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RESEARCH

Impact of transport outcomes of outborn newborns with critical congenital heart disease on surgery time and mortality rates

Kritik konjenital kalp hastalığı olan yenidoğanların nakil sonuçlarının ameliyat süresi ve mortalite oranlarına etkisi

Tugay Tepe[1], Ahmet İbrahim Kurtoğlu[1], Hacer Yapıcıoğlu Yıldızdaş[1], Mustafa Özdemir[1], Nejat Narlı[1], Ferda Özlü[1], Sevcan Erdem[1], İlker Ünal[1]

[1]Cukurova University, Adana, Turkey

Abstract

Purpose: Transport of neonates with critical congenital heart disease (CCHD) necessitates professional and experienced staff and, well-equipped facilities for both the procedure and post-operative care. In this study, we aimed to evaluate the effect of transport on operation time and survival in neonates with CCHD and determine the relationship between transport characteristics and clinical status.

Materials and Methods: A retrospective cross-sectional cohort study was conducted on all infants with CCHD who were transported to a university hospital between January 1, 2019 and December 31, 2019. Transport characteristics such as transport distance, accompanying healthcare provider, vital signs, oxygen saturation levels, prostaglandin E1 (PGE) use, and respiratory support were recorded. The effects of transport characteristics on surgery time, complications, and mortality were analyzed. The Society of Thoracic Surgeons-European Association for Cardio-Thoracic Surgery (STAT) Score was used to analyze mortality-related risks for congenital heart disease. They were compared with inborn newborns with CCHD.

Results: A total of 55 patients with CCHD were evaluated. Thirty-one newborns (56.4%) were inborn (Inborn group), and 24 newborns (43.6%) were transferred from another center (Outborn group). There was no difference between the groups in terms of gender, gestational age, birth weight, pre-operative time, and hospital stay. Although the Outborn group had fewer STAT Score categories, there was no difference in the 30-day survival or mortality rates. In the Outborn group, five patients (20.8%) with duct-dependent CCHD were transported without PGE treatment and six duct-dependent (25%) patients received oxygen during transport inappropriately.

Öz

Amaç: Kritik konjenital kalp hastalığı (KKKH) olan yenidoğanların nakli, profesyonel ve deneyimli personelin yanı sıra hem girişim hem de ameliyat sonrası bakım için tam donanımlı tesisler gerektirir. Bu çalışmada, KKKH olan yenidoğanlarda naklin, ameliyat süresi ve sağ kalım üzerine etkisini değerlendirmeyi ve nakil özellikleri ile klinik durum arasındaki ilişkiyi belirlemeyi amaçladık.

Gereç ve Yöntem: Üniversite hastanesine 1 Ocak 2019 ile 31 Aralık 2019 tarihleri arasında nakledilen tüm KKKH olan bebekler üzerinde retrospektif kesitsel bir kohort çalışması gerçekleştirildi. Nakil mesafesi, eşlik eden sağlık çalışanı, vital bulgular, oksijen satürasyon seviyeleri, prostaglandin E1 (PGE) kullanımı ve solunum desteği gibi nakil özellikleri kaydedildi. Nakil özelliklerinin ameliyat süresi, komplikasyonlar ve mortalite üzerindeki etkileri analiz edildi. Konjenital kalp hastalığı için mortalite ile ilişkili riskleri analiz etmek için Göğüs Cerrahları Derneği-Avrupa Kardiyo-Torasik Cerrahi Derneği (STAT) Skoru kullanıldı. Bu hastalar hastanemizde doğan KKKH'lı yenidoğanlarla karşılaştırıldı.

Bulgular: Toplam 55 kritik konjenital kalp hastalığı tanılı hasta değerlendirildi. Otuz bir yenidoğan (%56,4) hastanemizde doğdu (Hastane grubu) ve 24 yenidoğan (%43,6) başka bir merkezden transfer edildi (Hastane dışı grup). Gruplar arasında cinsiyet, gebelik yaşı, doğum ağırlığı, ameliyat öncesi süre ve hastanede kalış süresi açısından fark yoktu. Hastane dışından gelen grupta daha az ciddi STAT skor kategori hastası olmasına rağmen, 30 günlük sağkalım veya ölüm oranlarında fark yoktu. Hastane dışı grubunda, duktus bağımlı KKKH olan beş hasta (%20,8) PGE tedavisi uygulanmadan nakledilmiş ve duktus bağımlı altı hastaya (%25) nakil sırasında uygunsuz şekilde oksijen verilmişti.

