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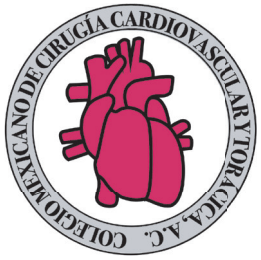

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EDITORIAL
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Simultaneous heart-kidney transplant in patients with extracorporeal life support as a bridge to transplantation: *"Non Semper ea sunt quae videntur, argumentum ad ignorantiam"*

Trasplante corazón-riñón simultáneo en pacientes con soporte vital extracorpóreo como puente a trasplante: "Non Semper ea sunt quae videntur, argumentum ad ignorantiam"

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Keywords: kidney transplant, heart transplant, organ transplants, extracorporeal membrane oxygenation, venoarterial extracorporeal membrane oxygenation.

Palabras clave: *trasplante renal, trasplante cardiaco, trasplante de órganos, oxigenación de membrana extracorpórea, oxigenación de membrana extracorpórea venoarterial.*

Abbreviations:
CKD = chronic kidney disease
ECMO = extracorporeal membrane oxygenation
ESRD = early end stage renal disease
LVADs = durable left ventricular assist devices
OPTN = Organ Procurement Transplantation Network
SHK = Simultaneous heart-kidney transplant
tMCS = temporary mechanical circulatory support
UNOS = United Network for Organ Sharing

Combined heart-kidney transplant was initially described in 1978 by Norman et al., who supported a patient experiencing "stone heart syndrome" after valvular surgery using an intracorporeal abdominal left ventricular assist device and dialysis until a suitable donor was identified. The cardiac allograft demonstrated satisfactory function; however, the renal allograft failed to perform adequately, necessitating continued dialysis post-transplant, and ultimately, the patient succumbed to sepsis on postoperative day 15.[1]

End-stage heart failure frequently coincides with renal dysfunction due to the interdependent nature of these organ systems. Simultaneous heart-kidney transplant (SHK) has shown success for select patients. Selection criteria for SHK are complex, highly nuanced, and continually evolving. Challenges persist in distinguishing patients whose renal impairment may be reversible following heart transplant from those with intrinsic advanced kidney disease, for whom SHK offers the most benefit.

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In 2019, a conference held in Boston, Massachusetts, focused on SHK brought together experts to develop candidate evaluation guidelines. The workgroup recommended that a transplant nephrologist assessment should occur when the glomerular filtration rate (GFR) is < 45 ml/min/1.73 m^2, as measured independently at least twice over two weeks. SHK may be considered for patients with GFR < 30 ml/min/1.73 m^2, as well as for those with GFR between 30-44 ml/min/1.73 m^2 accompanied by strong indicators of chronic kidney disease, such as reduced kidney size or persistent proteinuria > 0.5 g/day, assessed individually.[2]

Furthermore, due to variability in SHK listing practices, the United Network for Organ Sharing (UNOS) implemented explicit allocation criteria and a safety net policy in September 2023. This policy seeks to promote equitable distribution of scarce donor organs by defining specific degrees and durations of renal dysfunction required for heart transplant candidates to qualify for SHK listing. It also ensures prioritization for candidates not eligible for simultaneous kidney transplant if severe renal dysfunction persists post-heart transplant. The guidelines stipulate a 90-day evaluation period for chronic kidney disease (CKD) patients and a six-week period for acute kidney injury cases.[3]

In October 2018, Organ Procurement Transplantation Network (OPTN) introduced a modified heart allocation system to better stratify medically urgent candidates and reduce geographic disparities in donor heart access. Recent studies report reduced waitlist times, unchanged waitlist mortality, and comparable survival for recipients under this new system, although heart-kidney candidates were excluded.[4,5]

Over the past decade, the annual number of SHKs performed has increased more than any other multi-organ transplant type.[6] Francke et al.[7] observed an increase in heart-kidney transplants from 181 to 243 during the 19 months surrounding the policy change, and a significant rise in patients who were bridged to heart transplants alone and multiorgan heart transplants using temporary mechanical circulatory support (tMCS) since the policy revision.[8] Although higher rates of acute kidney injury requiring dialysis have been noted among heart transplant-only recipients, no differences were observed in mortality, allograft survival, or rejection within this cohort.[9] Conversely, patients receiving SHK post-policy change exhibited worsened overall survival and kidney allograft outcomes compared to solitary kidney transplant recipients, with an increased risk of death relative to those receiving a kidney after heart transplantation.[7,10]

The first published study in the heart-kidney population reported inferior one-year post-transplant survival for recipients following the allocation policy change.[11] Francke corroborated these results and found that, prior to the allocation change, heart-kidney recipients had similar one-year survival rates to heart-only transplant recipients. After 2018, no added benefit regarding waitlist death/deterioration and heart transplant was detected, despite shorter waitlist times, and one-year post-transplantation survival was worse for heart-kidney recipients under the revised UNOS policy. Changing practice patterns in heart-kidney transplant post-policy era may have resulted in higher-acuity patients undergoing transplantation. While data by Francke et al.[7] indicated similar medical acuity between SHK and heart-only candidates' post-policy change, Clerkin et al.[12] showed that hemodynamic variables did not predict adverse waitlist or transplantation outcomes in status 2 patients. The increased use of tMCS and venoarterial extracorporeal membrane oxygenation (VA-ECMO) in heart-kidney recipients after the policy change likely reflects a sicker patient profile or evolving center strategies to improve the status of patients with advanced renal disease. These factors may contribute to poorer outcomes.

The work of Feng et al.[13] is of particular note. They examined dual transplant outcomes and highlighted challenges for specific patient groups. Their analysis distinguished SHK patients on VA-ECMO (n = 50) from those not on ECMO (n = 724), noting a gradual increase in the use of extracorporeal membrane oxygenation (ECMO) at the time of transplantation, rising from 2% in 2018 to 6% in 2023. Despite higher rates of temporary dialysis perioperatively among ECMO-supported recipients (56 vs 28%), long-term renal function remained similar between groups, as did rates of chronic dialysis and graft failure at two years. However, cardiac outcomes and overall survival were substantially lower among ECMO-supported patients, with discharge survival rates at 76 vs 92.7%, and two-year post-transplant survival at 71.7 vs 83% ($p < 0.001$ and $p = 0.004$, respectively). Cardiac allograft failure was also higher (10 vs 2.7%), and VA-ECMO use was independently associated with increased mortality and cardiac allograft failure.

Limited alternative therapies for critically ill patients with durable left ventricular assist devices (LVADs) compound the clinical complexity, as studies indicate worse survival and elevated post-transplant dialysis utilization in this group.[14] A comprehensive evaluation must look beyond post-transplant outcomes to consider allocation system constraints and registry data limitations. For example, comparable waitlist mortality between ECMO and non-ECMO patients suggests efficient prioritization for the sickest patients, though this does not account for relevant donor or procedural variables.

The challenge of selecting appropriate SHK candidates on VA-ECMO remains substantial, while predicting renal recovery following heart transplant in patients with chronic kidney disease continues to be difficult. Notably, higher creatinine clearance in the ECMO group raises questions about the contributions of irreversible versus reversible

kidney damage. In light of organ shortages and increasing SHK demand, safety net policies may provide opportunities to balance post-HT kidney recovery against risks associated with delayed transplantation in early end stage renal disease (ESRD) patients. SHK in VA-ECMO-supported individuals is particularly demanding and tends to be associated with less favourable outcomes compared to more stable populations.

Looking ahead, the impact of new OPTN regulations on transplantation and outcomes remains to be fully understood. Stricter criteria for SHK may reduce the pool of heart candidates with moderate-to-severe kidney disease if concerns about early mortality prompt caution among transplant centers. Addressing the needs of patients falling into "GFR limbo"–whose eGFR is insufficiently low for heart-kidney listing but at risk of deterioration following immunosuppression–requires careful consideration.

Future research should analyze variables including ECMO configuration, ambulation, nutrition, complications, donor characteristics (donation after circulatory death versus donation after brain death), organ recovery approach, ischemic time, primary graft dysfunction, and postoperative vasoplegia. Despite recent policy changes, evidence regarding elevated mortality among SHK recipients is inconclusive, and it is imperative to recognize that policy impacts often stem more from behavioral adaptation than from the policies themselves. Nonetheless, given that SHK offers lifesaving therapy for patients on VA-ECMO with ESRD and limited alternatives, these findings should not preclude its use among carefully selected candidates.

"Non Semper ea sunt quae videntur, argumentum ad ignorantiam". Things are not always what they seem.

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ORIGINAL ARTICLE

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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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ORIGINAL ARTICLE

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Prevalence of aortic arch defects in the neonatal period in a reference hospital. Are we achieving optimal results?

