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Prognostic factors for in-hospital mortality in neonates with Covid-19: a cross-sectional study in south of Iran

Shahnaz Pourarian[1], Reza Bahrami[1], Raheleh Nemati[1], Khadijeh sadat Najib[1], Razieh Sadat Mousavi-Roknabadi[2*]

[1] Neonatal Research Center, Shiraz University of Medical Sciences, Shiraz, Iran.
[2] Health System Research, Vice-Chancellor of Treatment, Shiraz University of Medical Sciences, Shiraz, Iran.

***Corresponding Author:** Dr. Razieh Sadat Mousavi-Roknabadi, Health System Research, Vice-Chancellor of Treatment, Shiraz University of Medical Sciences, Shiraz, Iran. Address: 5th Floor, Administration Building of Shiraz University of Medical Sciences, Zand St., Shiraz, Iran. PO Box: 71348-14336, Email: mousavi_razieh@sums.ac.ir, Tel: +989131563018.

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Abstract

Introduction: Due to high neonatal, maternal mortality and adverse pregnancy outcome, Covid-19 in neonates is concerned. This study aimed to determine the prognostic factors for in-hospital mortality in neonates with Covid-19.

Methods: This retrospective cross-sectional study (February-November 2020) was performed on infected neonates (<60 days) who were clinically diagnosed as Covid-19 and were hospitalized in Covid-19 wards in Shiraz University of Medical Sciences affiliated hospitals, southern Iran. Data were extracted from the patients' medical files, and were gathered in a data collecting form; including demographic characteristics, laboratory and clinical outcome. The patients were categorized as survivor and non-survivors groups, and then were compared.

Results: Totally, 96 neonates were enrolled. The mean±SD of age was 13.01±10.88 days, and most of them were in the age group of 6-15 days (33.3%). Fifty-nine (61.5%) was male. The mortality rate was 12.5%. Lower gestational age (P=0.031), and the more frequency of having underlying diseases (P=0.010) was observed in non-survivors. The most signs and symptoms were respiratory distress (58.3%), lethargy (46.9%), and poor feeding (37.5%). Pulmonary radiological involvement was more in non-survivors (P<0.001), and it was more severe in these patients (P<0.001). The results of Multivariate Logistic Regression Model showed that only receiving IVIG (OR=20.2, P<0.001) was the independent predictor factor for in-hospital mortality in these patients.

Conclusions: The in-hospital mortality was obtained as 12.5% in the current study, and only receiving IVIG was the independent predictor factor for in-hospital mortality in neonates with Covid-19.

Keywords: Covid-19, Epidemiology, Infant, Mortality, Prevalence, Prognosis.

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Introduction

Since December 2019, a new type of coronavirus, called SARS-CoV-2, the cause of disease named Covid-19, was identified in Wuhan, China, which cause significant challenges to global health[1-3]. Respiratory disorder caused by this virus is the main concern much attention due to its rapid spread and global spread[4,5]. The percentage of mortality varies in different age groups and conditions, but in general. However, due to the high transmissibility, the mortality rate and economic costs associated with patients in communities are significant[6,7].

Some studies suggested that children were less likely to be infected with this virus or their symptoms were so mild that they could not be detected[8]. On the other hand, some studies stated that delivery in mothers infected with Covid-19 should be performed separately, and that neonates should be separated from infected mothers and caregivers[9-12].

Our literature review showed that despite the importance of Covid-19 disease in neonates, limited studies have addressed it, especially in Iran. Therefore, this study aimed to evaluate the prognostic effects of clinical and paraclinical findings on in-hospital mortality in neonates with Covid-19.

Methods

The current retrospective cross-sectional study (February-November 2020) was conducted on all neonates (<60 days), who were clinically diagnosed as Covid-19 and were hospitalized in Covid-19 wards in Namazi and

Hafez Hospital, affiliated to Shiraz University of Medical Sciences, south of Iran. The exclusion criteria were patients with uncompleted or missed medical files. The patients were selected using census sampling methods.

