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Factors associated with neonatal cardiac surgery outcomes

Factores asociados con resultados de cirugía cardiaca neonatal

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ABSTRACT

Introduction: *neonatal cardiac surgery has evolved remarkably in recent years. However, it continues to be a challenge due to morbidity and mortality in this group of patients; since not only the type of heart disease influences but also the factors of this group such as the immaturity of the organs, weight, gestational age among others. Objective: to know which are the main associated factors that influence the results of surgical procedures in this group.* ***Material:*** *we carried out a descriptive, cross-sectional study where we evaluated the main factors associated with surgical results in the neonatal stage. Results: a total of 233 patients were evaluated, of which 59.7% correspond to the male gender. Main factors that were associated with mortality were the transfer time greater that 10 days with mortality of 68% (p = 0.005), the time in thar surgery was performed in the five-day group (p = 0.000) and critical heart disease with a mortality of 81% (p = 0.000). Conclusions: it is necessary to improve prenatal care, transfer times and planning the time of surgical intervention for the adequate care of these patients.*

Keywords: congenital heart disease, neonatal cardiac surgery, postoperative complications, risk factors, surgical outcomes.

RESUMEN

Introducción: *la cirugía cardiaca neonatal ha evolucionado notablemente en los últimos años. Sin embargo, continúa siendo un reto por la morbilidad y mortalidad en este grupo de pacientes; ya que no solo influye el tipo de cardiopatía sino también los factores propios de este grupo como la inmadurez de los órganos, peso, edad gestacional entre otros.* ***Objetivo:*** *conocer cuáles son los principales factores asociados que influyen en los resultados de los procedimientos quirúrgicos en este grupo.* ***Material:*** *realizamos un estudio descriptivo, transversal donde evaluamos los principales factores asociados a los resultados quirúrgicos en la etapa neonatal.* ***Resultados:*** *se evaluaron un total de 233 pacientes de los cuales el 59.7% corresponden al género masculino. Los principales factores que se asociaron a mortalidad fueron el tiempo de traslado mayor a 10 días con una mortalidad del 68% (p = 0.005), el tiempo en que se realizó la cirugía en el grupo de cinco días (p = 0.000) y las cardiopatías críticas con una mortalidad del 81% (p = 0.000).* ***Conclusiones:*** *se requiere mejorar la atención prenatal, tiempos de traslado y planeación del tiempo de intervención quirúrgica para la atención adecuada de estos pacientes.*

Palabras clave: *cardiopatías congénitas, cirugía cardiaca neonatal, complicaciones postoperatorias, factores de riesgo, resultados quirúrgicos.*

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Congenital heart defects constitute the most prevalent category of congenital anomalies, with moderate to severe variants manifesting in approximately six per 1,000 live births. Patients afflicted with critical congenital heart defects typically necessitate therapeutic intervention within the first 24 hours of life.[1] Notwithstanding the dramatic evolution of neonatal cardiac surgery over the past 50 years, which has yielded satisfactory outcomes, it is widely acknowledged that this subspecialty remains exceptionally challenging due to the inherent surgical complexity and the intrinsic fragility of the patients' immature physiological systems.[2] Moreover, the availability of human resources and infrastructure for perioperative care exerts a profound influence on outcomes.[3] It is established that discrete, modifiable factors exist which warrant targeted attention to optimize the care of these patients, with a view to mitigating morbidity and mortality. The primary objective of this study was to identify and assess the modifiable factors impacting surgical outcomes within this patient cohort, with the overarching goal of enhancing the quality of cardiac surgical care afforded to them.

MATERIAL

We conducted a descriptive, cross sectional study of newborns who required cardiac surgery at our center. We assessed the impact of gestational age, weight, transfer time and age at which the surgical procedure was performed. Outcomes included mortality and length of stay in the neonatal intensive care unit. We recorded medians, maximums and minimums for continuous and for numerical variables percentages.

RESULTS

Demographic characteristics

A total of 233 patients were admitted, of whom 39.9% were female. The mean age at diagnosis was 20 days and their weight were 2,500 grams. Patients were divided into two groups based on weight with the over 2 kg group predominating at 62.2%: premature patients accounted for 35.6%. The main demographic characteristics are listed in *Table 1*.

Clinical characteristics

The most common heart disease was ductus arteriosus (38.6%) and the least common was Tetralogy of Fallot (0.8%). Critical heart disease accounted for 61.3% the most common of which was pulmonary atresia, followed by coarctation of the aorta. As this is a referral hospital, some patients were transferred from other units, with a median transfer time of 13 days. Patients were divided into two groups based on transfer time with a predominance of more than 10 days in 56.2%. The median time to surgical procedure was four days.