Prevalencia de defectos de arco aórtico en el periodo neonatal en un hospital de referencia. ¿Estamos logrando resultados óptimos?

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ABSTRACT

Introduction: coarctation of the aorta and interruption of the aortic arch are frequent pathologies in the neonatal stage, being one of the main causes of cardiogenic shock and death. **Objective:** the objective of this study is to know the frequency, demographic data, management, and surgical results of aortic arch defects in the neonatal period in a period of five years. Material: this is a descriptive, observational, cross-sectional, retrospective, and case series study, from 2019 to 2024. Recording of media, maximum, and minimum was made for continuous numerical variables and for categorical variables the percentage was measured. **Results:** we found a total of 44 patients with predominance in the male gender (56.8%), 11.4% of the cases represent Interruption of the Aortic Arch, the maximum transfer time for management was 18 days in 9.1% of the cases, mortality overall was 13.6%. **Conclusions:** it is common for aortic arch defects in the neonatal period to present as critical heart disease, that is, pathologies that if not detected and treated in time, patients have a high risk of dying in the first ten days of life. It is important to perform an adequate physical examination and cardiological screening for the timely detection and transfer of these patients.

Keywords: aortic coarctation, congenital heart disease, cardiac surgery.

RESUMEN

Introducción: *la coartación de la aorta y la interrupción de arco aórtico son patologías frecuentes en la etapa neonatal siendo una de las principales causas de choque cardiogénico y muerte.* ***Objetivo:*** *el objetivo de este estudio es conocer la frecuencia, datos demográficos, manejo y resultados quirúrgicos de los defectos de arco aórtico en el periodo neonatal en un periodo de cinco años. Material: se trata de un estudio descriptivo, observacional, transversal, retrospectivo y serie de casos, del 2019 a 2024. Se realizó registro de medias, máximos y mínimos para las variables numéricas continuas y para las variables categóricas se midió el porcentaje.* ***Resultados:*** *encontramos un total de 44 pacientes con predominio en el género masculino (56.8%), el 11.4% de los casos representan interrupción de arco aórtico, el tiempo máximo de traslado para manejo fue de 18 días en el 9.1% de los casos, la mortalidad global fue de 13.6%.* ***Conclusiones:*** *los defectos de arco aórtico en el periodo neonatal es común que se presenten como cardiopatías críticas, es decir patologías que si no se detectan y tratan a tiempo los pacientes tienen un alto riesgo de fallecer en los primeros diez días de vida. Es importante realizar una exploración física adecuada y el tamiz cardiológico para la detección y traslado oportuno de estos pacientes.*

Palabras clave: *coartación aórtica, cardiopatía congénita, cirugía cardíaca.*

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Abbreviation:
IAA = interrupted aortic arch

Aortic arch defects are congenital anomalies that frequently manifest with signs of cardiogenic shock during the neonatal period.[1] Coarctation of the aorta accounts for approximately 5 to 7% of all congenital heart defects, with a prevalence of 0.2 per 1,000 live births, occurring predominantly in males.[2,3] Interrupted aortic arch (IAA), characterized by a complete discontinuity between the ascending and descending aorta, has a reported prevalence of 0.03 per 1,000 live births.[4] In 1959, Celoria and Paton introduced a classification system based on the site of interruption relative to the origins of the major branches, dividing IAA into types A, B, and C.[5] During the neonatal stage, these conditions commonly present as critical congenital heart defects, specifically as duct-dependent lesions, whose clinical presentation may mimic neonatal sepsis.[5]

In our state, only a few public hospitals perform cardiac surgery, which frequently leads to significant delays in care for these patients, substantially increasing their mortality.[6]

The aim of this study is to evaluate the surgical outcomes of neonates with aortic arch defects treated at our institution and, indirectly, to assess the time required for their transfer to a surgical center.

MATERIAL AND METHODS

This was a descriptive, observational cross sectional and retrospective study of patients who underwent aortic arch defect repair during the neonatal period at our institution. The study was conducted over a five-year period spanning from 2019 to 2024.

Demographic data, surgical outcome, and postoperative follow up were described. Mean, maximum and minimum values were recorded for continuous numerical variables, and percentages were measured for categorical variables.

Ethical considerations: informed consent was obtained from the patients 'families for the study, and the study was approved by the hospital's ethics committee.

RESULTS

A total of 44 patients were admitted, 56.8% of whom were male. Eleven percent had interrupted aortic arches one of which was type C and two were types A and B, respectively. Twenty-three patients with aortic coarctation were accompanied by other heart conditions, primarily atrial septal defects, ventricular septal defects and bicuspid aorta; three patients had imperforate anus, two had Turner syndrome and three patients with interrupted aortic arch had dysmorphic syndrome.

The mean weight was 3.2 kg with a mean maternal age of 23 years and a mean gestational age of 37 weeks. Demographic data are presented in *Table 1*.

The mean transfer time in days was 12 (P25: 9, P75: 12). Patients were divided into two group gassed on the time: less than 10 days and equal to or greater than 10 days. The first group was found to have only 32.6% of the patients transferred while group 2 accounted for 67.4%. All of the patients with interrupted aortic arch were in the greater than 10 days group.

The mean age at surgery was 15 days (P25: 8, P75: 20). Patients were divided into two groups was 10 days or younger, representing 28.2%, and the second group was 10 days or older, representing 71.7%. The mean weight in kilograms at the time of surgery was 3.2 (P25: 3, P75: 3.5). Regarding clinical presentation 61.4% (N = 27) presented cardiogenic shock.

The preoperative echocardiogram showed a mean gradient of the descending aorta in mmHg of 54 (P25: 45, P75: 65). The left ventricular function measured in percentage was 55 (P25: 43, P75: 67). The mean z scores include aortic valve 1.4, transverse arch 1.8, aortic arch −1.6, coarctation zone −3, and descending aorta 1.9. Echocardiographic values are listed in *Table 2*.

The most common surgical procedure performed was extended end to end cortectomy (50%), and graft placement was the least common (9.1%). However, it was the primary surgical technique for repairing cases with interrupted aortic arch. The mean aortic cross clamping time was 18 minutes, and the surgical time was 161 minutes. All surgical date is presented in *Table 2*. Median sternotomy was performed in patients with interrupted aortic arch and in those with severe aortic arch hypoplasia, which accounted for 16% of patients.

Table 1: Demographic data of the study population.

Variable	Mean [range]
Weight, kg	3.2 [1.9-3.8]
Maternal age, years	23 [16-38]
Weeks of gestation	37 [35-41]
Gender, n	
Male	25
Female	19
Primary diagnosis, n	
Aortic coarctation	39
Interrupted aortic arch	5
Associated heart defects, %	
Bicuspid aortic valve	27.3
Ventricular septal defect	47.7
Atrial septal defect	56.8

WOG = weeks of gestation.

Table 2: Echocardiographic data, intraoperative values, and surgical procedures.

Variable	Mean [range]	Percentiles P25, P50, P75
LVEF (%)	55 [20-80]	43, 56, 67
Z score		
Aortic valve	1.4 [−2.7-2.5]	−2.75, 1.8, 2.07
Transverse arch	1.8 [−2.7-2.5]	−2.2, 1.8, 2.0
Arch	−1.6 [−6-−2.3]	−2.4, −1.6, 1.95
Coarctation zone	−3 [−5.6-−1.5]	−3.9, −3.0, −2.3
Aortic cross-claming (min)	18 [15-30]	15, 17.5, 22
Total surgical time (min)	161 [50-290]	122.5, 165, 207
	n (%)	
Aortic coartectomy	22 (50.0)	
Aortic advancement	13 (29.5)	
Graft placement	9 (9.1)	

LVEF = left ventricular ejection fraction.

The remainder were performed via lateral thoracotomy. No patients underwent correction of associated defects, only ligation of the ductus arteriosus.

Overall mortality was 13.6%, including 100% patients with aortic arch interruption. All patients who died were in the group admitted to the hospital more than 10 days before. No correlation was found between mortality and low weight. All patients who died had cardiogenic shock.

Regarding follow up, the average follows up time is 1.5 years, with a minimum of five months and a maximum of five years. To date, only two patients have presented with aortic recoarctation in the first six months after surgery, managed with interventional therapy. Both weighed less than 3 kg at the time of surgery.

DISCUSSION

Congenital heart defects are the most common birth abnormalities, with aortic arch obstructions being particularly prevalent in the neonatal period. Recognizing these defects is crucial as they fall under the category of critical heart diseases.[7] While specific clinical signs can aid detection, the initial presentation often involves shock, which can be mistaken for sepsis,[5] delaying diagnosis and management.

The primary associated cardiac conditions include patent ductus arteriosus, ventricular septal defect, and aortic stenosis. A bicuspid aortic valve is present in approximately two-thirds of patients, while mitral valve abnormalities are less common.[8] In our series, the most frequently associated pathology was an atrial septal defect, followed by a ventricular septal defect.