The patients' data were extracted from their medical files and recorded in a data gathering form. It was designed by the researchers according to previous researches. It included three main parts; a) demographic characteristics (including age, gender, type of delivery, gestational age, Apgar score, type of feeding, and maternal employment), b) the neonates and their mothers' clinical and para clinical findings, c) the patients' outcome. Incomplete records were completed via doing an interview or having a telephone call the parents. Acute Care of at-Risk Newborns (ACoRN) criteria were used to assess neonatal lung status, pulmonary involvement in RDS, pulmonary involvement in these patients, and subsequently the patients were divided into three categories: mild, moderate, and severe degree of pulmonary opacity[13].

Data analysis were performed with SPSS version 16.0 for Windows. The normal distribution of quantitative data was evaluated using the Kolmogorov-Smirnov test. Independent sample t or Mann-Whitney test was used for two-group comparisons of continuous variables. Chi-square and Fisher's exact tests were used for proportions. In the Univariate logistic regression analysis, each variable was separately entered. Variables with a P<0.2 from the Univariate analysis were entered into the multivariate logistic regression analysis, using the Enter method to determine predictive factors for in-hospital mortality, and odds ratios (OR) were reported.

To consider the ethical issue, the collected data were not revealed to anyone, except for the researchers; hence, patients' names were kept confidential. The current study was approved and financially supported by the Vice-Chancellor of Research and Technology (grant No. 21941), as well as the Local Ethics Committee of Shiraz University of Medical Sciences (IR.SUMS.MED.REC.1399.439).

Results

Totally, 96 neonates were enrolled. The mean±SD of age was 13.01±10.88 (range; 1, 53) days, and most of them were in the age group of 6-15 days (33.3%). Fifty-nine (61.5%) was male (P=0.76). The mortality rate was 12.5%. Therefore, the patients were categorized in two groups of survivors and non-survivors. As was shown in Table 1, two groups were the same in all demographic characteristics, except gestational age that it was lower in non-survivors (P=0.031). Also, the frequency of having underlying diseases was more in non-survivors (P=0.010).

The most clinical findings at the time of admission were respiratory distress (58.3%), lethargy (46.9%), poor feeding (37.5%), and fever (24%). All the clinical symptoms were similar in both groups. Pulmonary radiological involvement in computed tomography (CT) scan was significantly more in non-survivors (P<0.001), and it was more severe in these patients (P<0.001). As was shown in Table 2, laboratory findings were also similar in both groups of survivors and non-survivors. However, the frequency of positive polymerase chain reaction (PCR) test was more in non-survivors (P=0.010). Also, receiving intravenous immunoglobulin therapy (IVIG) (P<0.001), oxygen (P=0.010), and ventilation (P<0.001) were significantly more in non-survivors.

Univariate Logistic Regression test was applied to determine the prognostic factors of in-hospital mortality in the patients. Gestational age, having underlying diseases, receiving IVIG, and receiving oxygen were entered to Multivariate Logistic Regression Model (Table3).

The results of Multivariate Logistic Regression Model showed that only receiving IVIG (OR=20.2, P<0.001) was the independent predictor factor for in-hospital mortality in neonates with Covid-19 (Table4).

Supplementary Table 1 shows the characteristics of patients with positive Covid-19 PCR test.

Table 1. The demographic characteristics and medical history in neonates with Covid-19

Variables	Total (n=96)	Survivors (n=84)	Non-survivors (n=12)	P-value	95% CI
Age (days)					
(mean±SD)	13.01±10.88	12.64±10.93	15.58±10.63	0.381	-9.69,
Min-max	1-53				3.74
Age groups (days) (%)					
≤5	29 (30.2)	27 (32.1)	2 (16.7)	0.401	-
6-15	32 (33.3)	27 (32.1)	5 (41.7)		
16-25	23 (24.0)	21 (25.0)	2 (16.7)		
26-35	11 (11.5)	8 (9.5)	3 (25.0)		
≥36	1 (1.0)	1 (1.2)	0 (0)		

