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Clinical paper

The current clinical landscape of preterm infants less than 32 weeks of gestation receiving delivery room chest compression in Jiangsu Province, China

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Abstract

Objective: To provide an updated review of the clinical profile and outcomes of delivery room chest compression (DR-CC) in China.

Method: Retrospective analysis of prospectively collected data from 23 neonatal intensive care units in Jiangsu, China (2019–2021). Antepartum, delivery room, and postpartum variables in DR-CC-receiving and no-DR-CC groups were compared using uni- and multivariate analyses. The main outcome measure was survival without major morbidities at discharge.

Results: Among 2120 preterm infants of <32 weeks gestational age, 112 (5.39%) received DR-CCs. Forty-two (37.50%) DR-CC-group infants survived without major morbidities at discharge, compared with 1299 (66.17%) no-DR-CC-group infants. The DR-CC group had a lower adjusted odds ratio (AOR) of survival without major morbidities (0.53 [0.31, 0.89]). In secondary outcomes, infants who received DR-CCs had more in-hospital mortality (AOR:1.95[1.12, 3.40]) and a significant increase in the rate of grade 3/4 intraventricular hemorrhage / periventricular leukomalacia or death (AOR: 2.35[1.40, 3.95]), ≥ moderate bronchopulmonary dysplasia or death (AOR: 2.02[1.21, 3.37]), ≥ stage 3 retinopathy of prematurity or death (AOR: 2.22[1.33, 3.69]), ≥ stage 2 necrotizing enterocolitis or death (AOR: 1.83[1.09, 3.07]) and late-onset sepsis or death (AOR:1.66[1.02, 2.70]). In DR-CC-group infants, use of a T-piece resuscitator, noninvasive respiratory support, and higher gestational age significantly influenced survival without morbidities.

Conclusion: This multicenter cohort study revealed the clinical landscape of preterm infants (<32 weeks gestational age) receiving DR-CCs, showing lower survival rates without major morbidities compared to those not receiving DR-CCs.

Keywords: Cardiopulmonary resuscitation, Infant, Premature, Survival, Morbidity

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Introduction

During delivery room (DR) resuscitation, chest compressions (CC) is performed for newborns with sudden cardiac arrest, severe bradycardia (heart rate: <60 beats per minute), or pulseless electrical activity. During DR-CC, adrenaline may need to be repeated every 3–5 min, and initial intratracheal administration is reasonable, facilitating the return of spontaneous circulation.[1,2] Compared with full-term infants, preterm infants have poor organ development and a higher DR-CC reception rate. Gestational age is a major risk factor for DR-CC reception.[3–8] According to data from neonatal networks in Israel, Canada, South Korea, and China, the DR-CC rates in very preterm (less than 32 weeks) infants were 3.6%, 5.2%, 5.4%, and 4%, respectively,[4–7] while data from 1511 extremely preterm infants (less than 28 weeks) in the California Permanent Quality Care Collaborative showed a 9.4% DR-CC rate.[8]

With advancements in perinatal medicine, the mortality rate of preterm infants of <32 weeks gestational age receiving DR-CCs decreased from 31.7% in 2010–2011 to 28% in 2019.[4,6] However, the risk of severe complications such as grade 3/4 intraventricular hemorrhage (IVH) or periventricular leukomalacia (PVL), or bronchopulmonary dysplasia (BPD), remains high in preterm infants receiving DR-CCs.[9] These conditions can lead to an increased economic burden, family psychological stress, and poor long-term prognosis. With the exception of reports from the Canadian Newborn Network, there was limited published data describing survivorship without major morbidities after DR-CC.[4–8,10–14] However, two previous studies on the relationship between DR-CCs and survival without major morbidities reached opposing conclusions.[4,14] Therefore, in the context of the rapid advancement of preterm infant treatment, more research exploring the relationship between DR-CC and survival without major morbidities is necessary, even though there may not be a direct causation.

We updated the clinical landscape of DR-CC in preterm infants born at a gestational age of 23–31 weeks and admitted to neonatal intensive care units (NICUs) in Jiangsu Province, China, with particular attention paid on survival and morbidity outcomes.

Methods

Study design

This multicenter retrospective study of prospectively collected data was conducted using clinical data from 2019 to 2021 on all preterm infants of <32 weeks gestational age from 23 NICUs in Jiangsu Province, China, who did or did not receive DR-CCs. It was approved by the local medical ethics committee; the requirement of informed consent was waived.

Setting

This study covered 23 municipal NICUs, including those in maternal and child health (9 NICUs), general (10 NICUs), and children's hospitals (4 NICUs). These tertiary-level 23 NICUs covered the leading medical institutions in 13 cities of Jiangsu Province as well as the critical neonatal care centers in their respective regions, and they can provide a good reflection of the level of premature infant care in Jiangsu Province. The number of hospital beds varies from 20 to 120. Further, the annual number of infants in the NICU was 168–2670. The maternal and child health and general hospitals have the obstetrics specialty; the four children's hospitals are local key clinical specialty institutions with a complete transportation system (The infants hospitalized in these hospitals are from the obstetrics of surrounding hospitals).