The management of aortic arch defects in neonates is primarily surgical. Some centers perform interventional management before surgery in patients with severe left ventricular dysfunction to improve function and reduce mortality. However, lacking a catheterization service at our center, all patients proceeded directly to surgery. Over 50% of our patient population presented with signs of cardiogenic shock, and all of them were referred to our facility when they were over 10 days old.

The definition of critical heart disease highlights that these are conduit-dependent heart diseases requiring timely management, ideally within the first 10 days of life, to reduce mortality.[5] Notably, transfer time was a significant variable in our study, with over 60% of cases transferred more than 10 days after birth. While the ideal timing for surgical correction of aortic coarctation in newborns depends on clinical manifestations, the descending aortic gradient, and ventricular function,[8] our findings indicate that late transfers significantly influence surgical timing, with an average of 15 days, thereby increasing patient morbidity and mortality.

Aortic arch defects are clinically suspected, but the initial diagnostic step is an echocardiogram, with other imaging techniques considered based on the findings. In our series, the mean gradient across the descending aorta was 54. The type of surgery performed is determined by aortic arch Z-values and anatomy. Our primary technique was simple anastomosis in 31.8% of cases (for simple aortic coarctation), while those with severe hypoplasia required graft placement (9.1%). All patients require follow-up, regardless of the surgical technique.

The increased risk of recoarctation in low birth weight patients has been widely discussed. A study by Bacha et al.[9] concluded that premature patients weighing less than 2 kg can undergo aortic coarctation repair with relatively low mortality. While the recoarctation rate remains significant in very low birth weight patients, it can be effectively treated with balloon dilation or reoperation. Notably, two patients in our series experienced recoarctation.

The overall mortality rate in our study was 13.6%, including 100% of patients with aortic arch interruption. All patients who died were admitted to the hospital after more than 10 days. No correlation was found between mortality and low weight. All deceased patients presented with cardiogenic shock, and it is important to mention that this level of care is not widely available in our state.

Despite our hospital being a reference center for the surgical management of these patients, the limited number of cases over five years is striking.

CONCLUSIONS

As previously mentioned, although we are a referral center in our state for the surgical care of patients with congenital heart disease, the number of cases in our series is limited;

furthermore, most patients were referred when they were older than ten days old, increasing their morbidity and mortality.

Despite significant technological advances in pediatric cardiology and cardiac surgery, a thorough physical examination remains essential for the early detection of congenital heart defects, ideally before birth. While not the primary focus of this study, it is worth noting that nationwide efforts are currently underway to implement mandatory cardiology screening. Although such screening is not without limitations, it undoubtedly represents a meaningful step forward compared to the absence of any early detection strategy, and plays a crucial role in improving the timely diagnosis and management of congenital heart disease.

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REVIEW
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New-generation antidiabetic agents in cardiac surgery: cardiovascular and renal benefits beyond glycemic control

Agentes antidiabéticos de nueva generación en cirugía cardíaca: beneficios cardiovasculares y renales más allá del control glucémico

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ABSTRACT

In recent years, new antidiabetic drugs have emerged, such as GLP-1 receptor agonists, sodium-glucose cotransporter 2 inhibitors, and dipeptidyl peptidase-4 inhibitors, which have gained relevance for offering benefits beyond glycemic control, especially in cardiovascular and renal protection. In this context, it is pertinent to examine their potential role in cardiac surgery. The manuscript aims to describe and analyze the positive and negative impact of these therapies on cardiovascular and renal outcomes in patients undergoing cardiac surgery, regardless of the presence of diabetes mellitus. A systematic search is conducted in PubMed, Scopus, and the Cochrane Library for studies published between 2020 and 2025. Studies evaluating the safety and efficacy of GLP-1 receptor agonists, sodium-glucose cotransporter 2 inhibitors, and dipeptidyl peptidase-4 inhibitors, and dipeptidyl peptidase-4 inhibitors were included. The outcomes analyzed are perioperative safety, glycemic control, cardiovascular complications, and renal function. GLP-1 receptor agonists improved perioperative glycemic control, reduced insulin requirements, and promoted cardiac recovery, without increasing hypoglycemia or serious adverse events. Sodium-glucose cotransporter 2 inhibitors demonstrated cardioprotective and nephroprotective effects, with a lower incidence of acute kidney injury, reduced inflammatory markers, and improved outcomes after coronary artery bypass grafting. In contrast, the evidence on dipeptidyl peptidase-4 inhibitors was inconsistent, with inconclusive

RESUMEN

En los últimos años han surgido nuevos fármacos antidiabéticos, como los agonistas del receptor de GLP1, los inhibidores del cotransportador sodio-glucosa tipo 2 y los inhibidores de la dipeptidil peptidasa-4, que han cobrado relevancia por ofrecer beneficios más allá del control glucémico, especialmente en la protección cardiovascular y renal. En este contexto, resulta pertinente examinar su papel potencial en la cirugía cardíaca. El objetivo de la presente revisión es describir y analizar el impacto positivo y negativo de estas terapias sobre los resultados cardiovasculares y renales en pacientes sometidos a cirugía cardíaca, independientemente de la presencia de diabetes mellitus. Se emplea una búsqueda sistemática en PubMed, Scopus y Cochrane Library de estudios publicados entre 2020 y 2025. Se incluyeron estudios que evaluaron la seguridad y eficacia de agonistas del GLP1, inhibidores del SGLT2 e inhibidores de DPP4. Los desenlaces analizados son seguridad perioperatoria, control glucémico, complicaciones cardiovasculares y función renal. Los agonistas del GLP1 mejoraron el control glucémico perioperatorio, redujeron los requerimientos de insulina y favorecieron la recuperación cardíaca, sin aumentar hipoglucemias ni eventos adversos graves. Los inhibidores del SGLT2 mostraron efectos cardioprotectores y nefroprotectores, con menor incidencia de lesión renal aguda, reducción de marcadores inflamatorios y mejores resultados tras cirugía de revascularización coronaria. En contraste, la evidencia sobre inhibidores del DPP-4 fue inconsistente, con beneficios poco

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benefits and even a possible risk of organ dysfunction. In summary, GLP-1 receptor agonists and odium-glucose cotransporter 2 inhibitors are emerging as safe and promising options in cardiac surgery, while routine use of dipeptidyl peptidase-4 inhibitors is not recommended due to limited and controversial evidence.

Keywords: cardiac surgery, GLP-1 agonists, SGLT2 inhibitors, DPP-4 inhibitors.

concluyentes e incluso un posible riesgo de disfunción orgánica. En conclusión, agonistas del GLP1 e inhibidores del SGLT2 se perfilan como opciones seguras y prometedoras en cirugía cardíaca, mientras que el uso rutinario de inhibidores del DPP4 no está recomendado por la evidencia limitada y controvertida.

Palabras clave: *cirugía cardíaca, agonistas GLP1, inhibidores SGLT2, inhibidores DPP4.*

Abbreviations:
AKI = acute kidney injury
CABG = coronary artery bypass grafting
CGM = continuous glucose monitoring
CPB = cardiopulmonary bypass
DM = diabetes mellitus
DPP-4i = dipeptidyl peptidase-4 inhibitors
GLP-1 RAs = glucagon-like peptide-1 receptor agonists
HF = heart failure
HFpEF = hearth failure with preserved ejection fraction
ICU = Intensive Care Unit
SGLT2i = sodium-glucose cotransporter type 2 inhibitors

INTRODUCTION

In recent years, new pharmacological agents have been developed for the management of diabetes mellitus (DM). These agents have demonstrated benefits that extend beyond glycemic control, contributing to both the prevention and treatment of cardiovascular diseases, thereby increasing their clinical relevance. Among these, the drugs with evidence of cardiovascular and renal protection, as well as positive effects in patients with heart failure (HF), stand out, namely, glucagon-like peptide-1 receptor agonists (GLP-1 RAs), dipeptidyl peptidase-4 inhibitors (DPP-4i), and sodium-glucose cotransporter type 2 inhibitors (SGLT2i).[1]

Emerging evidence suggests that these agents exert protective effects in various organs beyond glucose regulation. Furthermore, it has been proposed that they may confer benefits to patients undergoing cardiac surgery, both in those with and without DM, particularly in the context of HF. In this regard, GLP-1 analogs, DPP-4i, and SGLT2i have emerged as promising therapeutic alternatives, with a favorable safety profile during the perioperative period.[1]

Over the past decades, cardiac surgery rates have steadily increased. Approximately 1.5 million such procedures are performed worldwide each year, reflecting the substantial global burden of cardiovascular diseases, which remain among the leading causes of morbidity and mortality.[2] It is estimated that around 32% of patients with these conditions have a high likelihood of requiring surgical intervention. Among the most common procedures is coronary artery bypass grafting (CABG), in which the prevalence of diabetes mellitus ranges between 10 and 44%. Both HF and acute kidney injury (AKI) represent major postoperative complications, as they significantly increase morbidity and mortality rates in these patients.[1,3]

Within this context, the objective of the present review is to describe and analyze the positive and negative impacts of novel antidiabetic agents on cardiovascular and renal outcomes in patients undergoing cardiac surgery, irrespective of the presence of DM. The scope of this review focuses on the individual use of these drugs (rather than combination therapy) and on outcomes observed during the immediate postoperative period.