Variables	Total (n=96)	Survivors (n=84)	Non-survivors (n=12)	P-value	95% CI
Gender (%)					
Male	59 (61.5)	51 (60.7)	8 (66.7)	0.761	-
Female	37 (38.5)	33 (39.3)	4 (33.3)		
Mothers' age (year)					
(mean±SD)	30.40±5.03	30.61±5.13	28.92±4.14	0.281	-1.39,
Min-max	20-42				4.77
Fathers' age (year)					
(mean±SD)	35.47±5.92	35.63±6.03	34.33±5.16	0.481	-2.34,
Min-max	20-50				4.94
Mothers' education (%)					
≤High school diploma	76 (79.2)	67 (79.8)	9 (75.0)	0.711	-
≥Bachelor's degree	20 (20.8)	17 (20.2)	3 (25.0)		
Fathers' education (%)					
≤High school diploma	77 (80.2)	67 (79.8)	10 (83.3)	0.999	-
≥Bachelor's degree	19 (19.80	17 (20.2)	2 (16.7)		
Mothers' job (%)					
Yes	11 (11.5)	11 (13.1)	0 (0)	0.350	-
No	85 (88.5)	73 (86.9)	12 (100)		
Fathers' job (%)					
Yes	96 (100)	84 (100)	12 (100)	-	-
No	0 (0)	0 (0)	0 (0)		
Place of live (%)					
The capital of the province	48 (50)	41 (48.8)	7 (58.3)	0.761	-
City	48 (50)	43 (51.2)	5 (5.2)		
Type of delivery (%)					
Vaginal	34 (35.4)	27 (44.3)	7 (63.6)	0.341	-
Cesarean	38 (39.6)	34 (55.7)	4 (36.4)		
Not determined	24 (25.0)	-	-		
Gestational age (week)					
(mean±SD)	35.55±3.78	38.87±3.60	33.33±4.44	0.031*	0.64, 4.81
Min-max	26-42				
Gestational age groups (week) (%)					
≤28	3 (3.1)	1 (1.2)	2 (16.7)	0.101	-
29-31	19 (19.8)	16 (19.0)	3 (25.0)		
32-35	17 (17.7)	15 (17.9)	2 (16.7)		
36-38	34 (35.4)	30 (35.7)	4 (33.3)		
≥39	23 (24.0)	22 (26.2)	1 (8.3)		
Birth weight (gr)					
(mean±SD)	2526.14±797.31	2575.70±784.23	2179.17±836.27	0.111	-87.83,
Min-max	800-4200				880.91
One-minute Apgar score					
(mean±SD)	7.85±1.52	7.83±1.49	8.0±1.81	0.732	-1.10, 0.77
Min-max	3-10				
Five-minute Apgar score					
(mean±SD)	9.18±1.11	9.19±1.0	9.08±1.78	0.761	-0.60, 0.79
Min-max	4-10				
Type of feeding (%)					
Breastfeeding	63 (65.6)	57 (67.9)	6 (50.0)	0.381	-
Formula	20 (20.8)	16 (19.0)	4 (33.3)		
Mixed	13 (13.5)	11 (13.1)	2 (16.7)		
Having underlying diseases (%)					
Yes	12 (12.5)	7 (8.3)	5 (41.7)	0.010*	-
No	84 (87.5)	77 (91.7)	7 (58.3)		
Mother with Covid-19 (%)					
Yes	12 (12.5)	11 (13.1)	1 (8.3)	0.999	-
No	84 (87.5)	73 (86.9)	11 (91.7)		

* Statistically significant; **CI**: confidence interval; **SD**: standard deviation

Table 2. The clinical findings at the time of admission in neonates with Covid-19

