of choice in many institutions, especially for preterm infants, due to the benefit of providing CPAP. This study showed that their use increased in all levels of cares, while the use of self-inflating bags decreased in tertiary centres. The ILCOR guidelines do not recommend one ventilator device over another to provide positive pressure ventilation, however a device that can provide PEEP is recommended for preterm infants if suitable equipment is available (2,8). Recommended PIPs have not changed since 2010 (2,8). Our results showed that healthcare staff tended to set PIP at the lower end, or less, of the recommended range. This may reflect their concerns about damaging the lungs of preterm infants when no monitoring is available and tidal volumes are unknown. The use of self-inflating bags with PEEP valves may reflect the limited availability of T-pieces in our country and the fact that our training programme explains that PEEP valves for self-inflating bags are available. However the reliability of PEEP valves is limited and inferior to the PEEP provided by T-pieces (26). Regarding CPAP, it is encouraging that its use increased in all levels of care, but the pressure range was wide and sometimes insufficient to develop functional residual capacity. Sustained inflations were provided in some centres in 2012, despite the fact that there is no evidence to show that this strategy improves clinical outcomes and no evidence to clarify what pressures and inflation times should be used. Furthermore, this is not a recommended intervention in our training programme. The advantages and disadvantages of different devices and pressures, and the lack of evidence to recommend sustained inflation, need to be discussed in training programmes until more evidence is available.

The improvements in how respiratory support is delivered during transfers to NICUs illustrates the efforts that have been made to improve quality of care. This critical time is not usually discussed in neonatal resuscitation surveys and there is lack of data on what strategies may be best with regard to improving clinical outcomes. We suggest this aspect to be reported in future studies.

Since 2010, the ILCOR guidelines for resuscitating newborn infants have advocated the use of exhaled carbon dioxide detectors to confirm endotracheal tube placement in neonates with spontaneous circulation (2). Their availability is very low in our country - only 5% of centres - and only 70% of the tertiary and 45% of the non-tertiary centres believed it was a useful device. This was not consistent with other international surveys, where reports say it has been used in 50-87% of centres (27,28). We speculate that, as many resuscitation courses are provided by instructors from tertiary centres, recommendations about using carbon dioxide detectors may be influenced by the instructors' self-confidence in neonatal intubation. However, the success intubation rates achieved by experienced consultants are not close to 100% (29) and this rate significantly decreases with less experience. Carbon dioxide detectors don't just provide reassurance to the operator, they also reassure the rest of the resuscitation team, including midwives and nurses. These advantages should be emphasised to increase their use in the delivery room.

Drugs are not commonly needed in the delivery room. The 2010 and 2015 ILCOR guidelines highlighted the importance of aiming to establish a vascular access to administer adrenaline (2,8). This was incorporated in our training programmes before this survey took place. However, our results reflected the challenge of having an intravascular access available by the time the administration of the first dose of adrenaline was discussed. Endotracheal administration may also be performed, as there is a lack of evidence to suggest that this access is never effective. We have no data to illustrate whether vascular access was attempted after adrenaline had been administered via an endotracheal tube, and if not, what the barriers were. We think this is an important theory into practice challenge that needs to be further evaluated and clarified in the neonatal resuscitation flowchart.

CONCLUSION

Equipment and practices in the delivery room significantly improved between 2007 and 2012, at all levels of care. We believe that this was due to our proactive policy in neonatal resuscitation training. However, it takes time to translate new knowledge and evidence into clinical practice. The current Spanish national training programme was updated in 2016, according to the ILCOR treatment recommendations released in 2015. It emphasises specific aspects highlighted in this study, like ethical discussion at the limits of viability, temperature control, SpO₂ monitoring, the use of CPAP for preterm infants, the use of carbon dioxide detectors to confirm successful intubation and the challenge of establishing vascular access for adrenaline administration.

We hope that these survey findings can help other healthcare providers and administrators to identify strategies to reduce the gap between the release of neonatal resuscitation guidelines and their successful implementation in clinical practice.

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CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

FINANCE STATEMENT

The authors declare that no external funding was sought or received to conduct this study.

ABBREVIATIONS

ILCOR, international liaison committee on resuscitation; NRG, neonatal resuscitation group; PEEP, positive expiratory pressure; HIE, hypoxic-ischaemic encephalopathy; SpO₂, oxygen saturation; PIP, positive inspiratory pressure; CPAP, continuous positive airway pressure.

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Table 1. Characteristics of participating centres according to level of care, number of deliveries per year and number of infants with birth weight <1,500g per year.

Number of centres per group	2007 (n=98)	2012 (n=98)	p value
Level of care			
Primary centres	8	10	ns
Secondary centres	28	19	ns
Tertiary centres	62	69	ns
Births/year			
<1,000	11	13	ns
1,000-2,500	44	38	ns
2,500-4,000	24	30	ns
>4,000	19	17	ns
Infants <1,500g/year			
<20	38	37	ns
20-50	31	31	ns
50-100	19	18	ns
>100	10	10	ns

ns: not statistically significant

Table 2. Composition of resuscitation team and training opportunities per centre.