These 23 units were members of the neonatology group of the Pediatric Branch of Jiangsu Medical Association. A standardized clinical research protocol was developed before the start of the study, including diagnostic criteria for the diseases and protocols for DR-CC. Prior to and throughout the duration of this multicenter study, we conducted multiple multicenter quality control meetings and prioritized the organization of Neonatal Resuscitation Program training. Furthermore, each center held at least 1–2 neonatal resuscitation training sessions per year to ensure consistent management practices across all participating centers. In China, adhering to the Neonatal Resuscitation Program guidelines (including the timing and procedures for positive pressure ventilation, chest compressions, and epinephrine administration) is the standard of care in all NICUs, and we presumed that these guidelines were followed for all neonates included in the study. The Children's Hospital of Nanjing Medical University designed and launched the study; it was the coordinating center and the promoter, and regularly conducted quality control.

Study population

All preterm infants of <32 weeks gestational age who were admitted to the 23 NICUs from January 2019 to December 2021 were deemed qualified based on the best obstetric assessment. The inclusion criteria were preterm infants of <32 weeks gestational age who did or did not receive CCs at birth and were subsequently moved into the NICU. Infants with severe congenital malformations and whose data were missing were excluded.

For infants transferred to the NICUs within our multicenter network, we only record one set of case information rather than duplicating the records. For those transferred to NICUs outside our multicenter network, we follow up on their outcomes and comprehensively record them in our database.

Data collection

DR-CC was defined as CC ($\geqslant$ 30 s) in the DR, with or without adrenaline use.[3–14]

The patients were divided into the group receiving DR-CCs (DR-CC group) and group that did not receive DR-CCs (no–DR-CC group). Prenatal variables included age, clinical chorioamnionitis, premature rupture of membranes (PROM), placental abruption, gestational diabetes, gestational hypertension, fetal distress, multiple gestations, polyhydramnios/oligohydramnios, and complete antenatal steroid exposure. The DR variables included gestational age, birth weight, sex, mode of delivery, T-piece use in the DR, and pulmonary surfactant use in the DR. Newborn data were collected until discharge. The data collected included respiratory support use, inhaled nitric oxide (iNO), pulmonary surfactant use, caffeine use, IVH/PVL, BPD, necrotizing enterocolitis (NEC), late-onset sepsis (LOS), retinopathy of prematurity (ROP), mortality, survival with major morbidities, and survival without major morbidities.

Definitions of morbidities and outcomes

Major morbidity referred to any of the following diseases: moderate-to-severe BPD(based on whether oxygen was administered, the fraction of inspired oxygen, and the mode of oxygen therapy at a corrected gestational age of 36 weeks, the conditions were classified into mild, moderate, and severe degrees),[15] NEC (≥stage II),[16] IVH (≥stage III)/PVL,[17] ROP (≥stage III) or ROP requiring treatment,[18] and LOS (defined as positive blood culture obtained at >72 h after birth or antibiotic treatment requirement for ≥5 days).[19] Survival without major morbidities was defined as survival without any of the aforementioned serious complications.[20]

The primary outcome was survival without major morbidities. The secondary outcomes were: 1) mortality; 2) major morbidities including BPD (moderate-to-severe), NEC (≥stage II), IVH (≥stage III)/PVL, ROP (≥stage III or treated), NEC, and LOS and 3) major morbidities or death.

Statistical analyses

Continuous variables are described using median values and interquartile ranges (IQRs); categorical variables are described using frequencies and percentages. Differences in categorical variables were analyzed using the chi-square test. Quantitative variables were compared using the Mann–Whitney *U* test. Unadjusted and adjusted risk ratios (RR, adjusted for gestational age and birth weight) compared the DR-CC and no-DR-CC groups. Variables with $P < 0.10$ from univariate analysis were incorporated into the subsequent multivariate analysis. Crude and adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were estimated for the identified variables. Statistical significance was set at $p < 0.05$.

Results

Baseline and clinical characteristics

During the study period, 2120 preterm infants of < 32 weeks gestational age were admitted to the 23 NICUs. Forty-five newborns were excluded: 38 and 7 because of missing data and severe congenital anomalies, respectively. Fig. 1 shows the patient inclusion flowchart. Among the patient, 112 (5.39%) received DR-CCs and 1963 (94.60%) did not. The gestational age and weight were 29.3 ± 1.6 weeks and 1373 ± 337 g, respectively; 1214 infants (58.50%) were male. The gestational age and weight distribution charts were shown in Figs. 2 and 3, respectively.

Four newborns were delivered out-born, and none of them required resuscitation at birth. Table 1 shows the comparison of the antepartum and delivery room variables. There was no significant difference in baseline characteristics between the two groups, except for the DR-CCs group having a lower incidence of PROM >24 h, a higher incidence of fetal distress and complete antenatal steroid treatment. Four newborns were delivered out-born, and none of them required resuscitation at birth.