Address for Correspondence: Tugay Tepe, Cukurova University Faculty of Medicine, Department of Pediatrics, Division of Neonatology, Adana, Turkey E-mail: drtugaytepe@yahoo.com
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Conclusion: The administration of PGE and oxygen therapies to specific transported infants was inappropriate. Therefore, referral or transport team members should be familiar infants with CCHD. The impact of transport on surgical timing did not yield a significant effect. However, similar mortality rates were observed in both groups, despite the Outborn group demonstrating lower STAT scores. This may indicate the significance of referring intrauterine transportation to experienced cardiovascular centers.

Keywords: Critical congenital heart disease, neonate, transport

Sonuç: Nakledilen bazı bebekler uygun olmayan PGE ve oksijen tedavileri almıştır. Bu nedenle, sevk veya nakil ekibi üyeleri KKKH hakkında bilgi sahibi olmalıdır. Nakil işleminin cerrahi zamanlama üzerindeki etkisi anlamlı bulunmamıştır. Bununla birlikte, hastane dışında doğan grubun daha düşük STAT skorları göstermesine rağmen, her iki grupta da benzer ölüm oranları gözlenmiştir. Bu durum, intrauterin naklin deneyimli kardiyovasküler merkezlere yönlendirilmesinin önemine işaret edebilir.

Anahtar kelimeler: Kritik konjenital kalp hastalığı, yenidoğan, nakil

INTRODUCTION

Congenital heart disease (CHD) is the most commonly diagnosed congenital anomaly worldwide, with a prevalence of approximately 8 to 12 per 1000 lives [1]. Critical CHD (CCHD) incidence that requires advanced cardiac evaluation is reported to be between 2.5 and 3 per 1000 live births [2]. CCHD is defined as a disease requiring surgery or catheter-based intervention in the first year of life [3]. Although most of patients with CCHD are diagnosed prenatally, some are diagnosed after birth only after they develop symptoms. Morbidity and mortality rates are lower in newborns with planned delivery in advanced centers with experienced perinatal teams and with early administration of prostaglandin E1 (PGE) and maintenance of systemic and pulmonary blood flow[3–8].

Transport of infants with CCHD is an essential part of the chain of care because it ensures rapid access to centers for specialized cardiac surgery, which has a substantial impact on patient outcome. Effective transport systems are essential for increasing survival rates and decreasing CCHD-related morbidity[9]. Moreover, advances in neonatal critical care have highlighted the importance of referring facilities, transport teams, and receiving centers with specialized knowledge and resources to work together effectively.

Pediatric cardiac surgery requires skilled and experienced staff and facilities well-equipped for both the procedure and postoperative care. Facilities without a dedicated cardiovascular surgery unit or the ability to provide suitable conditions refer patients to specialized centers. The transport of neonates with CCHD is organized by 112 emergency command centers in Turkey. Most often, paramedics accompany the patients; however, general practitioners or nurses can be involved in the transport team as needed. Our hospital is a pediatric cardiac surgery center consisting of maternal-fetal medicine specialists, pediatric cardiologists, pediatric cardiac surgeons, and neonatologists. Neonates with suspected or diagnosed CCHD from an external center are referred prenatally or postnatally for cardiac intervention.

We evaluated the effects of transport characteristics on clinical status, survival, and surgery time in neonates with CCHD from external centers. Additionally, to investigate the potential effects of transport, this study compared mortality rates based on the operative risk scores of newborns born at our hospital versus those born at an external facility.

MATERIALS AND METHODS

Study design

A retrospective cross-sectional cohort study of all newborn infants with CCHD born or referred to a university hospital, was performed between January 1, 2019 and December 31, 2019. This study was approved by the Ethics Committee of the Medical Faculty at Cukurova University (Approval number 2022-125). Informed consent was obtained from the legal guardians. This study was conducted in accordance with the Declaration of Helsinki. This study was conducted at the neonatal care units of Cukurova University Balcali Hospital. Our hospital has a pediatric cardiac center that serves approximately 10 provinces in the southern part of Turkey. The neonatal intensive care unit (NICU) has 36 incubators and meets the specific needs of both surgical and medical patients. The Turkish Neonatology Association guidelines and Ministry of Health grading system were used to identify the NICU levels as level 3, level 2, and level 1. Infants at

high risk were monitored at level 3 and those at moderate and mild risk at the second and first levels, respectively [10]. All deliveries were attended to by a resident or a neonatologist. Neonates with CCHD are followed in the NICU during both the pre-operative and post-operative periods with the collaboration of pediatric cardiologists and pediatric surgery teams.