MATERIAL AND METHODS

A comprehensive literature review was conducted using the most current data available. The bibliographic search was performed across scientifically validated databases, including PubMed, Scopus, and the Cochrane Library, among others. Keywords related to both novel antidiabetic agents (GLP-1 RAs, SGLT2i, DPP-4i) and cardiac surgery interventions were used, such as *"Cardiac Surgical Procedures," "Benefits of new antidiabetics in surgery,"* and *"SGLT2 inhibitors and cardiac surgery"*. Boolean operators were applied to refine the search strategy, for example: *"Cardiac Surgical Procedures" [MeSH] OR "cardiac surgery" OR "CABG"* AND *"Sodium-Glucose Transporter 2 Inhibitors" [MeSH] OR SGLT2 inhibitors OR dapagliflozin OR empagliflozin*, among others.

Initially, 15 relevant studies were identified. After applying the selection criteria, 10 articles were included, focusing on those published within the last five years (2020-2025).

Inclusion criteria: studies that individually evaluated one of the three agents of interest (without combination therapy), included participants with or without diabetes mellitus, and had a sample size greater than 20 subjects, to ensure adequate statistical robustness and alignment with the study objective.

Exclusion criteria: studies involving combined treatments or published more than five years prior, as these fell outside the intended scope of this review.

Description of novel oral antidiabetic agents and their benefits

1. **Glucagon-Like Peptide-1 Receptor Agonists (GLP-1 RAs).** GLP-1 is a 30–amino acid peptide hormone primarily produced in the intestine and, to a lesser extent,

in the hypothalamus.[4] Its main physiological role is the regulation of blood glucose; however, its half-life is short due to rapid degradation by the enzyme dipeptidyl peptidase-4 (DPP-4). GLP-1 exerts its effects through a high-affinity G protein-coupled receptor that stimulates insulin secretion and inhibits glucagon release, thereby promoting glucose homeostasis.[5]

GLP-1 analogs have been structurally modified to resist hydrolysis by DPP-4, which prolongs their therapeutic activity. This results in improved glycemic control and significant reductions in body weight. Moreover, cardiovascular outcome trials have demonstrated that these agents reduce the incidence of major adverse cardiovascular events, as well as overall mortality and hospitalization rates in the general population. It is noteworthy that these mortality benefits are primarily observed in patients without preexisting heart failure, whereas no significant effects have been reported in those with established HF.[1] Additionally, GLP-1 RAs have shown a clinically relevant impact on weight reduction.[6]

In the perioperative setting, the American Society of Anesthesiologists (ASA) and the American Gastroenterological Association (AGA) published a 2024 guideline supporting the safe use of these drugs in patients who are not at high risk for delayed gastric emptying or aspiration. The decision to continue or discontinue treatment during the preoperative period should be based on a multidisciplinary consensus among the surgical team.[1,7]

2. **Dipeptidyl Peptidase-4 Inhibitors (DPP-4i).** The catalytic enzyme dipeptidyl peptidase-4 (DPP-4), also immunologically known as CD26, is an exopeptidase that cleaves peptides after the second position of the amino-terminal end. It is expressed in multiple cell types, including hepatocytes, endothelial cells, and pancreatic islet endocrine cells. Inhibition of DPP-4 prevents the degradation of incretin hormones such as glucagon-like peptide-1 (GLP-1) and glucose-dependent insulinotropic polypeptide (GIP), thereby prolonging their half-life and enhancing insulin secretion while reducing glucagon release.[1,8]

   DPP-4 inhibitors are characterized by a lower risk of hypoglycemia and weight gain compared to other antidiabetic drugs, such as sulfonylureas. These agents have been reported to provide benefits in patients with DM and hearth failure with preserved ejection fraction (HFpEF), as they are associated with a reduced risk of cardiovascular death, HF hospitalization, and renal function decline. However, some studies have indicated that saxagliptin and alogliptin may increase the risk of serious heart failure events, possibly due to mechanisms involving sympathetic overactivity.[1,9]

   In this regard, the EXAMINE and SAVOR-TIMI 53 clinical trials reported a significant increase in heart failure hospitalizations among patients treated with saxagliptin compared with placebo, leading to contraindication of its use in this population.[10,11] In contrast, alogliptin may be considered in patients with DM and HF, provided that it is administered under close medical supervision. Currently, GLP-1 receptor agonists and SGLT2i are preferred agents for managing heart failure and preventing major adverse cardiovascular events.

   Regarding the perioperative management of DPP-4 inhibitors, there are two divergent perspectives: some authors recommend continuing their use on the day of surgery, while others advise discontinuation at least 24 hours before the procedure.[12,13]

3. **Sodium-Glucose Cotransporter Type 2 Inhibitors (SGLT2i).** It acts by blocking this transporter, located on the apical membrane of the proximal convoluted tubule, which is responsible for the reabsorption of sodium and glucose from urine into the bloodstream. Inhibition of this transporter increases urinary glucose excretion, lowers serum glucose levels, and is associated with a lower risk of hypoglycemia. Furthermore, the combination of natriuresis and osmotic diuresis induced by glucosuria produces hemodynamic benefits by reducing preload, afterload, and myocardial wall stress.[14,15]

   This class of drugs has the strongest clinical evidence regarding cardiovascular and renal benefits. The DELIVER trial (2022) demonstrated that dapagliflozin reduced the risk of worsening heart failure (HF) or cardiovascular death in patients with HF and preserved ejection fraction (LVEF >40%).[16] Similarly, the SOLOIST-WHF study (2020), conducted in hospitalized patients with DM experiencing acute HF exacerbation, showed that early post-discharge administration of sotagliflozin reduced cardiovascular mortality, hospital readmissions, and Intensive Care Unit (ICU) admissions compared with placebo.[17] Additionally, the CREDENCE trial (Canagliflozin and Renal Outcomes in Type 2 Diabetes and Nephropathy) found that canagliflozin use led to a 30% relative risk reduction in the composite primary outcome of end-stage kidney disease, doubling of serum creatinine, or death from cardiovascular or renal causes. This renal protection was attributed to a reduction in intraglomerular pressure.[18]

   Based on these findings, the latest American Heart Association (AHA) guidelines include dapagliflozin and empagliflozin as first-line agents in the management of heart failure with preserved ejection fraction (HFpEF), marking them as the first drugs to demonstrate improved prognosis and survival in this condition.[19]

   In the perioperative context, expert consensus statements diverge regarding management. While some recommend

discontinuing SGLT2 inhibitors at least 24 hours before elective surgery or invasive procedures, clinical evidence supporting this recommendation remains limited.[1,20] Conversely, the U.S. Food and Drug Administration (FDA) advises interrupting therapy at least 72 hours before surgery due to the drugs' prolonged half-life.[1,21] Reintroduction may occur 24 hours after surgery, provided the patient is under close monitoring for potential adverse effects.