Treatment-related variables and complications

Table 2 shows the comparison of treatment-related variables and complications in neonates who did and did not receive DR-CCs in the NICU. During treatment in the NICU, 70.53% and 90.88% of preterm infants in the DR-CCs and non–DR-CCs groups, respectively, received noninvasive respiratory support ($p < 0.001$). Furthermore, except for significant differences in the initial continuous positive airway pressure (CPAP) ratio between the DR-CCs and non–DR-CCs groups (50% *vs* 69.3%, $p < 0.001$), there were no significant intergroup differences in the other noninvasive respiratory support ratios. The rate of receiving invasive respiratory support was higher in the DR-CC group. In addition, the DR-CC group had a higher pulmonary surfactant use rate. However, there was no significant intergroup difference in the usage rates of extracorporeal membrane oxygenation (ECMO), iNO, and caffeine ($p > 0.05$).

Outcome indicators

Table 3 shows the outcome indicators for the groups. Regarding the primary outcome, the rate of survival without major morbidities was lower in the DR-CC group (37.50% *vs* 66.17%, adjusted odds ratio [ARR]: 0.53 [0.31, 0.89]). With regard to the secondary outcomes, the unadjusted comparison between the two groups showed a significant increase in in-hospital mortality, a significant increase in the rate of grade 3/4 IVH-PVL and ≥ moderate BPD, and a significant increase in the rate of major morbidities or death (including grade

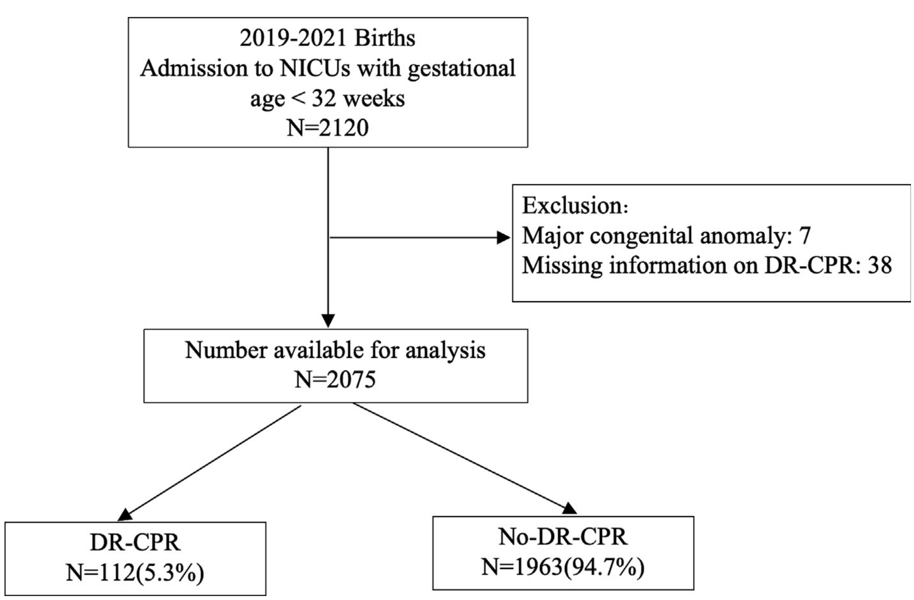

Fig. 1 – Flow diagram of patient inclusion.

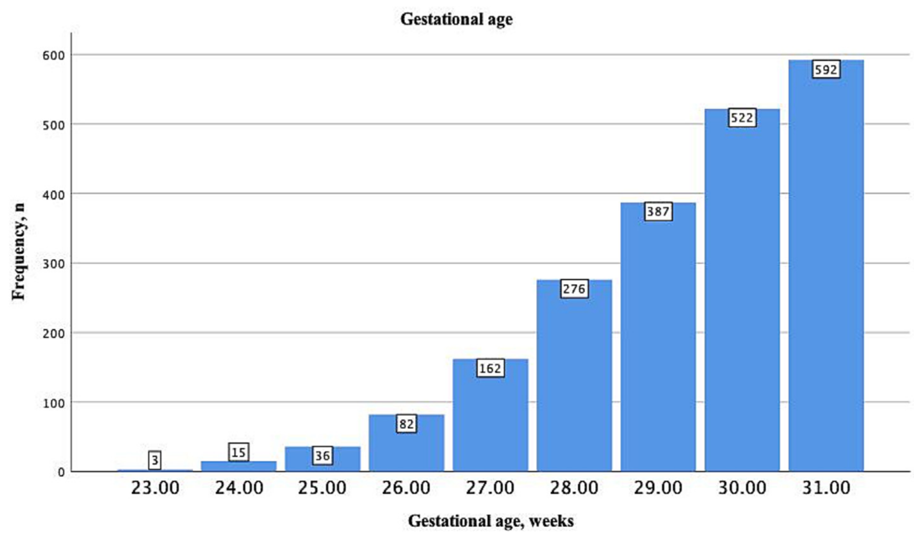

Fig. 2 – Gestational age distribution chart.