Surgical characteristics

Corrective surgery was performed in 78.1% of the patients of whom 23.6% required cardiopulmonary bypass. The mean time of aortic cross clamping was 42 minutes, and the time of cardiopulmonary bypass was 113. The mean length of stay was 51 days; patients were divided into two groups based on length of stay, with the group with a length of stay greater than 15 days predominating at 95.7%. Overall mortality was 18.09% of which 81.8% were due to critical heart disease *(Table 2)*.

Associations

Associations were performed to assess the main factors influencing surgical outcomes at this stage. The three main factors associated with mortality were transfer time greater than 10 days, corresponding to 68.1% ($p = 0.005$), the time at which surgery was performed (45% of those who underwent surgery more than five days before the procedure) ($p = 0.005$); and the type of heart disease, with critical heart disease accounting for 81% ($p = 0.000$) of those who died. Neither gestational age nor weight influenced surgical outcomes. Patients weighing less than 2 kg or premature patients who died accounted for 29%.

DISCUSSION

Neonatal surgical capabilities have undergone substantial advancements in recent decades; however, the morbidity and mortality associated with certain surgical procedures remain elevated, thereby posing a significant challenge.

Table 1: Demographic characteristics.

Variable	n (%)
Gender	
Male	139 (59.7)
Female	93 (39.9)
Age at diagnosis (days), mean [IQR]	20 [1-35]
Weight (grams), mean [IQR]	2,500 [780-4,830]
Weight group	
Less than 2 kg	88 (37.8)
More than 2 kg	145 (62.2)
Height (cm), mean [IQR]	44 [31-59]
Premature	83 (35.6)

IQR = interquartile range.

Table 2: Surgical characteristics.

Variable	n (%)
Type of surgery	
Palliative	51 (21.9)
Corrective	182 (78.1)
Extracorporeal circulation	55 (23.6)
Surgical characteristics, mean [IQR]	
Aortic cross clamping time (min)	42 [34-142]
Extracorporeal circulation time (min)	113 [98-208]
Circulating arrest time	34 [22-47]
Bleeding (ml)	14 [8-22]
In-hospital stay (days), mean [IQR]	51 [2-120]
In-hospital stay group	
Less than 15 days	10 (4.3)
Greater than 15 days	223 (95.7)

IQR = interquartile range.

A multitude of studies have investigated the identification of independent factors that exert a profound influence on outcomes subsequent to neonatal cardiac surgery. One of the most extensively scrutinized factors has been gestational age at the time of surgical intervention, inasmuch as both prematurity and congenital heart disease constitute two leading determinants of mortality and disability during the perinatal period.[4] In a study by Lass et al.,[5] the authors proffer the conclusion that premature birth is associated with an approximate fourfold augmentation in mortality risk for neonates afflicted with congenital heart disease, with this excess mortality being circumscribed to premature infants under 35 weeks of gestation. However, this study neglects to specify the particular type of cardiac pathology manifesting within the study population, nor does it adequately control for other prematurity-related factors that may potentially confound the results. Our own results failed to discern a significant correlation between gestational age and mortality, with only 29% of the patients in our series who succumbed corresponding to premature individuals. Furthermore, within this subgroup, a mere four patients presented with critical cardiac disease. Consonant results are observable in the study by Savorgnan et al.,[6] wherein the authors analyzed patients spanning 34 to 36 weeks of gestation and ascertained that this cohort exhibits a heightened mortality risk vis-à-vis patients exceeding 36 weeks of gestation. The authors so far as to posit that this factor ought to be duly considered during the planning of cardiac surgical interventions, ultimately concluding that premature patients do not incur a higher mortality risk post-cardiac surgery compared to term-born counterparts. The paramount finding, however, was that gestational age should be regarded as a potentially salient factor associated with surgical outcomes and may constitute a critical consideration in the planning of cardiac interventions. As previously elucidated within the context of our study, gestational age did not emerge as a significant factor associated with mortality, a finding that is consonant with the conclusion proffered by Shin,[7] which avers that while the incidence and mortality rates of critical cardiac disease are indeed higher in premature infants relative to full-term counterparts, the determinants underpinning this risk remain obscure and may be inextricably linked to factors such as birth weight, the presence of comorbidities attendant to prematurity, and the therapeutic regimen itself.

Advances in surgical techniques and the technological refinement of the cardiopulmonary bypass pump have culminated in enhanced survival rates, even for the most diminutive patients. Notwithstanding these advancements, the confluence of low birth weight, congenital heart disease, and prematurity continues to pose a formidable management challenge. Birth weight has historically been scrutinized as an independent predictor of outcomes. In the present study, we failed to discern a significant association between low birth weight and mortality amongst patients necessitating cardiac surgical intervention. This finding is consonant with the study undertaken by Curzon et al.,[8] who retrospectively reviewed the surgical experience in neonates undergoing either palliative or corrective procedures. Their analysis revealed that infants weighing less than 2.5 kg incurred a significantly higher mortality risk, albeit exclusively in surgical procedures necessitating extracorporeal circulation pump support, stratified according to RACHS-1 risk levels two through six and Aristoteles complexity levels two through four. In a 2014 study, Kalfa et al.[9] assessed the impact of birth weight on mortality in neonatal patients, concluding that while weight constitutes a factor in early mortality, this association is not inherently linked to the surgical procedure per se. However, their study underscores that the most pivotal factor influencing outcomes is the presence of a multidisciplinary team dedicated to the provision of specialized neonatal cardiac care.