Patient population

Infants with CCHD were defined as those with duct-dependent systemic and pulmonary circulation, aortic arch anomalies, transposition of great arteries (TGA), truncus arteriosus, pulmonary atresia/stenosis, tetralogy of Fallot with pulmonary atresia, Ebstein's anomaly, and hypoplastic left heart syndrome. 10 newborns were excluded as eight of them had missing transport data and two had life-threatening congenital abnormalities.

Newborns born in our hospital and those transported from the delivery room to the neonatal unit and hospitalized for CCHD were defined as the Inborn group, and newborns transferred from other centers were defined as the Outborn group. Prenatal diagnosis, echocardiography results, admission day, hospital stay, surgery time, and demographic data were recorded. All infants were reevaluated by pediatric cardiology after admission. Echocardiographic findings were grouped as left-sided obstructive lesions, such as hypoplastic left heart syndrome, coarctation of the aorta, interrupted aortic arch, or aortic atresia; right-sided obstructive lesions, such as pulmonary atresia/stenosis, tetralogy of Fallot with pulmonary atresia, and Ebstein's anomaly; and parallel circulations, such as transposition of the great arteries and truncus arteriosus. Duct-dependent lesions were hypoplastic left heart syndrome, coarctation of the aorta, or interrupted aortic arch for left-sided obstructive lesions; tetralogy of Fallot with pulmonary atresia, pulmonary atresia, pulmonary atresia with truncus arteriosus, major aortopulmonary collateral arteries with truncus arteriosus, and pulmonary atresia or pulmonary atresia with transposition of great arteries for right-sided obstructive lesions; transposition of great arteries or double-outlet right ventricle with transposition of great arteries for parallel circulations. The transposition of the great arteries or double-outlet right ventricle with transposition of the great arteries depended on the ductus arteriosus for parallel circulation.

Data collection

The transport characteristics of outborn newborns, including transport distance, companion healthcare provider, vital signs during transport and arrival, oxygen saturation levels, PGE administration, and ventilator support, were recorded. Data were recorded at the time of admission to the unit in the Inborn group and at the time of admission to the emergency department in the Outborn group. The Society of Thoracic Surgeons-European Association for Cardio-Thoracic Surgery (STAT) Score is a validated tool designed to assess the mortality risk associated with congenital heart surgery interventions. The lowest mortality rates are in Category 1, whereas the highest mortality rates are in Category 5. STAT Score was used to analyze mortality-associated risks for congenital heart disease [11]. Additionally, the Vasoactive Inotropic Score (VIS) formula was recorded as dopamine dose (g/kg/min) + dobutamine dose (g/kg/min) + 100 x epinephrine dose (g/kg/min) + 10 x milrinone dose (g/kg/min) + 10,000x vasopressin dose (U/kg/min) + 100x norepinephrine dose (g/kg/min) for 72 h after surgery, and the highest value was used for analysis[12]. Mortality was defined as death during hospitalization. Cases with incomplete transport information, life-threatening extracardiac abnormalities, or non-critical CHD were excluded.

Statistical analysis

Categorical variables were expressed as numbers and percentages, whereas continuous variables were summarized as mean and standard deviations and as the median and interquartile range (IQR) where appropriate. Fisher's exact test's or Pearson's chi-square test was used to compare categorical variables between groups, depending on whether the expected value problem was present or not. The normality of the distribution of continuous variables was confirmed using the Shapiro-Wilk test. For the comparison of continuous variables between the two groups, the Student's t-test or Mann–Whitney U test was used depending on whether the statistical hypotheses were fulfilled or not. For the univariate analysis, event-free survival was calculated using the Kaplan–Meier method, and a log-rank test was performed. The Statistical Package for Social Sciences software version 20.0 (SPSS Inc., Chicago, Illinois, USA) was used for the statistical analysis. The statistical level of significance for all tests was considered 0.05.