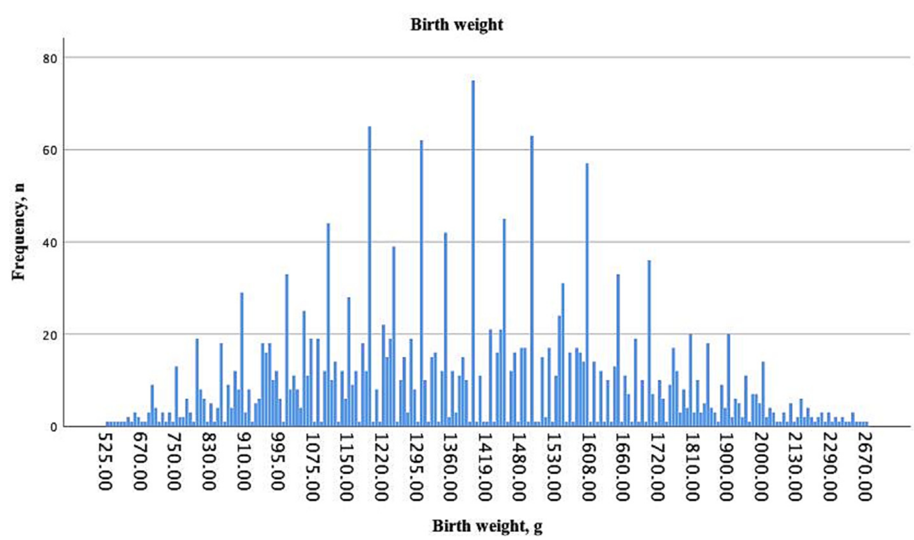

Fig. 3 – Birth weight distribution chart.

3/4 IVH-PVL or death, ≥ moderate BPD or death, ≥ stage 3 ROP or death, ≥ stage 2 NEC or death, LOS or death). After adjustment, for preterm infants of <32 weeks gestational age there were intergroup differences in in-hospital mortality and major morbidities or death, while there was no difference in major morbidities.

The time until death outcomes in the DR-CC and no-DR-CC groups was 5 [2, 19.25] days and 5 [2, 18.5] days, respectively. The top three causes of death were respiratory failure, pulmonary hemorrhage, and shock.

For extremely preterm infants (gestational age less than 28 weeks) who did and did not receive DR-CCs the comparison of outcome indicators was shown in Table 3. Regarding the primary outcome, the rate of survival without major morbidities was lower in the infants receiving DR-CCs (8.10% *vs* 28.35%, ARR: 0.23 [0.06, 0.80]). With regard to the secondary outcomes, there was no difference in both unadjusted and adjusted outcomes between the groups.

Survival and survival without major morbidities at different gestational ages

Fig. 4 shows the survival and survival without major morbidities of preterm infants of <32 weeks gestational age who did and did not receive DR-CCs at different gestational ages (24–31 weeks; all preterm infants born at 23 weeks died). The survival rates for infants born at 24, 25, and 26 weeks in the DR-CC group were 50%, 57.1%, and 75%, respectively; however, the rates of survival without major morbidities for infants born at 24, 25, and 26 weeks in the DR-CC group were 0%. Survival rates differed statistically between the DR-CC group and the no-DR-CC group at 29 and 30 weeks ($p = 0.001$ and $p < 0.001$, respectively), but not in other gestational age groups. No difference in survival without major morbidities was found within any gestational age group by DR-CC status.

In the DR-CC groups, survival rates didn't significantly differ by gestational age ($p = 0.57$), but survival without major morbidities did ($p = 0.001$).

Table 1 – Antepartum and delivery room characteristics in preterm infants of <32 weeks gestational age who did or did not receive delivery room chest compressions.

Variable, n (%)	DR-CC group (*n* = 112)	No–DR-CC group (*n* = 1963)
Antepartum		
Maternal age > 36 years	23(20.53)	306(15.58)
Maternal age < 18 years	0(0.00)	9(0.45)
PROM > 24 h	7(6.25)	285(14.51)
Maternal clinical chorioamnionitis	9(8.03)	134(6.82)
Gestational diabetes	17(15.17)	312(15.79)
Gestational hypertension	20(17.85)	288(14.67)
Fetal distress	16 (14.28)	141(7.18)
Multiple gestations	30(26.78)	462(23.53)
Oligohydramnios	1(0.89)	14(0.71)
Polyhydramnios	10(8.92)	139(7.08)
Placental abruption	5(4.46)	87(4.43)
Complete antenatal steroid treatment	25(22.32)	839(42.74)
Delivery room		
Gestational age, weeks, median (IQR)	28(27, 30)	30(28, 31)
Gestational age of less than 28 weeks	37(33.03)	261(13.29)
Sex, Male	68(60.71)	1146(58.38)
Birth weight, g, median (IQR)	1155(991, 1395)	1400(1150, 1600)
Small for gestational age	12(10.71)	138(7.03)
Cesarean	59(52.67)	1073(54.66)
Meconium contamination of amniotic fluid	4(3.57)	35(1.78)
T-piece use in the delivery room	9(8.03)	263(13.39)
Pulmonary surfactant use in the delivery room	2(1.78)	30(1.52)

DR-CC, delivery room chest compression; PROM, premature rupture of membrane; IQR, interquartile range.

Table 2 – The treatment-related variables and complications in preterm infants of <32 weeks gestational age who did and did not receive delivery room chest compressions.