Novel antidiabetics and cardiac surgery

1. **GLP-1 analogs.** GLP-1 analogs have demonstrated cardioprotective effects in various contexts, raising the possibility that these benefits may also extend to patients undergoing cardiac surgery. Although evidence in this specific setting remains limited, some clinical trials have explored this relationship.
   A randomized trial in patients with DM undergoing cardiac surgery with cardiopulmonary bypass (CPB), aged 20–80 years, compared the use of liraglutide plus insulin versus insulin infusion alone for perioperative glycemic control. Sixty patients were included and evenly divided into two groups. The results showed that liraglutide combined with insulin achieved significantly lower perioperative glucose levels compared to insulin alone, with a mean difference of 15.9 mg/dl. Additionally, during the first postoperative hour, hyperglycemia incidence was lower in the combination group (43.75 vs. 67.85%; p = 0.061), an effect that persisted until postoperative day two (23.65 vs. 32.79 mg/dl; p = 0.018).[22] Similar findings were reported by Oosterom et al., in a study of 25 patients (with and without DM), where 13 received liraglutide and 12 received placebo. Continuous glucose monitoring demonstrated a significant improvement in perioperative glucose range, with an absolute difference of 25% (95% CI: −41.4 to −8.9; p = 0.004). Time in range was higher in the liraglutide-treated group (72 vs 47%).[23]
   Hulst et al., investigated not only glycemic control but also the effect of liraglutide on myocardial function after cardiac surgery. In this study, which included 261 patients, echocardiographic, hemodynamic, biomarker, and inotropic support requirements were evaluated. Findings showed that a higher proportion of patients treated with liraglutide maintained normal postoperative left ventricular systolic function (68 vs 53%; difference 15%, 95% CI: 0-30; p = 0.049). A higher mean heart rate was also observed in this group (83 ± 11 vs 77 ± 11 bpm; p < 0.001). No differences were noted in other hemodynamic parameters, vasoactive drug use, or serum biomarkers.[24]
   Exenatide has also been evaluated in a randomized, double-blind trial in patients undergoing CABG or aortic valve replacement. The study assessed its impact on mortality and major organ failure over a 5.9-year follow-up. No significant differences were observed compared to placebo regarding time to first event, though the authors noted that further research is needed to clarify its potential role in this context.[25]
2. **DPP-4 Inhibitors.** Research on DPP-4 inhibitors in the context of cardiac surgery is particularly relevant, not only due to their increasing prescription rates over recent decades but also because of controversies regarding their effects on heart failure, particularly with saxagliptin and alogliptin.
   In a clinical trial involving 182 adult patients with DM undergoing CABG, the efficacy of sitagliptin versus placebo for perioperative hyperglycemia prevention and management was evaluated. Treatment began one day prior to surgery and continued during hospitalization. The primary endpoint was the incidence of postoperative hyperglycemia. No significant differences were found in hypoglycemia frequency, daily mean glucose, surgery duration, ICU or hospital stay, vasopressor requirements, perioperative complications, reoperations, or readmissions. However, sitagliptin-treated patients required lower mean daily insulin doses after transfer to the regular ward compared to placebo (21.1 ± 18.4 vs 32.5 ± 26.3 units; p = 0.007).[1,26]
   Parker et al., assessed the impact of DPP-4 inhibitors in cardiac surgery and found that sitagliptin did not significantly improve glycemic control. Repeated measures analysis revealed similar mean blood glucose levels between groups (147.2 ± 4.8 mg/dl in the intervention group vs 153.0 ± 4.6 mg/dl in the control group; p = 0.388). Additionally, lower DPP-4 activity correlated with greater organ dysfunction and poorer outcomes in ICU patients after CPB. In a cohort of 46 patients undergoing CPB, an inverse correlation was observed between DPP-4 levels and biomarkers such as lactate and creatinine. Organ-protective effects associated with higher DPP-4 activity were particularly evident in postoperative renal function, an important consideration since acute kidney injury complicates up to 30% of cardiac surgery recoveries, highlighting the cardiorenal interaction.[27]
3. **SGLT2 Inhibitors.** Currently represent the oral antidiabetic class with the strongest evidence due to their well-established benefits in the prevention and treatment of cardiovascular and renal diseases. Their role in cardiac surgery is of particular interest.
   A multicenter study by Sardu et al., included 648 patients with ischemic heart disease, with and without DM, undergoing minimally invasive CABG with extracorporeal circulation (MiECC). The study assessed the effects of SGLT2 inhibitors on inflammatory response and clinical outcomes (all-cause mortality, cardiovascular mortality, nonfatal myocardial infarction, stroke, and need for repeat revascularization). After five years of follow-

up, non-diabetic patients showed lower inflammatory marker levels compared to diabetic patients. Within the DM group, those treated with SGLT2 inhibitors exhibited significantly lower levels of leukocytes, CRP, IL-1, IL-6, and TNF-α compared to untreated patients. At one year, SGLT2 users had lower rates of cardiovascular mortality and repeat revascularization ($p < 0.05$).[28]

Similarly, Snel et al., conducted a phase IV pilot trial in 55 patients undergoing cardiac surgery with CPB, who received empagliflozin (n = 25) or placebo (n = 30) starting three days before the procedure. The aim was to determine its impact on acute kidney injury (AKI), measured through biomarkers such as NGAL, KIM-1, HIF-1α, and their ratios with urinary creatinine. While serum NGAL levels on postoperative day two did not differ significantly, AKI incidence (KDIGO criteria) was markedly lower in the empagliflozin group (20 vs. 66.7%; $p < 0.001$). This group also showed lower glucose peaks, reduced hyperglycemia incidence, and decreased insulin requirements during the first 48 postoperative hours.[29]

Taghiyev et al. also documented a nephroprotective effect of SGLT2 inhibitors in patients undergoing cardiac surgery with CPB. Thirty-six hours after surgery, the estimated glomerular filtration rate (eGFR) was significantly higher in the treated group (mean difference 11.8 ml/min; 95% CI: 3.12-20.44; $p = 0.009$). Although albuminuria reduction was not statistically significant, a favorable trend toward lower urinary albumin concentrations was observed in the intervention group.[30]

Finally, Fardman et al., retrospectively evaluated the safety and effects of SGLT2 inhibitors in patients with left ventricular assist devices (LVADs). Among 138 patients, 29 received SGLT2 inhibitors post-implantation (23 empagliflozin, 6 dapagliflozin). Follow-up showed a significant reduction in daily furosemide dose (47 to 23.5 mg/day; mean difference 23.5 mg/day, 95% CI: 8.2-38.7; $p = 0.004$) and a decrease in body weight (−2.5 kg; 95% CI: 0.7-4.3; $p = 0.008$). Additionally, systolic blood pressure decreased by 5.6 mmHg compared to the control group (95% CI: 0.23-11; $p = 0.042$).[31]

DISCUSSION

Novel oral antidiabetic agents have gained significant relevance in recent years due to their cardiovascular benefits and their capacity to provide organ protection, particularly for the heart and kidneys, in addition to improving glycemic control. In the context of cardiac surgery, these effects are especially important, as they may contribute to both patient safety and prognosis. Within this group, SGLT2 inhibitors and GLP-1 analogs emerge as the agents with the strongest scientific support for perioperative use. In contrast, DPP-4 inhibitors show more controversial results: although they aid in glycemic control, some studies suggest a potential risk of organ dysfunction. The main characteristics and evidence of each pharmacological class are summarized in *Table 1*.

GLP-1 receptor agonists are considered a safe option for perioperative management, as they promote more stable glycemic control, reduce insulin requirements, and help preserve postoperative cardiac function. Furthermore, no increase in hypoglycemia incidence or adverse effects has been observed compared with conventional insulin therapy.

Although available evidence remains limited, several studies support these benefits. It is worth noting that two of the three trials evaluating liraglutide included relatively small populations; however, a favorable aspect is that both diabetic and non-diabetic patients were included. Specifically, the study by Oosterom et al., included only 25 patients and presented methodological limitations, such as bias in glucose measurement using continuous glucose monitoring (CGM) compared with reference arterial determinations. While CGM may take longer to detect hyperglycemic episodes, it offers a safety advantage by lowering the threshold for imminent hypoglycemia alarms. In this trial, CGM readings did not meet the strict ISO 15197:2013 criteria, achieving 62% of samples, although this percentage was higher than previously reported studies (41%).[20]

Hulst et al. reported improved echocardiographic function in the liraglutide-treated group compared with placebo. However, no differences were observed in postoperative serum biomarkers, likely because, in cardiac surgery, marker release is related to direct myocardial injury during the procedure, unlike in percutaneous coronary intervention studies where elevations are ischemia-driven.[21] An additional limitation was that only 170 patients underwent perioperative echocardiography to establish baseline status. Despite these constraints, findings suggest that preoperative administration of liraglutide may modestly improve postoperative cardiac function, alter immediate hemodynamic parameters (e.g., increased heart rate), and better preserve left ventricular function on follow-up echocardiography. These results support the need for larger clinical trials focusing on postoperative cardiovascular outcomes in patients undergoing cardiac surgery.[1,21]

Regarding DPP-4 inhibitors in cardiac surgery, evidence remains limited. In the previously mentioned study by Cardona et al., their use in type 2 diabetic patients undergoing CABG was associated with a significant reduction in mean daily insulin requirements. However, no differences in postoperative glucose levels in the ICU were observed, suggesting limited clinical benefit. Conversely, Noels et al., reported that DPP-4 inhibitors not only lack significant relevance for perioperative glycemic control but may even be harmful by promoting postoperative organ dysfunction. This finding is particularly relevant considering that, although experimental animal studies suggested potential

Table 1: Comparison of novel antidiabetic agents in the context of cardiac surgery.