Variables	Total (n=96)	Survivors (n=84)	Non-survivors (n=12)	P-value	95% CI
Signs and symptoms (%)					
Respiratory distress	56 (58.3)	47 (56.0)	9 (75.0)	0.351	-
Lethargy	45 (46.9)	39 (46.4)	6 (50.0)	0.999	-
Poor feeding	36 (37.5)	31 (36.9)	5 (41.7)	0.762	-
Fever	23 (24.0)	21 (25.0)	2 (16.7)	0.733	-
Cough	5 (5.2)	5 (6.0)	0 (0)	0.999	-
Jaundice	4 (4.2)	4 (4.8)	0 (0)	0.999	-
Nausea/vomiting	4 (4.2)	4 (4.8)	0 (0)	0.999	-
Diarrhea	2 (2.1)	2 (2.4)	0 (0)	0.999	-
Seizure	2 (2.1)	2 (2.4)	0 (0)	0.999	-
Cyanosis	1 (1.0)	1 (1.2)	0 (0)	0.999	-
Stomach bleeding	1 (1.0)	1 (1.2)	0 (0)	0.999	-
Nasal congestion	1 (1.0)	1 (1.2)	0 (0)	0.999	-
Skin problems	0 (0)	0 (0)	0 (0)	-	-
Rhinorrhea	0 (0)	0 (0)	0 (0)	-	-
Fetal distress	0 (0)	0 (0)	0 (0)	-	-
Pulmonary radiological involvement (%)					
Yes	49 (51.0)	37 (44.0)	12 (100)	<0.001*	-
No	47 (49.0)	47 (56.0)	0 (0)		
Severity of lung involvement (%)					
Mild	14 (14.6)	14 (16.7)	0 (0)		
Moderate	23 (24.0)	18 (21.4)	5 (41.7)	<0.001*	-
Severe	12 (12.5)	5 (6.0)	7 (58.3)		
Length of hospital stay (day)					
(mean±SD)	17.47±18.20	16.66±17.15	23.27±24.75	0.260	-18.24, 5.01
NICU admission (%)					
Yes	86 (89.6)	47 (88.1)	12 (100)	0.351	-
No	10 (10.4)	10 (11.9)	0 (0)		
Laboratory findings (mean±SD)					
WBC (10^9/L)	10.69±5.85	10.66±4.98	10.92±10.44	0.891	-3.86, 3.35
Hemoglobin (g/dL)	13.28±2.57	13.42±2.50	12.29±2.97	0.160	-0.44, 2.70
Neutrophil (%)	51.08±14.81	51.34±15.42	49.24±9.73	0.650	-7.01, 11.21
Lymphocyte (%)	42.73±14.70	43.31±14.18	38.71±18.10	0.311	-4.40, 13.60
Platelets (mL)	277.53±150.05	273.85±133.26	303.33±284±43	0.552	-126.66, 67.68
CRP (mg/L)	19.64±33.82	19.06±32.41	23.68±43.98	0.660	-25.42, 16.20
Covid-19 PCR test (%)					
Positive	12 (12.5)	7 (8.3)	5 (41.7)	0.010*	-
Negative	84 (87.5)	77 (91.7)	7 (58.3)		
Treatments (%)					
Antivirals	0 (0)	0 (0)	0 (0)	-	-
Antibiotics	82 (85.4)	72 (85.7)	10 (83.3)	0.691	-
Corticosteroids	1 (1.0)	0 (0)	1 (8.3)	0.130	-
IVIG	13 (13.5)	5 (6.0)	8 (66.7)	<0.001*	-
Surfactant	16 (16.7)	12 (14.3)	4 (33.3)	0.110	-
Symptomatic therapy	26 (27.1)	21 (25.0)	5 (41.7)	0.301	-
Oxygen	39 (40.6)	30 (35.7)	9 (75.0)	0.010*	-
Ventilator	37 (38.5)	25 (29.8)	12 (100)	<0.001*	-
Type of feeding (%)					
Oral feeding	74 (77.1)	66 (78.6)	8 (66.7)	0.460	-
Tube feeding	22 (22.9)	18 (21.4)	4 (33.3)		

* Statistically significant; **CI**: confidence interval; **CRP**: C-reactive protein; **IVIG**: intravenous immunoglobulin therapy; **NICU**: neonatal intensive care unit; **PCR**: Polymerase chain reaction; **SD**: standard deviation; **WBC**: white blood cell.