Variable, n (%)	DR-CC group (*n* = 112)	No–DR-CC group (*n* = 1963)	RR(95%CI)	*P*-value
Noninvasive respiratory support initial	79(70.53)	1784(90.88)	0.23(0.15, 0.36)	< 0.001
CPAP initial	56(50)	1361(69.3)	0.442(0.302, 0.448)	< 0.001
NIPPV initial	9(8)	247(12.6)	0.607(0.303, 1.215)	0.155
BiPAP initial	9(8)	116(5.9)	1.391(0.686, 2.820)	0.358
HFNC initial	5(4.5)	54(2.8)	1.652(0.647, 4.215)	0.289
NHFOV initial	0(0)	6(0.3)	–	0.558
Invasive respiratory support	93(83)	759(38.7)	7.732(4.682, 12.711)	< 0.001
Pulmonary surfactant	86(76.8)	1070(54.5)	2.745(1.755, 4.295)	< 0.001
ECMO	0(0)	5(0.3)	–	0.751
iNO	4(3.6)	29(1.5)	2.464(0.851, 7.134)	0.198
Caffeine therapy	82(73.2)	1395(71.1)	1.113(0.724, 1.710)	0.625

DR-CC, delivery room chest compression; RR, relative risk; CI, confidence interval; CPAP, continuous positive airway pressure; NIPPV, noninvasive positive pressure ventilation; BiPAP, bi-level positive airway pressure; HFNC, high-flow nasal cannula; NHFOV, noninvasive high-frequency oscillatory ventilation; iNO, inhaled nitric oxide; ECMO, extracorporeal membrane oxygenation.

"Noninvasive respiratory support initial" referred to having received noninvasive respiratory support; "Invasive respiratory support" referred to having received invasive respiratory support.

Factors influencing survival without major morbidities in the DR-CC group

Further, multivariate analysis showed that after adjusting for variables such as invasive respiratory support, pulmonary surfactant use, and birth weight that differed significantly in the univariate analysis, T-piece use in the DR, gestational age, and noninvasive respiratory support in NICUs were the factors influencing survival without major morbidities in the DR-CC group (Fig. 5).

Discussion

In our cohort study, preterm infants of <32 weeks gestational age receiving DR-CCs had lower survival rates without major morbidities than those without. Among them, higher gestational age, T-piece use in the DR, and noninvasive support influenced survival without morbidities.

Table 3 – The outcome indicators among preterm infants of <32 weeks gestational age who did and did not receive delivery room chest compressions.

Variable, n (%)	DR-CC group	No–DR-CC group	Crude RR (95% CI)	*P*-value	Adjusted RR (95% CI)[a]	*P*-value
Preterm infants of <32 weeks gestational age (DR-CC group *vs.* No–DR-CC group: *n* = 112 *vs. n* = 1963)						
Survival without major morbidities	42(37.50)	1299(66.17)	0.30(0.20, 0.45)	<0.001	0.53(0.31, 0.89)	<0.001
Secondary outcomes						
In-hospital mortality	34(30.35)	213(10.85)	3.58(2.33, 5.49)	<0.001	1.95(1.12, 3.40)	<0.001
Grade 3/4 IVH-PVL	6(5.35)	40(2.03)	2.27(1.12, 6.56)	0.02	2.03(0.79, 5.23)	0.12
BPD (≥moderate)	18(16.07)	180(9.16)	1.89(1.12, 3.21)	0.01	0.96(0.49, 1.87)	1.00
ROP (≥stage 3)	5(4.46)	60(3.05)	1.48(0.58, 3.76)	0.40	1.37(0.51, 3.65)	0.58
NEC (≥stage 2)	3(2.67)	74(3.76)	0.70(0.21, 2.26)	0.55	0.76(0.23, 2.55)	0.86
LOS	18(16.07)	252(12.83)	1.30(0.77, 2.19)	0.32	0.68(0.34, 1.37)	0.18
Grade 3/4 IVH-PVL or death	38(33.92)	244(12.42)	3.61(2.39, 5.47)	<0.001	2.35(1.40, 3.95)	<0.001
BPD (≥moderate) or death	52(46.42)	381(19.40)	3.59(2.44, 5.30)	<0.001	2.02(1.21, 3.37)	0.01
ROP (≥stage 3) or death	39(34.82)	271(13.80)	3.33(2.21, 5.02)	<0.001	2.22(1.33, 3.69)	0.01
NEC (≥stage 2) or death	36(32.14)	279(14.21)	2.85(1.88, 4.33)	<0.001	1.83(1.09, 3.07)	0.04
LOS or death	49(43.75)	436(22.21)	2.72(1.84, 4.01)	<0.001	1.66(1.02, 2.70)	0.03
Preterm infants of < 28 weeks gestational age (DR-CC group *vs.* No–DR-CC group: *n* = 37 *vs. n* = 261)						
Survival without major morbidities	3(8.10)	74(28.35)	0.22(0.06, 0.74)	<0.001	0.23(0.06, 0.80)	0.02
Secondary outcomes						
In-hospital mortality	14(37.83)	78(29.88)	1.42(0.69, 2.92)	0.32	1.28(0.59, 2.77)	0.52
Grade 3/4 IVH-PVL	4(10.81)	17(6.51)	1.74(0.55, 5.48)	0.34	1.58(0.49, 5.07)	0.44
BPD (≥moderate)	12(32.43)	66(25.28)	1.41(0.67, 2.98)	0.35	1.43(0.67, 3.03)	0.35
ROP (≥stage 3)	4(10.81)	16(6.13)	1.85(0.58, 5.88)	0.28	1.90(0.59, 6.06)	0.27
NEC (≥stage 2)	3(8.10)	18(6.89)	1.19(0.33, 4.25)	0.78	1.20(0.33, 4.31)	0.77
LOS	7(18.91)	55(21.0)	0.87(0.36, 2.09)	0.76	0.82(0.34, 1.99)	0.67
Grade 3/4 IVH-PVL or death	16(43.24)	88(33.71)	1.49(0.74, 3.01)	0.25	1.34(0.62, 2.88)	0.44
BPD (≥moderate) or death	26(70.27)	139(53.25)	2.07(0.94, 4.37)	0.05	1.94(0.90, 4.21)	0.09
ROP (≥stage 3) or death	18(48.64)	94(36.01)	1.68(0.84, 3.36)	0.13	1.57(0.75, 3.27)	0.22
NEC (≥stage 2) or death	16(43.24)	93(35.63)	1.37(0.68, 2.76)	0.36	1.25(0.59, 2.62)	0.55
LOS or death	20(54.05)	117(44.82)	1.44(0.72, 2.89)	0.29	1.31(0.63, 2.73)	0.46