RESULTS

Patient characteristics

Sixty-five neonates were diagnosed with CCHD during the study period. Ten newborns were excluded because eight of them had missing transport data and two had life-threatening congenital abnormalities. Of 55 newborns, 31 (56.4%) were in the Inborn group, and 24 (43.6%) were in the Outborn group.

The rate of prenatal diagnosis was higher in the Inborn group compared with Outborn (n:30, 96.8% vs n:12, 50%, p=0.001). Most of the patients in the Outborn group were diagnosed by a pediatrician (58.3%), (p=0.029). There were no significant differences between the groups in terms of gender, birth weight, or gestational age (p>0.05). The number of cesarean sections was higher in the Inborn group (p=0.035). There was a significant difference between the groups in terms of the type of cardiac defect (p = 0.047). Left and right obstructive lesions were more common in the Inborn group. The characteristics of the congenital cardiac lesions are shown in Table 1. Outborn patients were admitted on average eight days after birth, whereas all patients in the Inborn group were admitted on the first day of life (p<0.001). 20 newborns (64.5%) in the Inborn group and 20 newborns (83.3%) in the Outborn group underwent cardiac surgery (p= 0.120). The duration of preoperative hospitalization and the length of hospital stay were similar (Table 2).

Transport results

Twenty-four outborn neonates were transported during the study. Of these, six were accompanied by a doctor, six by a paramedic, and 12 by a nurse. These patients were transported from locations with a median distance of 54 (10–195) km. All thirty-one newborns at our hospital had a prenatal diagnosis, except for one who was identified as having a cardiac murmur in the obstetric ward. They were all accompanied by a pediatric resident.

There were no significant differences in oxygen saturation, pulse rate, systolic and diastolic pressure, and body temperature between the groups during transport (Table 3). In addition, there were no significant differences between vital signs and oxygen saturation levels during transport and at admission in the Outborn group (p>0.05). In terms of respiratory support, the Outborn group had more patients who needed oxygen supply. (p=0.001). The Outborn group had higher rates of invasive ventilation (10 (41.7%) vs 6 (19.4%) p=0.071), whereas the Inborn group had more noninvasive ventilation (11 (35.5%) vs 1 (4.2%) p=0.005).

Table 1. Characteristics of congenital cardiac lesions in the Inborn and Outborn groups

	Inborn (n=31)	**Outborn (n=24)**
Left-sided obstructive lesions	10 (32.2%)	2 (8.3%)
Hypoplastic left heart syndrome	6	1
Aortic atresia	3	-
Coarctation of the aorta	1	1
Right-sided obstructive lesions	17 (54.8%)	8 (33.3%)
Fallot with pulmonary atresia	3	-
Tetralogy of Fallot	6	2
Pulmonary atresia	6	5
Cardiac teratoma	1	-
Ebstein's anomaly	1	1
Parallel circulations	2 (6.5%)	10 (41.6%)
TGA	2	7
Truncus arteriosus	-	3
Other	2 (6.5%)	4 (16.6%)
DOLV	1	1
DORV	1	3

Data are presented as frequency (%); TGA, transposition of the great arteries; DOLV, double outlet left ventricle; DORV, double outlet right ventricle

Table 2. Comparison of demographic data

Variable	Inborn (n=31)	Outborn (n=24)	P value
Male gender, n[a]	17 (45.5%)	16 (54.5%)	0.116
Birth weight, kg[d]	2.7±0.55	2.8±0.55	0.583
Gestational age, weeks[d]	37.6±1.6	38.1±2.1	0.421
Caesarian section, n[a]	25 (80.6%)	14 (54.2%)	**0.035**
Prenatal diagnosis, n[b]	30 (96.8%)	12 (50%)	**0.001**
First diagnosed by, n[a]			
Obstetrician	22 (71%)	10 (41.7%)	**0.029**
Pediatrician†	9 (29%)	14 (58.3%)	
Age at admission, days[c]	0 (0-0)	8 (2-20)	0.000
LOS, days[c]	12 (6-35)	14 (7-20)	0.899
Preoperative LOS, days[c]	4 (0-7)	4 (2-11)	0.524
Operation, n[a]	20 (64.5%)	20 (83.3%)	0.120
The type of cardiac defect, n[b]			
Left-sided obstructive lesions	10 (32.2%)	2 (8.3%)	
Right-sided obstructive lesions	17 (54.8%)	8 (33.3%)	**0.047**
Parallel circulations	2 (6.5%)	10 (41.6%)	
Other	2 (6.5%)	4 (16.6%)	