Table 3. Univariate Logistic Regression test

Variables	β	SE	OR	P-value	95% CI	
					Lower	Lower
Gestational age	-0.17	0.08	0.85	0.040	0.73	0.99
Having underlying diseases	2.01	0.71	7.86	0.010	1.97	31.36
Pulmonary radiological involvement	20.08	5862.75	5239.73	0.999	0.0	0.0
Receiving IVIG	3.45	0.77	31.6	<0.011	7.03	141.97
Receiving oxygen	1.67	0.70	5.4	0.022	1.36	21.48
Receiving ventilator	20.47	5232.68	7754.27	0.999	0.0	0.0

CI: confidence interval; IVIG: Intravenous Immunoglobulin Therapy; OR: odd's ratio; SE: standard error.

Table 4. Multivariate Logistic Regression Model

Variables	β	SE	OR	P-value	95% CI	
					Lower	Lower
Gestational age	-0.36	0.34	0.70	0.290	0.36	1.36
Having underlying diseases	0.94	0.98	2.58	0.331	0.38	17.47
Receiving IVIG	3.01	0.81	20.2	<0.001*	4.18	98.89
Receiving oxygen	0.83	0.93	2.29	0.370	0.37	14.16

* Statistically significant; CI: confidence interval; IVIG: Intravenous Immunoglobulin Therapy; OR: odd's ratio; SE: standard error.

Discussion

Since the beginning of the COVID-19 pandemic, 19 experts have provided recommendations for high risk groups, including pregnant women, neonates, and children. Studies have shown that children and neonates had milder symptoms, faster recovery, and better prognosis than adults[14]. To date, advanced interventions have been taken around the world to prevent the spread of this viral disease. However, due to the abnormality of the symptoms of this disease in neonates and children and the predictability of its transmission between family members, more efforts should be made to protect this high-risk population. Although there is currently no direct evidence of vertical transmission (pregnant to infant), the rescue of infected pregnant neonates during delivery should not be delayed[15]. The present study evaluated the factors affecting in-hospital mortality of 98 neonates, who were clinically diagnosed as Covid-19 and were hospitalized in Covid-19 wards in main hospitals in south of Iran.

In the current study, the mean±SD of length of hospital stay was obtained as 17.47±18.20 days, and 12.5% patients were died in the hospitals. The reported mortality rate was different in similar previous studies. Ng et al. stated that all 70 neonates and neonates with Covid-19 were discharged[16]. Also, the results of a meta-analysis by Bhuiyan et al. revealed that among 1,214 children younger than five years with laboratory-confirmed Covid-19, only one patient was died[17]. A study by Khera et al. showed that Covid-19 mortality rate is U-shaped in childhood, which is initially decreases, reaching the minimum at the ages 3-10 years, and then increases throughout life[18]. In the Karabay et al.' systematic review, no infant mortality due to Covid-19 were reported, and only one death occurred because of prematurity[19]. No death were reported in Liu et al.'s study, which was conducted on 19 neonates born to mothers with Covid-19[9]. In a study by Mamishi et al. on 24 children under 10 years of age, the mortality rate was reported as 12.5% [20]. In adults, Jangjou et al. reported a mortality of 9.3% in hospitalized patients with confirmed Covid-19[21]. Also, this rate was stated as 16% in Mousavi et al.'s study[22]. In the study of Meo et al., the mortality rate was informed as 4.8% [23]., an d it was reported as 11% in Chen et al.[24], and 28% in Zhou et al.'s studies[25]. However, a meta-analysis by Li et al. showed that the overall mortality rate was 5.6% among patients with Covid-19[26]. The cause of the difference in Covid-19 mortality rate between different studies can be due to the various population with different sampling methods and study design, influence of genetics

and nutrition of individuals, as well as the study period time.

Most of previous studies did not pay attention to the underlying disease in neonates. In the present study, 12.5% neonates had the underlying disease such as metabolic disease, asphyxia, the fissure between the trachea and esophagus, and bladder exstrophy. Prematurity did not cause any deaths in our study, while in the studies by Panahi et al. [27] and Karabay et al. [19], the reason of both neonates' deaths was prematurity. Furthermore, the results of a study by Moeller et al. showed that children with asthma and cystic fibrosis are at higher risk for Covid-19[28]. Also, in the current study, it was found that the frequency of having underlying diseases and lower gestational age were more in non-survivors neonates. It seems that paying special attention to the past medical history neonates and their symptoms associated is necessary for better patients' management.