DR-CC, delivery room cardiopulmonary resuscitation; RR, risk ratio; CI, confidence interval; BPD, bronchopulmonary dysplasia; NEC, necrotizing enterocolitis; IVH/PVL, intraventricular hemorrhage/periventricular leukomalacia; ROP, retinopathy of prematurity; LOS, late-onset sepsis.

[a] The adjusted covariates were gestation age and birth weight.

Regardless of its necessity in preterm or full-term infants, CC is associated with adverse outcomes. Survival rates are often low among preterm infants of <32 weeks gestational age receiving DR-CCs; this finding is consistent with those reported previously.[4,21] However, owing to the inability to predict which newborns receive CCs and the limited DR-CC use, recent clinical studies have been aimed at determining the best way to perform CCs for newborns to prevent adverse outcomes. Considering the unique physiological characteristics of neonatal cardiac arrest, such as hypoxia/asphyxia, the current chest compressions and ventilation ratio, CC depth, and the most effective oxygen concentration during resuscitation are only based on expert opinions and consensus, and remain controversial.[22] Successful methods for shortening the duration of key resuscitation interventions, such as tracheal intubation and the first adrenaline dose, may help improve the outcomes of DR-CC.[23]

Recently, the survival rate of preterm infants of <32 weeks gestational age has increased; however, improving the quality of life may be more difficult than increasing the survival rate. A multicenter study conducted by a group of 25 Chinese NICUs showed that the survival rate of very low-birth-weight infants was 76.1%, while the survival rate without major morbidities was 54.1%.[24] With treatment advancements, data from the China Newborn Network in 2018 show that the survival rate of preterm infants of <32 weeks gestational age increased to 87.6%, while the survival rate without major morbidities was only 51.8%, indicating no significant increase in the latter.[25] How to improve the survival rate without major morbidities while improving the survival rate has become an important issue of global concern.[26] Our study found that gestational age was an important factor influencing survival without major morbidities in preterm infants receiving DR-CCs. The survival rate of preterm infants aged less than 26 weeks receiving DR-CCs was 54.5%, and the survival rate without major morbidities in this group was 0%. In the DR-CCs groups, survival rates did not significantly vary by gestational age, but survival without major morbidities did. No difference in survival without major morbidities was found within any gestational age group by DR-CC status. The confidence in the non-significant differences was constrained by the small sample size. Additionally, it was also possible that with improvements in asphyxia resuscitation techniques, survival rates were indeed increasing in China. In a study conducted using data from the Canadian Newborn Network over 10–16 years, the survival rate of preterm infants aged less than 26 weeks receiving DR-CCs was 54% and the survival rate without major morbidities was 17.6%.[14] The current survival rate of preterm infants receiving DR-CCs in China is comparable to the levels in developed countries a few years ago. Nevertheless, there remains a significant gap in the survival rate without major morbidities in China compared with developed countries. To ensure the life quality of preterm infants, meticulous management, including prenatal, intrapartum, and postpartum care, is necessary throughout. We hope that with the improvements in neonatal resuscitation technology and