† The prenatal diagnosis performed by pediatric cardiology was included in the pediatrician group; Data are presented as mean (± SD), median (IQR), or frequency (%); Categorical variables were evaluated using an [a] X^2 test and a [b] Fisher test; The variables were analyzed using the [c] Mann-Whitney U test and, the [d] Student's t-test
LOS, length of hospital stay

PGE infusion was administered to 19 (61.2%) infants in the Inborn group and 14 (58.3%) infants in the Outborn group (p>0.05). Six newborns (46.2%) in the Outborn group with PGE infusion received oxygen supply during transport, whereas no patients in the Inborn group received oxygen during PGE infusion (p=0.001). There were 5 (35.7%) duct-dependent neonates (3 patients with TGA, 2 patients with pulmonary atresia) in the Outborn group without PGE infusion, although they were diagnosed before transport. Table 3 summarizes the transport characteristics of the two groups.

Blood gas values obtained on admission to the NICU are shown in Table 4. The two groups showed significant differences in pH, PCO2, and HCO3 levels (p<0.05).

Table 3. Characteristics of neonates during transport

	Inborn (n=31)	Outborn (n=24)	P value
Transport distance, km[a]	0 (0-0)	54 (10-195)	**0.000**
NICU level at referral, n[d]			
Level-I	0 (0%)	1 (4.2%)	
Level-II	0 (0%)	1 (4.2%)	0.186
Level-III	31 (100%)	22 (91.7%)	
Intubation, n[c]	6 (19.4%)	10 (41.7%)	0.071
CPAP, n[d]	11 (35.5%)	1 (4.2%)	**0.005**
SPO_2 levels, %[b]	85±10	87±9	0.371
Pulse, bpm[b]	149±12	149±21	0.966
Systolic blood pressure, mmHg[b]	73±12	72±10	0.662
Diastolic blood pressure, mmHg[b]	38±10	39±8	0.677
Temperature, °C[b]	36.1±0.5	36.2±0.3	0.343
PGE, n[c]	19 (61.2%)	14 (58.3%)	0.437
Apnea, n[d]	3 (9.7%)	2 (8.3%)	1
Oxygen supply, n[d]	1 (3.2%)	9 (37.5%)	**0.001**

Data are presented as mean (± SD), median (IQR), or frequency (%)
The variables were analyzed using a [a] Mann-Whitney U test and, [b] Student's t-test ; Categorical variables were evaluated using the [c] X^2 test and the [d] Fisher test; CPAP, continuous positive airway pressure; PGE, prostaglandin E1

Table 4. Biochemical parameters reflecting the cardiorespiratory status at admission

Variable	†Inborn (n=31)	Outborn (n=24)	P value
Venous pH[a]	7.26±0.11	7.33±0.11	**0.028**
PCO2, mm Hg[a]	56.8±12.5	48.3±18.3	**0.046**
PO2, mm Hg[a]	40.5±10	43±19.8	0.539
HCO3, meq/L[a]	20.3±4.14	24±5.28	**0.006**
Base excess[b]	-2 (-6.2/-0.6)	-2 (-3.7/1.8)	0.188
Lactate, mmol/l[b]	2.9 (2.4/5.1)	3 (2/4.1)	0.377
Glucose, mg/dL[b]	67 (55/87)	76 (67/95)	0.126

†Biochemical parameters obtained in the first 1 h of life in the Inborn group
Data are presented as mean (± SD), median (IQR), or frequency (%)
Variables were analyzed using by [a] Student's t-test and [b] Mann-Whitney U test

Parameters after admission and mortality variables

Ventilatory support, inotrope, and PGE use in the first 72 h of admission were similar between the groups, as shown in Table 5. VIS of patients who were operated on or underwent angiography was similar in both groups; however, severe STAT mortality categories (categories 4 and 5) were higher in newborns operated on or underwent angiography in the Inborn group (p=0.01), (Table 5). The 30-day survival and mortality rates were similar.

Mortality variables

Transport distance in the Outborn group was not different in newborns who were discharged or did not survive during hospitalization (105 (IQR 10–190) km vs. 188 (IQR 12–365) km), (p=0.234). In the Inborn group, ventilator support during the first 72 h after admission was higher in newborns who died (p=0.005); and in the Outborn group, inotrope use in the first 72 h after admission was higher in newborns who did not survive (p=0.050) (Table 6).