In this study, the most clinical findings at the time of admission were respiratory distress, lethargy, poor feeding, and fever. All the clinical symptoms were similar in both groups. No fatal distress was observed in Liu et al.'s study[9]. Developed fever and lower respiratory tract involvement were reported as 63% and 50% of neonates and neonates with Covid-19, respectively, in Ng et al.'s study[16]. Karabay et al. showed that the most common clinical manifestations of Covid-19 in neonates were respiratory problems and fever, respectively. Also, 50% of neonates showed some gastrointestinal symptoms such as diarrhea, malnutrition, and abdominal distention[19]. In the meta-analysis by Bhuiyan et al, 43% of children under five years with Covid-19 in were asymptomatic[17]. Panahi et al. reported dry cough and fever as the most common symptoms in in newborns and pediatrics with Covid-19[27]. The most common presenting symptoms were fever, dry cough, tachypnea, abdominal pain, and vomiting in Mousavi et al.'s study[22]. The most clinical symptoms at the time of admission were dyspnea and cough in the study Jangjou et al. which was conducted on adults' patients with Covid-19. In their study, all symptoms were similar in both groups of survivors and non-survivors, except fever, which was more in non-survivors[21]. In another study on adults, the most common clinical symptoms were fever, cough, and fatigue[29]. Fever and cough were the most common symptom in Wei et al.'s study[30]. Cao et al., reported that the most prevalent clinical findings were fever, cough, shortness of breath, myalgia or fatigue, and respiratory distress in a meta-analysis[31].

It was mentioned by Zhen-Dong et al. that chest CT findings are less severe than those for adults[14]. However, one of the strength of the current study is that CT scan findings were assessed, which were less found in previous similar studies. Pulmonary radiological involvement was observed in 51% of patients, which were significantly higher in non-survivors, and it was more severe in these patients in the current study. Mamishi et al. reported that typical pulmonary involvement was found in 25% of patients, and 58% of patients showed pulmonary involvement as atypical findings. They stated that high rate of an atypical form of pulmonary involvement may indicate a more accurate assessment for pediatric involvement in the pandemic and use more sensitive diagnostic and clinical criteria by pediatricians[20].

Totally, 89.6% of neonates were admitted in NICU. In Smith et al.'s study, 76.92% of neonates with Covid-19 needed NICU admission[32]. Moeller et al. showed that among the nine children with bronchopulmonary dysplasia and Covid-19, two were admitted to a pediatric intensive care unit (PICU) requiring invasive ventilation[28]. Zhou et al. showed that 26% of adult patients with Covid-19 were admitted to the intensive care unit (ICU), which was significantly higher in non-survivors[25]. However, the frequency of ICU admission in the patients of both groups was not significantly different in our survey. Also, the results of the current study revealed that 100% of patients with NICU admission died. In the study by Auld et al., the mortality rate of adult patients with ICU admission was reported as 33.9%, which was lower than our obtained result. This rate was informed as 50-67% in other previous studies on adults[33,34].

As was shown in the present study, out of 96 neonates with clinically diagnosis of Covid-19, who had typical disease symptoms, only 12 patients had a positive pharyngeal PCR test. This issue indicates a high probability of false-negative results of test in neonates. Despite the positive tests of 12.5% of mothers, in this study, virus's vertical transmission was not evaluated. Although this frequency was statistically similar in both groups; it raised the possibility of vertical transmission in pregnant mothers and shows the need for further studies. It indicates two aspects: 1) there is a possibility of false negatives in the babies born to these mothers, 2) if the negative PCR test of their babies are actual, the vertical transmission is broadly raised; as in the Run-Ming et al.'s study was discussed[14]. However, Bhuiyan et al. reported that of 139 newborns from Covid-19 infected mothers, 3.6% were Covid-19 positive[17].