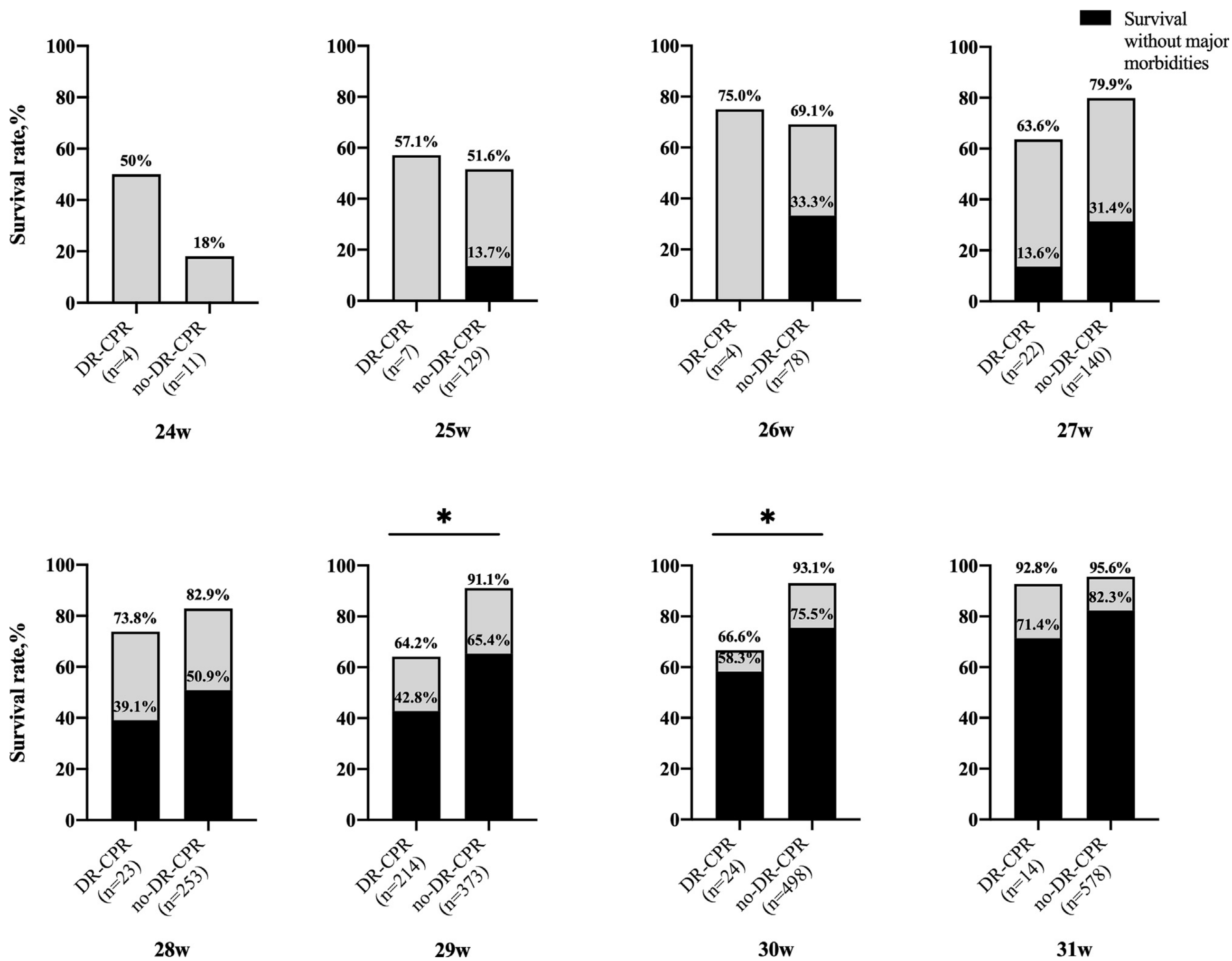

Fig. 4 – The rates of survival and survival without major morbidities of preterm infants who did and did not receive delivery room chest compressions at different gestational ages. DR-CC, delivery room chest compression. The black part represents the survival rate without major morbidities. The grey part represents the survival rate. *Statistically significant difference in survival rates between the DR-CC group and the no-DR-CC group (p < 0.05).

NICU treatment, the life quality of preterm infants receiving DR-CCs will improve.

In the analysis of factors influencing survival without major morbidities in preterm infants receiving DR-CCs, T-piece use in the DR was a significant factor influencing survival without major morbidities at discharge. Transitioning from liquid-filled lungs in non-breathing infants to inflated lungs in breathing infants receives establishing functional residual capacity.[27] Previously, the resuscitation bag-valve-mask was commonly used during resuscitation in the DR, but now T-piece resuscitators are recommended as an alternative due to their advantages.[28,29] A T-piece resuscitation is ideal for precise airway pressure control, especially for preterm infants. Bag-valve-mask is versatile but may need extra oxygen adjustment and has unstable pressure. In addition, the T-piece resuscitation decreased intubation rates and diminished the requirement for pulmonary surfactant.[30] Every year in Jiangsu Province, we conduct neonatal resuscitation training and advocate for every maternity ward to be equipped with T-piece devices. One of the objectives of the resuscitation training is to teach individuals at various locations to proficiently use them. In addition, our study also found that providing noninvasive respiratory support to preterm infants of <32 weeks gestational age receiving DR-CCs significantly affects survival without major morbidities, which can be understood as only providing invasive respiratory support being a significant risk factor for mortality/survival with major morbidities. To improve survival without morbidities, preterm infants not intubated should use CPAP or NIPPV immediately after birth. For those on mechanical ventilation in the NICU, shorten ventilation to transition to noninvasive support as soon as possible.[31] Furthermore, with an overall caffeine use rate of 71.1%, the lower usage of caffeine also deserves attention, considering its potential benefits in reducing short-term complications.[32]

This study has some limitations. First, this study did not consider the effects of resuscitation duration and intensity on preterm infants. Second, preterm infants for whom treatment was abandoned or who died in the DR were not included. Third, the size, composition, and immediate availability of the resuscitation team for all deliveries can also be a varying factor among hospitals. Due to the limitation in the number of research centers, unfortunately, it is not feasible