Table 5. Parameters that may affect mortality

	Inborn (n=31)	Outborn (n=24)	P value
Ventilatory support†, n[a]	17 (54.8%)	9 (37.5%)	0.201
Inotropes†, n[b]	4 (12.9%)	4 (16.7%)	0.718
PGE†, n[a]	20 (64.5%)	12 (50%)	0.279
STAT mortality category, n[b]			
Category 1	0 (0%)	1 (4.2%)	
Category 2	2 (6.5%)	8 (33.3%)	**0.010**
Category 3	1 (3.2%)	0 (0%)	
Category 4	12 (38.7%)	11 (45.8%)	
Category 5	5 (16.1%)	0 (0%)	
VIS score‡[c]	23 (0-58)	18 (0-38)	0.651
Mortality, n[a]	13 (41.9%)	7 (29.2%)	0.329
30-day survival, n[a]	19 (61.3%)	17 (70.8%)	0.681

† During the first 72 h after admission; ‡ Among patients who underwent surgery or angiography
Data are presented as mean (± SD), median (IQR), or frequency (%); Categorical variables were evaluated using an [a] X^2 test, and a [b] Fisher test; Variables were analyzed using the [c] Mann-Whitney U test ; PGE, prostaglandin E1; STAT, Society of Thoracic Surgeons-European Association for Cardio-Thoracic Surgery; nVIS, vasoactive inotropic score

Table 6. Mortality variables

	Discharge	Mortality	P value
Inborn	(n=18)	(n=13)	
Ventilatory support†, n[a]	6 (33.3%)	11 (84.6%)	**0.005**
Inotropes†, n[b]	1 (5.6%)	3 (23.1%)	0.284
PGE†, n[b]	10 (55.6%)	10 (76.9%)	0.275
STAT mortality category‡, n[b]			
Category 4	8 (44.4%)	4 (30.8%)	0.257
Category 5	1 (5.6%)	4 (30.8%)	
VIS score‡[c]	22 (0-58)	42 (0-60)	0.441
Outborn	(n=17)	(n=7)	
Transport distance, km[c]	105 (10–190)	188 (12–365)	0.234
Ventilatory support†, n[b]	5 (29.4%)	4 (57.1%)	0.356
Inotropes†, n[b]	1 (5.9%)	3 (42.9%)	**0.050**
PGE†, n[b]	7 (41.2%)	5 (71.4%)	0.371
STAT mortality category‡, n[b]			
Category 2	7 (41.2%)	1 (14.3%)	0.546
Category 4	7 (41.2%)	4 (57.1%)	
VIS score‡[c]	16 (0-30)	38 (0-90)	0.147

† During the first 72 h after admission; ‡ Among patients who underwent surgery or angiography
Data are presented as mean (± SD), median (IQR), or frequency (%); Categorical variables were evaluated using an [a] X^2 test, and [b] Fisher test; The variables were analyzed using the [c]Mann-Whitney U test, the [d] Student's t-test; PGE, prostaglandin E1; STAT, Society of Thoracic Surgeons-European Association for Cardio-Thoracic Surgery; VIS, vasoactive inotropic score

DISCUSSION

In this study, we have shown that the transport of neonates with CCHD did not lead to differences in survival, the timing of surgery, or the length of hospital stay in our NICU. In addition, we found that invasive ventilator support and oxygen exposure rates were significantly higher in the Outborn group during transport. Although there were no significant differences between the groups for 30-day survival and mortality rates, STAT scores showed that there were more severe cases of CCHD in the Inborn group. Furthermore, no significant differences were noted between the groups in terms of length of hospital stay, pre-operative hospital stay, and operation time, except for the duration of admission. We believe that a later transfer of the Outborn group to the hospital may affect mortality rates. Infants in the Outborn group would have a better chance of survival if preoperative stabilization and transport were more timely and in better clinical conditions.