We found that receiving IVIG, oxygen, and ventilation were significantly more in non-survivors, which indicated more severe disease in non-survivors. Also, the results of Multivariate Logistic Regression Model showed that only receiving IVIG was the independent predictor factor for

in-hospital mortality in neonates with Covid-19, which could increase in-hospital mortality. There are controversy in administration of IVIG in patients with Covid-19. Tabarsi et al. concluded that the use of IVIG in combination with hydroxychloroquine and lopinavir/ritonavir in treatment of severe Covid-19 patients are not beneficial[35]. On the other hand, Sakoulas et al. stated that IVIG significantly improved hypoxia and reduced hospital length of stay and progression to mechanical ventilation in Covid-19 patients with A-a gradient >200 mm Hg[36]. Also, Pourahmad et al. found that IVIG is a favorable options low side effects and risks for prevention and treatment of patients with Covid-19[37]. However, the results of a review by Moradimajd et al. showed that there are many limitations in evaluating clinical improvements using IVIG therapy in patients with Covid-19, and it is not possible to make a correct judgment on the therapeutic effect of IVIG in these patients and needs clinical trials[38].

The current study had some positive points, such as assessing clinical and para clinical (such as laboratory, pharyngeal swabs and radiological) findings in all neonates, who were clinically diagnosed as Covid-19. Moreover, this study was multi-central research, and using the results of the current study can be effective in physicians' clinical decisions. Despite these strengths, this study also had some limitations. The retrospective nature of the study, lack of recording all data accurately, and lack of follow-up of discharged patients were among the limitations of this study. Since the continued spread of this disease and new mutations in the virus' genetics, and transmission power, there is a greater tendency for children and neonates to become involved. Hence, performing prospective surveys with emphasis on new variants such as New English, Indian, African, and American ones, on larger population and assessing other factors, especially the effect of vaccination, as well as the drug doses and their complications are recommended.

Conclusion

The results of this study revealed that that respiratory distress, lethargy, poor feeding, and fever were the most common symptoms in neonates with Covid-19. Also, it was showed that neonates who have an underlying disease are more at risk for this disease. The in-hospital mortality was obtained as 12.5%, and only receiving IVIG was the independent predictor factor for in-hospital mortality in these patients.

Ethics approval and consent to participate

The current study was conducted in accordance with the Declaration of Helsinki, and it was approved by the vice-chancellor of research and technology, as well as the local ethics committee of Shiraz University of Medical Sciences (IR.SUMS.MED.REC.1399.439). To consider the ethical issue, the collected data were not revealed to anyone, except for the researchers; hence, patients' names were kept confidential.

This was a retrospective cross-sectional study, which was conducted on patients' medical files. Therefore, informed consent was not required for this survey. To consider the ethical issue, the collected data were not revealed to anyone, except for the researchers; hence, patients' names were kept confidential.

Research Highlights

What Is Already Known?

- Covid-19 causes significant challenges to global health.
-Some studies suggested that children are less likely to be infected with Covid-19 or their symptoms were so mild that they could not be detected.
-Limited studies have addressed Covid-19 in neonates, especially in Iran.

What Does This Study Add?

- The in-hospital mortality was obtained as 12.5% in neonates with Covid-19.
- Only receiving IVIG was the independent predictor factor for in-hospital mortality in these patients.

Human and animal rights

No animals/humans were used for the studies that are the basis of this research.

Consent for publication

Not applicable.

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Competing interests

The authors have no conflicts of interest to declare for this study.

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Authors' contributions

SP and RB contributed to supervision, conception, and design. SP, RB, RN, KN and RSM contributed to the search literature and related studies. SP, RB, RN, and KN contributed to data acquisition. RN and RSM contributed to data analysis. All authors contributed to write the first draft of the manuscript, reviewed and edited it. All authors approved the final version of the manuscript.

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List of abbreviations

CI: confidence interval
CRP: C-reactive protein
CT: Computed tomography
ICU: Intensive care unit
IVIG: Intravenous immunoglobulin therapy
NICU: neonatal intensive care unit
OR: Odds ratio
PCR: Polymerase chain reaction
SE: Standard error
SD: Standard deviation
WBC: white blood cell

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