Pharmacological Group	Main Benefits	Risks / Limitations	Evidence in Cardiac Surgery	Current Recommendation
GLP-1 Agonists (liraglutide, exenatide)	- Improved perioperative glycemic control - Reduced insulin requirements - Possible preservation of left ventricular function	- Modest effects on hemodynamic function - Small sample sizes in studies - Heterogeneous results	Small trials and some RCTs show improvements in glycemia and echocardiographic parameters	Promising and safe, but larger studies are needed
DPP-4 Inhibitors (sitagliptin, saxagliptin, alogliptin)	- Lower risk of hypoglycemia - Possible reduction in insulin doses	- Inconsistent evidence in glycemic control - Risk of heart failure with saxagliptin/alogliptin - Potential for organ dysfunction	Trials show conflicting results; some do not demonstrate significant differences in glycemia	Not routinely recommended in cardiac surgery
SGLT2 Inhibitors (empagliflozin, dapagliflozin, sotagliflozin)	- Cardioprotective and nephroprotective effects - Lower incidence of acute kidney injury (AKI) - Reduced perioperative inflammation - Lower cardiovascular mortality and revascularization rates	- Risk of ketoacidosis (low but present) - Evidence still limited in cardiac surgery - Several studies with small sample sizes	Pilot trials and retrospective studies show reduced AKI and improved long-term outcomes	Highly promising, with the highest level of current evidence; larger RCTs required

AKI = acute kidney injury. RCT = randomized controlled trial.

cardioprotective effects of DPP-4 inhibition, these results cannot be directly extrapolated to complex clinical scenarios such as human cardiac surgery.[25]

SGLT2 inhibitors represent the antidiabetic class with the most promising outcomes in cardiac surgery, as available studies suggest both cardioprotective and nephroprotective effects. Nevertheless, several methodological limitations should be noted. For example, the study by Snel et al., had a small sample size and an open-label design, introducing the possibility of chance influencing observed intergroup differences. While the findings align with the study's objectives, they should primarily be regarded as hypothesis-generating for future research. Moreover, the absence of ketoacidosis cases in this pilot study, although not definitive evidence of safety due to the low incidence of this complication, is an encouraging observation. It should also be noted that insulin-dependent type 2 diabetic patients were not included, although the glucose/insulin administration protocol would likely have mitigated the risk of ketoacidosis if it had occurred.[27]

In the Sardu et al., study, a notable consideration is that diabetic patients were already on chronic SGLT2 inhibitor therapy, and therapy allocation was not randomized. This lack of randomization and blinding could introduce bias and limit the validity of the results. Therefore, further studies in larger populations with robust methodological design and extended follow-up are recommended to definitively clarify the molecular, cellular, and clinical effects of SGLT2 inhibitors in diabetic patients undergoing CABG with MiECC.[26]

CONCLUSION

Although available information is limited, particularly regarding DPP-4 inhibitors, it can be concluded that both GLP-1 analogs and SGLT2 inhibitors are safe for perioperative use and provide cardiovascular and renal benefits in the postoperative period for patients undergoing various types of cardiac surgery, regardless of whether the patient has underlying DM.

Regarding DPP-4 inhibitors, due to mixed and controversial evidence, their perioperative use is recommended to be restricted, as there is insufficient evidence of glycemic control benefit and a potential risk of organ failure.

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Designing the ideal training program for cardiothoracic surgery in the modern era

Diseñando el programa de entrenamiento ideal para cirugía cardiotorácica en la era moderna

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ABSTRACT

The landscape of cardiothoracic surgery has undergone significant evolution over the past 15 years, driven by advances in minimally invasive techniques, endovascular procedures, robotic technology, and mechanical circulatory support. Consequently, training programs must adapt to prepare residents for the broad spectrum of modern cardiothoracic practice. This article proposes a framework for the ideal hospital and cardiothoracic surgery residency program, emphasizing infrastructure, faculty expertise, and structured rotations that reflect contemporary surgical demands. Pediatric and adult care should be integrated, and conventional surgery, although less frequent in some centers, remains essential.

Keywords: cardiac surgical procedures, education medical graduate, trends, internship and residency, models educational, thoracic surgical procedures.

RESUMEN

El campo de la cirugía cardiotorácica ha experimentado una evolución significativa en los últimos 15 años, influenciada por avances en técnicas mínimamente invasivas, procedimientos endovasculares, tecnología robótica y soporte circulatorio mecánico. Como resultado, los programas de formación deben adaptarse para preparar a los residentes para el amplio espectro de la práctica cardiotorácica moderna. Este artículo propone un marco para el hospital y el programa de residencia ideales en cirugía cardiotorácica, haciendo énfasis en la infraestructura, la experiencia del profesorado y las rotaciones estructuradas que reflejen las demandas quirúrgicas contemporáneas. La atención pediátrica y adulta deben integrarse, y la cirugía convencional, aunque sea menos frecuente en algunos centros, sigue siendo fundamental.

Palabras clave: *procedimientos quirúrgicos cardíacos, educación médica de posgrado, tendencias, internado y residencia, modelos educativos, procedimientos quirúrgicos torácicos.*

The training of cardiothoracic surgeons in the twenty-first century stands at a global inflection point. Accelerated population aging, the escalating burden of cardiovascular disease, and the rapidly expanding technological complexity of surgical interventions have converged to create unprecedented demands on residency programs. These programs must now produce specialists with advanced technical proficiency, sound operative judgment, and a sophisticated understanding of hybrid and minimally invasive therapies.[1] In Latin America –and particularly in Mexico– this need is further magnified by structural inequities in access to cardiac surgery and by marked regional variability in hospital infrastructure.

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International surgical societies have repeatedly emphasized that traditional training models –characterized by inconsistent case exposure and predominantly opportunistic learning– are no longer sufficient to guarantee reliable surgical outcomes or to sustain the growth of the specialty in the coming decades.[2-4] They advocate for standardized curricula, high-fidelity simulation, competency-based evaluation, and early exposure to advanced procedures. Leading programs have already incorporated these elements in an effort to bridge the widening gap between clinical demands and the availability of adequately trained surgeons.[5]

In Mexico, where cardiovascular disease remains the foremost cause of mortality[6] and the supply of specialists is limited, strengthening residency programs represents both a public-health priority and a matter of long-term systemic sustainability. The development of a contemporary Cardiothoracic Surgery Residency requires not only an adequate procedural volume but also the integration of modern educational methodologies, a culture of patient safety, continuous certification, and participation in multicenter learning networks.[7]

This article presents the structure, outcomes, and guiding principles of a current Cardiothoracic Surgery Residency Program in Mexico, designed in accordance with international standards and adapted to local realities. Its purpose is to offer a replicable model that integrates academic rigor, technical competence, and social responsibility—ultimately preparing surgeons capable of meeting the cardiovascular needs of the country in the decades ahead.

THE IDEAL CARDIOTHORACIC SURGERY TRAINING PROGRAM: CORE CHARACTERISTICS

1. **Infrastructure**
   a. Dedicated hybrid operating rooms for endovascular and minimally invasive procedures.
   b. Robotic surgical systems available for daily clinical use.
   c. ECMO and ventricular assist device (VAD) programs with on-site coordination teams.
   d. Pediatric cardiothoracic surgical units integrated within the institution.
   e. Simulation labs equipped for open, endoscopic, and robotic technique practice.

2. **Faculty expertise**
   a. A diverse team of specialized cardiothoracic surgeons:
      - Experts in minimally invasive valve surgery.
      - Robotic surgeons performing routine clinical cases.
      - Endovascular specialists for thoracic aortic pathologies.
      - Pediatric and congenital heart surgeons.
      - Transplant and mechanical circulatory support specialists.

   b. Active research staff supporting academic development and innovation.

3. **Case volume and variety**
   a. High procedural volume across subspecialties to ensure adequate resident exposure.
   b. Balance of elective and emergent cases.
   c. Opportunity to rotate through affiliated high-volume centers if local caseload is limited (especially for coronary artery bypass surgery).

THE MODERN RESIDENCY PROGRAM: PROPOSED ROTATIONS AND STRUCTURE

Two years of general surgery residency prior to cardiothoracic surgery residency

Year 1-2: general surgery residency

Year 3-4: surgical foundations and ICU management
- Dedicated cardiothoracic ICU experience.
- Basic open-heart surgery exposure.

Core adult cardiothoracic surgery
- Conventional cardiac surgery (valves, CABG, aortic surgery).
- Introduction to endovascular techniques.
- Elective rotation in minimally invasive approaches.
- Thoracic non-cardiac surgery.

Pediatric and congenital heart surgery
- Pediatric cardiac ICU.
- Surgical repair of congenital heart disease in infants and children.
- Adult congenital heart disease rotations.

Year 5-6: advanced and minimally invasive techniques
- Robotic cardiac and thoracic surgery.
- Advanced endovascular and hybrid procedures.
- Exposure to transcatheter structural interventions (TAVI, TEVAR).