As a tertiary referral center, our institution assumes the responsibility of treating not only neonates born within our own hospital, but also those referred from external regional hospitals and even from other states. Consequently, one of the variables we undertook to scrutinize was transfer time, which emerged as a principal factor associated with mortality within our study cohort. The mean transfer time was 13 days, with a maximum duration of up to 29 days. For the purposes of statistical analysis, we dichotomized the patient population into two subgroups, with 56.2% of patients falling within the cohort exceeding 10 days of age, which manifested a mortality rate of 68.1% ($p = 0.0053$). Notably, we were unable to identify any extant literature that specifically assesses this factor. However, the timing of surgical intervention, which is inextricably linked to transfer time, has been subjected to

prior scrutiny. Within our own study, the timing of surgery emerged as a significant determinant of mortality, owing to its robust association with this outcome. The timing of surgical intervention constitutes a potentially modifiable variable; however, it has not been subjected to rigorous evaluation.[10] In the study by Anderson et al.,[11] the authors reported that advanced age at the time of surgery was significantly correlated with augmented morbidity and heightened cost. They further elucidated that the association between morbidity and age was negative on or before the third day of life, whereas a positive correlation obtained the third day of life. Kang et al.[12] reported a significant relationship between age and mortality was ascertained ($p = 0.0002$). These results stand in contrast to those shown by Padley et al.[13] and Kumar et al.,[10] wherein no significant association was discerned between mortality and age at the time of surgical intervention. However, it is crucial to underscore that the mean temporal interval at which surgical intervention was undertaken within our center was 17 days, with a maximum duration of up to 32 days, whereas the extant literature reports a maximum mean interval of 10 days. Consequently, it is patently evident that, within our series, the timing of surgical intervention constitutes a determinative factor for mortality, which is inextricably linked to the transfer time to our unit. Finally, another factor associated with mortality within our series is the presence of complex cardiac disease, which accounted for 81.8% of the total number of patients who succumbed; however, the majority of these patients were transferred within the subgroup exceeding 10 days of age. In the study conducted by Smith et al.,[14] the authors analyzed a cohort of 2,536 neonates from 47 hospitals and ascertained that non-urgent surgical procedures undertaken between days two and seven were not associated with mortality; however, delays in the timing of surgery may potentially augment the cost of preoperative resources.

Survival rates for neonatal surgery have undergone substantial improvements as a direct consequence of advancements in surgical techniques and perioperative management; however, significant morbidity persists as a formidable challenge. The precision with which mortality factors are measured is rendered questionable, insofar as the results typically exhibit a wide range of variability. The ultimate objective of this study, consonant with numerous analogous investigations, is to identify modifiable factors that may be leveraged to enhance surgical outcomes and mitigate morbidities within this patient population. However, the care of these patients is inherently complex, necessitating due consideration of concomitant genetic syndromes, non-cardiac anatomical abnormalities, and preoperative factors such as circulatory support and mechanical ventilation, among others.[15] Furthermore, it is axiomatic that the success of inpatient centers and cardiovascular health institutes within our country is contingent not only upon the attainment of favorable surgical outcomes, but also upon the presence of a robust support infrastructure that furnishes the requisite resources for accurate diagnosis and informed preoperative decision-making.[2] As Dr. Jacqueline Noonan astutely observed: *"*Pediatric cardiology has always necessitated a multidisciplinary team comprising pathologists, physiologists, cardiologists, surgeons, intensivists, interventionalists, and anesthesiologists, all of whom play an indispensable role in the treatment of children afflicted with congenital heart disease".[16]

Limitation of the study: this is a single center where the results were analyzed some factors such as transfer time, the time in which the surgery is performed are not totally dependent of the surgical and cardiology team.

CONCLUSIONS

The three most important factors associated with mortality in our series were a transfer time of more than 10 days, critical heart disease and a surgical time of more than five days after hospital admission. To improve these factors must be modified in our state's care measures for these patients:

1. Improve prenatal care for these patients, attempting to schedule delivery in institutions where some type of procedure can be performed and coordinate with the surgical team for timely care of these patients.
2. Reduce travel time for patients born outside our institution.
3. Although we are in the process of achieving this goal our institution still needs to establish a truly united multidisciplinary team that can work together with optimal patient outcomes as its sole objective.

We hope this study will serve as the basis for many large-scale projects in the future.

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