Number of centres(%) per group						
	Non-tertiary centres			Tertiary centres		
	2007	2012	p value	2007	2012	p value

Resuscitation team members						
Neonatologist	12 (33.3%)	22 (61.1%)	<0.05	53 (85.5%)	58 (93.5%)*	ns
Paediatric Resident	8 (22.2%)	14 (38.9%)	ns	47 (75.8%)	49 (79%)*	ns
General Paediatrician	33 (91.7%)	34 (94.4%)	ns	38 (61.3%)	39 (62.9%)*	ns
Midwife	23 (63.9%)	24 (66.7%)	ns	30 (48.4%)	36 (58.1%)	ns
Nurse	16 (44.4%)	21 (58.3%)	ns	22 (35.5%)	24 (38.7%)	ns
Anaesthesiologist	30 (83.3%)	20 (55.6%)	<0.05	29 (46.9%)	24 (38.7%)	ns
Training opportunities						
Instructors in hospital/area	20 (55.6%)	30 (83.3%)	<0.05	51 (82.2%)	58 (93.5%)	ns
Courses availability in hospital/area	23 (63.9%)	32 (88.9%)	<0.05	58 (93.5%)	60 (90.8%)	ns
Courses provided at least annually	16 (44.4%)	21 (58.3%)	ns	27 (43.5%)	37 (59.7%)	ns

*Significant difference between non-tertiary and tertiary centers in 2012 ($p < 0.001$).

ns: not statistically significant

Table 3. Changes in delivery room equipment over time

DR equipment	Number of centres (%) per group					
	Non-tertiary centres (n=36)			Tertiary centres (n=62)		
	2007	2012	p value	2007	2012	p value
Plastic wrap	6 (16.7%)	20 (55.6%)	<0.001	24 (38.7%)	49 (79%)*	<0.001
Pulse oximeter	19 (52.8%)	31 (86.1%)	<0.01	41 (66.1%)	60 (96.8%)	<0.001
Gas blender	13 (36.1%)	30 (83.3%)	<0.001	30 (48.4%)	54 (87.1%)	<0.001
Exhaled CO ₂ sensor	0 (0%)	1 (2.8%)	ns	1 (1.6%)	4 (6.5%)	Ns
Self-inflating	29	36	ns	54	58	Ns

bag	(80.6%)	(100%)		(87.1%)	(93.5%)	
Self-inflating bag with PEEP valve	12 (33.3%)	20 (55.6%)	ns	27 (43.5%)	37 (59.7%)	Ns
T-piece resuscitator	12 (33.3%)	21 (58.3%)	<0.05	29 (46.8%)	49 (79%)	<0.001

*Significant difference between non-tertiary and tertiary centres in 2012 ($p < 0.01$). ns: not statistically significant.

Table 4. Changes in delivery room practices over time.

Delivery room equipment	Number of centres per group					
	Non-tertiary centres			Tertiary centres		
	2007	2012	p value	2007	2012	p value
Plastic wrap	6 (16.7%)	20 (55.6%)	<0.001	24 (38.7%)	49 (79%)	<0.001
Temperature set $>26^{\circ}\text{C}$	22 (61.1%)	11 (30.6%)	<0.05	35 (56.5%)	21 (33.9%)	<0.05
Passive cooling	0 (0%)	26 (72.2%)	<0.001	0 (0%)	56 (90.3%)	<0.001
Gas blender	13 (36.1%)	30 (83.3%)	<0.001	30 (48.4%)	54 (87.1%)	<0.001
Pulse oximeter (always)	0 (0%)	18 (50%)	<0.001	9 (14.5%)	37 (59.7%)	<0.01
Exhaled CO_2 sensor use	0 (0%)	0 (0%)	ns	1 (1.6%)	2 (3.2%)	Ns
Exhaled CO_2 sensor consider	14 (38.9%)	16 (44.4%)	ns	41 (66.1%)	38 (61.3%)	Ns

useful for tube placement						
Self-inflating bag	19 (52.8%)	15 (41.7%)	ns	34 (54.8%)	19 (30.6%)	<0.01
Self-inflating bag with PEEP valve	12 (33.3%)	16 (44.4%)	ns	18 (29%)	26 (41.9%)	Ns
PIP/PEEP for preterm infants (always)	11 (30.6%)	21 (58.3%)	<0.05	40 (64.5%)	54 (87.1%)*	<0.01
CPAP for preterm infants	9 (25%)	22 (61.1%)	<0.01	34 (54.8%)	59 (95.2%)	<0.01

Significant difference between non-tertiary and tertiary centres in 2012 (*p<0.001).

ns: not statistically significant

Figure 1: Gestational age thresholds for neonatal resuscitation in non-tertiary and tertiary centres (* p<0.05).

Figure 2: Initial pressure settings for very preterm infants (<32 weeks of gestation).

Footnote: Changes over time are expressed as medians and interquartile ranges.

There are no significant differences between 2007 and 2012.

Figure 1: Gestational age thresholds for neonatal resuscitation in LI-II and LIII centers (* $p < 0.05$)

Figure 2. Initial pressure settings for very preterm infants (<32 weeks' gestation). Changes over time expressed as medians and interquartile ranges. There are no significant differences between 2007 and 2012.

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