Transplantation and mechanical circulatory support
- Heart and lung transplantation.
- VAD implantation and ECMO management.
- Elective time for research or sub-specialization.

Academic and professional development
- Structured mentorship for research, publication, and presentation.
- Leadership and communication training.
- Annual surgical skill assessments and simulation labs.

THE MODERN RESIDENCY PROGRAM: PROPOSED ROTATIONS AND STRUCTURE

Direct admission to cardiothoracic residency program

Year 1: surgical foundations and ICU management
- General surgical rotations (vascular, thoracic, trauma).
- Dedicated cardiothoracic ICU experience.
- Basic open-heart surgery exposure.

Year 2-3: core adult cardiothoracic surgery
- Conventional cardiac surgery (valves, CABG, aortic surgery).
- Introduction to endovascular techniques.
- Elective rotation in minimally invasive approaches.
- Thoracic non-cardiac surgery.

Year 3-4: pediatric and congenital heart surgery
- Pediatric cardiac ICU.
- Surgical repair of congenital heart disease in infants and children.
- Adult congenital heart disease rotations.

Year 4-5: advanced and minimally invasive techniques
- Robotic cardiac and thoracic surgery.
- Advanced endovascular and hybrid procedures.
- Exposure to transcatheter structural interventions (TAVI, TEVAR).

Year 5-6: transplantation and mechanical circulatory support
- Heart and lung transplantation.
- VAD implantation and ECMO management.
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Academic and professional development
- Structured mentorship for research, publication, and presentation.
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FINAL COMMENTARY

The development of a contemporary Cardiothoracic Surgery Residency Program in Mexico is not merely a curricular exercise; it constitutes an intentional act of institutional reconstruction—a deliberate stance toward the challenges already shaping the future of our specialty. In a country where the burden of cardiovascular disease continues to rise, where human resources remain insufficient, and where therapeutic complexity grows at an exponential pace, clinging to traditional training paradigms would be, at best, imprudent and, at worst, irresponsible. Our program seeks to break that inertia.

The experience described here demonstrates that it is indeed possible to establish a structured, competency-driven, intensive, and ethically grounded training framework, even within the constraints of the national context. The incorporation of advanced simulation, continuous assessment, early participation in complex interventions, and an explicit emphasis on clinical reasoning, patient safety, and professional maturity are not academic luxuries—they are the minimum requirements for producing surgeons capable of responding to Mexico's cardiovascular realities in the decades to come.

Moreover, this model is not intended as an isolated initiative. It aims to provide a replicable, adaptable, and continually improvable framework for other centers seeking to modernize their training paradigms. The objective is not to prescribe a rigid formula, but to offer a critical reference point that invites reflection, constructive debate, and most importantly, collective action.

Ultimately, surgical training is an intergenerational covenant: what we build today determines who will operate, innovate, and lead tomorrow. If we accept that cardiothoracic surgery in Mexico demands a qualitative leap forward, then this program stands as a deliberate and meaningful first step toward that higher standard. Our commitment is both sober and far-reaching: to train surgeons prepared not only to practice the medicine of today, but to sustain –with rigor, clarity, and excellence– the medicine that is still to come.

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CASE REPORT
Vol. 11 No. 1 January-March 2026
doi: 10.35366/122232

Atypical aortic pseudocoarctation in a pediatric patient

Pseudocoartación aórtica atípica en un paciente pediátrico

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ABSTRACT

Aortic pseudocoarctation, a rare congenital aortic anomaly, mimics coarctation but typically lacks significant hemodynamic impact. We present a six-year-old male evaluated for systemic arterial hypertension. Diagnosis involved echocardiography revealing preductal coarctation and a wide patent ductus arteriosus, confirmed by cardiac CT angiography showing atypical double narrowing and angulation. Surgical coarctectomy and patent ductus arteriosus ligation via left thoracotomy were successfully performed. The critical role of advanced imaging in differentiating this condition is crucial.

Keywords: aortic arch, congenital heart, cardiac surgery.

RESUMEN

La pseudocoartación aórtica, una anomalía aórtica congénita poco frecuente, simula una coartación, pero generalmente carece de impacto hemodinámico significativo. Presentamos el caso de un niño de seis años evaluado por hipertensión arterial sistémica. El diagnóstico se realizó mediante ecocardiografía, que reveló coartación preductal y un conducto arterioso persistente ancho, confirmado mediante angiografía cardíaca por TC, que mostró un doble estrechamiento y angulación atípicos. Se realizó con éxito una coartectomía quirúrgica y una ligadura del conducto arterioso persistente mediante toracotomía izquierda. La imagenología avanzada es crucial para diferenciar esta afección.

Palabras clave: *arco aórtico, cardiopatía congénita, cirugía cardíaca.*

Aortic pseudocoarctation, an infrequent congenital aortic anomaly, involves the elongation, stenosis, and kinking of the aorta, primarily at the isthmus. Despite its shared clinical presentation with aortic coarctation, pseudocoarctation typically does not produce a substantial gradient in the descending aorta or significant hemodynamic sequelae. Given this overlap and crucial distinction, comprehensive imaging techniques –foremost among them cardiac CT angiography and catheterization– are paramount for accurate differential diagnosis.[1] The specific case we report was an incidental discovery during the management of systemic arterial hypertension.

CASE DESCRIPTION

This is the case of a six-year-old male presenting with an eight-month history of systemic arterial hypertension, referred to our service for evaluation and to rule out cardiac pathology.

On physical examination, we noted rhythmic heart sounds with a grade II/VI ejection murmur at the accessory aortic focus, along with a grade II/VI systolic murmur in the posterior hemithorax and physiological splitting of the second heart sound. There was no hepatomegaly, but pulses in the lower limbs were diminished.

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A transthoracic echocardiogram revealed a preductal aortic coarctation with a maximum gradient of 25 mmHg and a wide patent ductus arteriosus, measuring 9 mm from the pulmonary mount. Subsequent cardiac CT angiography of the heart and great vessels confirmed a double area of narrowing, exhibiting both counterclockwise and posterior clockwise angulation *(Fig. 1)*, in addition to a wide patent ductus arteriosus. This imaging effectively ruled out other aortic arch pathologies.

The patient was presented at a medical-surgical session and accepted for coarctectomy and ligation of the arterial duct.

Via a left lateral thoracotomy, dissection was performed in layers to access the thoracic cavity, exposing the aortic arch, ductus arteriosus, left common carotid artery, left subclavian artery, brachiocephalic trunk, and descending thoracic aorta. Both the juxtaductal aortic coarctation and the ductus arteriosus were clearly visualized. We then performed proximal and distal clamping of the ductus arteriosus, sectioning both ends and ligating them with 5-0 polypropylene. Vascular clamps were applied to the aortic arch and distal aorta, followed by an extended end-to-end anastomosis towards the arch using 4-0 polypropylene, achieving good filling with no evidence of leaks. During the procedure, we observed an atypical angulation of the aortic arch, consistent with the CT angiography findings *(Fig. 2)*. The aortic clamping time was 17 minutes, and the total operative time was 180 minutes. Postoperative echocardiography showed no significant residual gradient.

The patient was extubated in the operating room and discharged 72 hours after the operation. He is currently under routine follow-up, remains complication-free, and maintains blood pressure within normal limits.

COMMENT

Pseudocoartation of the aorta constitutes an exceedingly rare congenital anomaly, precipitated by the embryonic compression of the middle third of the seventh dorsal aortic segment. This segment, being anomalously shorter than anticipated, culminates in an elongated aortic arch that convolutes around the ductus arteriosus.[2,3] Consequently, this elongation engenders a distinct gap between the origin of the left carotid artery and that of the left subclavian artery.[4]

It can be concomitantly associated with an array of other cardiac anomalies, including aortic coarctation, bicuspid aortic valve, ventricular and atrial septal defects, as well as patent

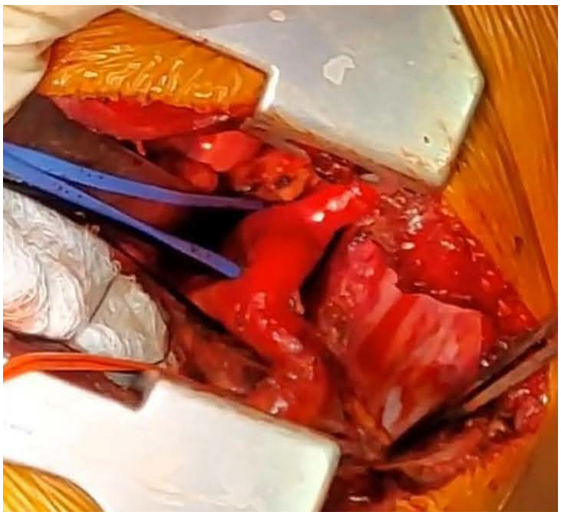

Figure 2: Intraoperative image showing the area of atypical angulation.