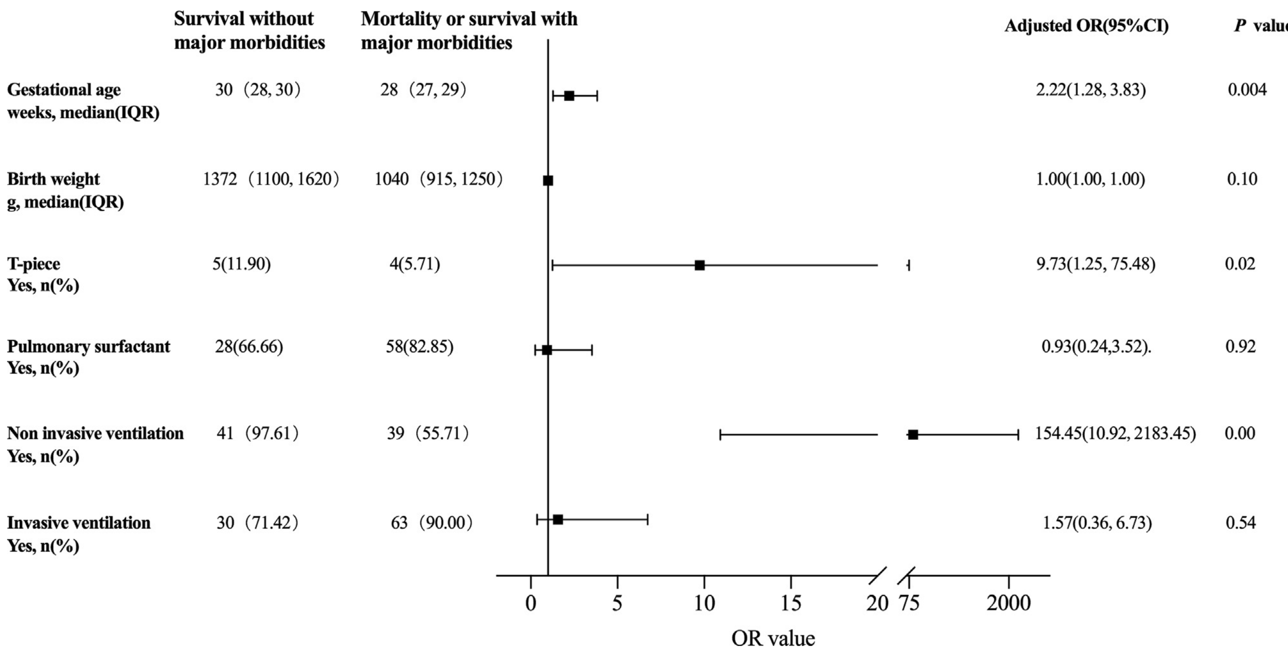

Fig. 5 – Factors influencing survival without major morbidities in preterm infants of <32 weeks gestation age receiving delivery room chest compressions. OR, odds ratio; CI, confidence interval; IQR, interquartile range. The adjusted covariates for the multivariate model were invasive respiratory support, pulmonary surfactant use, and birth weight.

to utilize clustering by site as a covariate in the regression model. In addition, the limited number of participants in all gestational age groups may have contributed to the lack of statistical significance. Finally, no long-term follow-up of nervous system function was conducted.

Conclusions

This was a multicenter cohort study that demonstrated the current clinical landscape of preterm infants (<32 weeks gestational age) receiving DR-CCs. In preterm infants receiving DR-CCs, no survival gap was found across gestation ages, but survival without major morbidities varied. Our findings provide a baseline level for future quality improvement of DR-CCs and comprehensively enhance the quality of treatment for preterm infants.

CRediT authorship contribution statement

Na Wang: Writing – original draft, Methodology, Conceptualization. **Weiwei Hou:** Writing – original draft, Methodology. **Huan Zhou:** Visualization, Investigation. **Shuping Han:** Visualization, Investigation. **Shanyu Jiang:** Visualization, Investigation. **Zuming Yang:** Visualization, Investigation. **Yan Xu:** Supervision. **Songlin Liu:** Supervision. **Yuting Zhu:** Supervision. **Huaiyan Wang:** Supervision. **Hong Li:** Validation, Software, Data curation. **Xinping Wu:** Validation, Software, Data curation. **Jibing Qiao:** Validation, Software, Data curation. **Daocheng Bao:** Validation, Software, Data curation. **Zhaojun Pan:** Validation, Software, Data curation. **Jinjun Zhou:** Validation, Software, Data curation. **Hongwei Wu:** Validation, Software, Data curation. **Mei Xue:** Validation, Software, Data curation. **Mengzhu Yu:** Validation, Software, Data curation. **Haiying Li:** Validation, Software, Data curation. **Zhidan Bao:** Validation, Software, Data curation. **Yan Gao:** Supervision. **Jia Zhang:** Writing – review & editing, Formal analysis. **Rui Cheng:** Writing – review & editing, Funding acquisition, Formal analysis.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2025.100905.

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