Transport of infants with CCHD should be performed more carefully and by competent healthcare professionals[9]. Inadequate transportation is a major challenge in the healthcare system faced by neonates in low- and middle-income countries[13]. While physicians were more common as accompanying healthcare professionals in the Inborn group, nurses were more prevalent in the Outborn group. We did not find significant differences between the groups in terms of intubation, SPo2 levels, systolic and diastolic blood pressure, body temperature, and administration of PGE during transport. Furthermore, patients who received oxygen while receiving PGE support during transport and duct-dependent patients who did not receive PGE infusion in the Outborn group during transport revealed that the transport team should be trained in terms of CCHD. Failure to maintain adequate hemodynamics until transport to the cardiac center may lead to clinical deterioration. Although blood gas analysis was poor in the Inborn group, we believe that this was due to the early postnatal adaptation period in the Inborn group. The need for inotropic support in the post-transport period in the Outborn group, which is associated with mortality, may be an indicator of inadequate support before referral.

Despite advances in fetal echocardiography, the incidence of prenatal diagnosis of CCHD remains inadequate. Levey et al. showed that the rate of prenatal diagnosis was only 67% for all CHDs[14]. Eckersley et al. reported that the expected fatality rate does not exceed 40% when CHD is diagnosed before the baby is discharged[15]. The benefits of prenatal diagnosis include a low rate of ventilator support or inotropes, less pre-operative acidosis, and less end-organ dysfunction[14,16–18]. In addition, it may improve

pre-operative clinical status and decrease perinatal mortality[19]. However, previous investigators have observed that a lack of prenatal diagnosis did not lead to differences in the length of stay and survival in CHD[16,20,21]. Recent research has demonstrated that early identification, rapid referral, and timely intervention improve the survival of a significant majority of newborns with CCHD[22]. In our study, the rates of prenatal diagnosis were higher in the Inborn group. The initial diagnosis was made by obstetricians in the Inborn group, whereas pediatricians made the first diagnosis in the Outborn group. However, we believe that the mortality rate could have been lower if the rate of prenatal diagnosis had been increased in the Outborn group. As a result, the STAT categories of these patients were less severe.

Adverse reactions during transport, such as hypoglycemia and hypothermia, and an increased need for cardiorespiratory support are associated with high mortality rates [23,24]. Yaeger et al. showed no significant difference in the rate of adverse incidents based on the distance of transport [25]. Similarly, we did not find any association between transport distance and mortality in the Outborn group. In addition, no significant difference was found in oxygen saturation, pulse rate, systolic and diastolic pressure, or body temperature between the groups at admission. Episodes of apnea were similar among the groups. In both groups, only one patient received inotropic support during transport. Invasive ventilation and oxygen exposure rates were higher in the Outborn group. At admission, blood glucose levels in both groups were within the normal range. Although lactate levels were high in both groups and no significant difference was found, the age at admission for the Outborn group was 8 (2–20) days. It can be postulated that patients in the Outborn group may be exposed to hypoperfusion or hypoxemia in terms of elevated lactate levels before admission.

It is critical to maintain ductal patency to ensure systemic or pulmonary blood flow for obstructed outflow lesions in patients with CCHD. PGE infusion is crucial for managing duct-dependent cardiac defects [26]. In our study, PGE infusion was initiated in 14 infants with duct-dependent CCHD in the Outborn group and was used inadvertently in six patients. In the Inborn group, PGE infusion was initiated in 19 patients, and only one patient required PGE infusion after hospitalization. We found no association between invasive ventilator support and PGE infusion during transport between the groups. However, the presence of patients who received oxygen support with PGE and those with ductus-dependent CHHD who did not receive PGE during transport in the Outborn group were considered to be misconceptions.

This is a single-center study and the study size is limited. Furthermore, the lack of detailed clinical information regarding neonates transferred to our hospital from referral centers was a limitation. Furthermore, no information was obtained from the delivery room. One limitation of this study is the heterogeneity of cardiac defects among the compared patients. Another limitation is that different scoring methods could be used to evaluate the effect of transport that can assess physiological status after transport, such as the Transport Risk Index of Physiologic Stability (TRIPS) score or the SNAP score (Score For Neonatal Acute Physiology). Unfortunately, these scoring methods could not be applied due to the lack of data.

Neonates with CCCH require careful intervention from the moment of birth, in the ward, or during transport. Despite the increased availability of prenatal and postnatal diagnostic options for newborns with CCHD, the transport of babies to advanced cardiac surgery centers is of greater importance. The establishment of regionalized pediatric cardiac surgery centers could enhance survival rates in patients with CCHD, while also offering a well-trained and organized transport team.

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