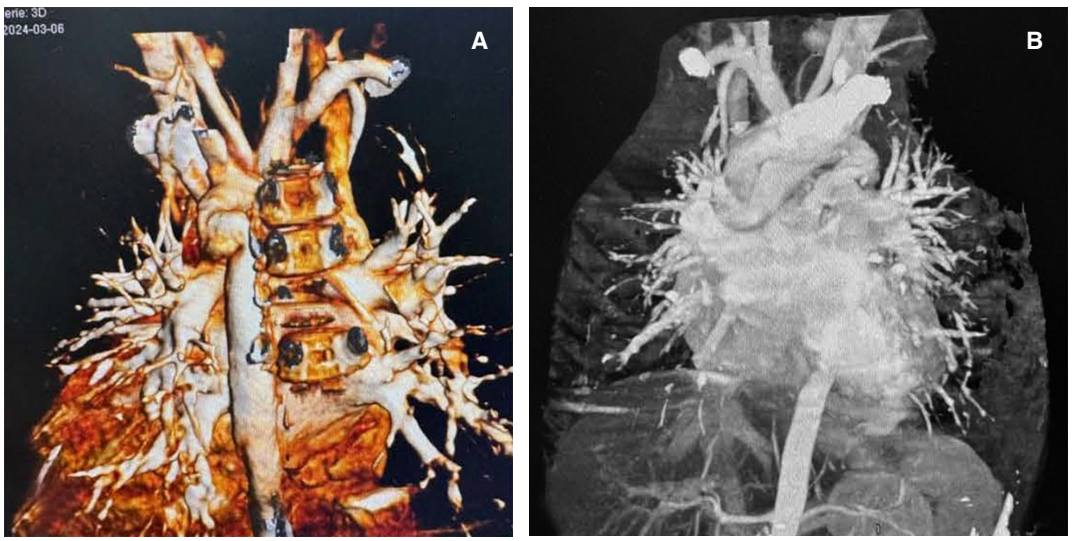

Figure 1:

Angiotomography showing a double zone of narrowing with clockwise and counterclockwise angulation.

ductus arteriosus,[5] the latter of which constitutes a pertinent association in our particular case. While collateral flow is commonly encountered in instances of aortic coarctation, pseudocoarctation is distinguished by the notable absence of such collateral flow.[6] Furthermore, pseudocoarctation may manifest as an integral component of more complex syndromes, such as Turner syndrome, Noonan syndrome, and Hurler syndrome.[2,7]

Clinically, pseudocoarctation manifests predominantly as resistant hypertension,[8] a presentation exemplified by the patient in our case, whose initial clinical manifestation was systemic arterial hypertension. The management paradigm for asymptomatic patients with pseudocoarctation of the aorta is generally considered to be conservative in nature. However, in the presence of overt clinical symptoms or significant concomitant cardiac abnormalities, surgical intervention ought to be duly considered.[2,4]

CONCLUSIONS

In culmination, it is imperative to underscore that pseudocoarctation of the aorta should not be regarded as a benign pathological entity. This exceedingly rare condition exhibits a pronounced clinical similitude to genuine coarctation, thereby mandating fastidious diagnostic acumen. The exemplar case we proffer herein was ascertained incidentally during the therapeutic management of systemic arterial hypertension.

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CASE REPORT
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Bentall and de Bono procedure in the context of double aortic valve lesion with right sinus of Valsalva aneurysm and ischemic cardiomyopathy: case report

Procedimiento de Bentall y de Bono en el contexto de doble lesión aórtica con aneurisma de seno de Valsalva derecho y miocardiopatía isquémica: a propósito de un caso

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Department of Cardiothoracic Surgery, Instituto Nacional de Cardiología Ignacio Chávez. Mexico City, Mexico.

ABSTRACT

The sinuses of Valsalva are subtle dilatations of the ascending aorta that correspond to the portion of the left ventricular outflow tract located between the aortic valve annulus and the sinotubular junction. We present a case of a right sinus of Valsalva aneurysm associated with ischemic cardiomyopathy, characterized by a 15-year history of cardiovascular symptoms, which prompted referral to our center in January 2024 following the incidental discovery of a cardiac murmur during a preoperative evaluation. The etiology, anatomy, histology, and diagnostic and surgical treatment guidelines for this condition are discussed.

Keywords: aorta, aortic sinus, aortic valve, Bentall procedure, coronary artery bypass grafting, sinus of Valsalva.

RESUMEN

Los senos de Valsalva son ligeras dilataciones de la aorta ascendente y corresponden a la porción anatómica del tracto de salida ventricular izquierdo que se localiza entre el anillo de la válvula aórtica y la unión sinotubular. Se presenta un caso de un aneurisma de seno de Valsalva derecho, asociado a miocardiopatía isquémica, con presencia de aproximadamente 15 años de síntomas cardiovasculares que es referido a nuestro centro asistencial en enero de 2024 debido al hallazgo de un soplo cardíaco en una evaluación preoperatoria. Se discute su etiología, anatomía, histología y pautas para el diagnóstico y tratamiento quirúrgico.

Palabras clave: *aorta, senos aórticos, válvula aórtica, procedimiento de Bentall, revascularización coronaria, seno de Valsalva.*

INTRODUCTION

The sinuses of Valsalva are slight dilatations of the ascending aorta that correspond to the anatomical portion of the left ventricular outflow tract located

Abbreviations:
CABG = coronary artery bypass grafting
ESC = European Society of Cardiology
LVEF = left ventricle ejection fraction

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between the aortic valve annulus and the sinotubular junction. There are three Valsalva sinuses: the right coronary sinus, the left coronary sinus, and the non-coronary sinus, each one connected to its respective coronary ostium. The anomalies of these sinuses can be explained by their histological characteristics. Notably, the superior margin of each sinus, at the peak of the semilunar insertion line, is known as the supravalvular ridge, which is mainly composed of elastic and collagen fibers interspersed with smooth muscle cells and fibroblasts.[1,2]

The left coronary sinus ridge contains a greater number of smooth muscle cells embedded within a dense extracellular matrix rich in type I collagen fibers. In contrast, the right coronary sinus contains fewer smooth muscle fibers immersed in type III collagen. It is known that the walls of the Valsalva sinuses are primarily composed of type I collagen fibers in their lower portions, closest to the insertion of the aortic leaflets, where there is also a slight presence of left ventricular muscle fibers. It is important to note that the amount of type I collagen fibers gradually decreases in an ascending direction while the amount of elastic fibers increases progressively within each sinus.[1,2]

Although aortic valve disease is relatively common, its association with sinus of Valsalva aneurysm is rare and only a limited case series have been reported in the past years. Nevertheless, the coexistence of these entities, particularly when accompanied by ischemic cardiomyopathy poses a unique diagnosis and therapeutic assessment. All of this underscores the relevance of the present case, in which a double aortic valve lesion, a right sinus of Valsalva aneurysm and ischemich cardiomyopathy were successfully managed with the Bentall and de Bono procedure.

CASE DESCRIPTION

A 78-year-old male patient with a past medical history of a transient loss of consciousness 15 years ago and an episode of chest pain 10 years ago was referred in January 2024 after a preoperative evaluation for inguinal hernioplasty, during which a cardiac murmur was detected. At a follow-up appointment in the outpatient clinic, a transthoracic echocardiogram was performed exhibiting significant leaflet thickening and calcification, severely restricting both opening and closure. These findings were associated with an eccentric systolic jet traversing an aneurysmal segment of the right sinus of Valsalva. The lesion resulted in mixed aortic valve disease, predominantly stenotic, with a peak transvalvular velocity of 3.7 m/s, a peak gradient of 55 mmHg, a mean gradient of 28 mmHg, and a left ventricular outflow tract velocity of 0.6 m/s. Mild aortic regurgitation was also present. Aortic measurements included an aortic annulus diameter of 2.0 cm (1.3 cm/m^2), sinus of Valsalva diameter of 3.9 cm (2.6 cm/m^2), sinotubular junction of 2.9 cm (1.9 cm/m^2), and ascending aorta diameter of 3.4 cm (2.2 cm/m^2). All of the following findings confirmed a tricuspid aortic valve with double aortic lesion and preserved left ventricle ejection fraction (LVEF), as well as the incidental finding of a right Valsalva sinus aneurysm *(Figure 1)*.

On September 19, 2024, a diagnostic coronary angiography was performed; finding a left-dominant coronary artery pattern was identified. The left anterior descending artery exhibited diffuse disease in the proximal and mid segments, with a focal lesion causing 70% stenosis in the distal segment. The circumflex artery also demonstrated diffuse disease, with a maximal stenosis of 70% in the distal segment. The right coronary artery showed diffuse proximal disease with

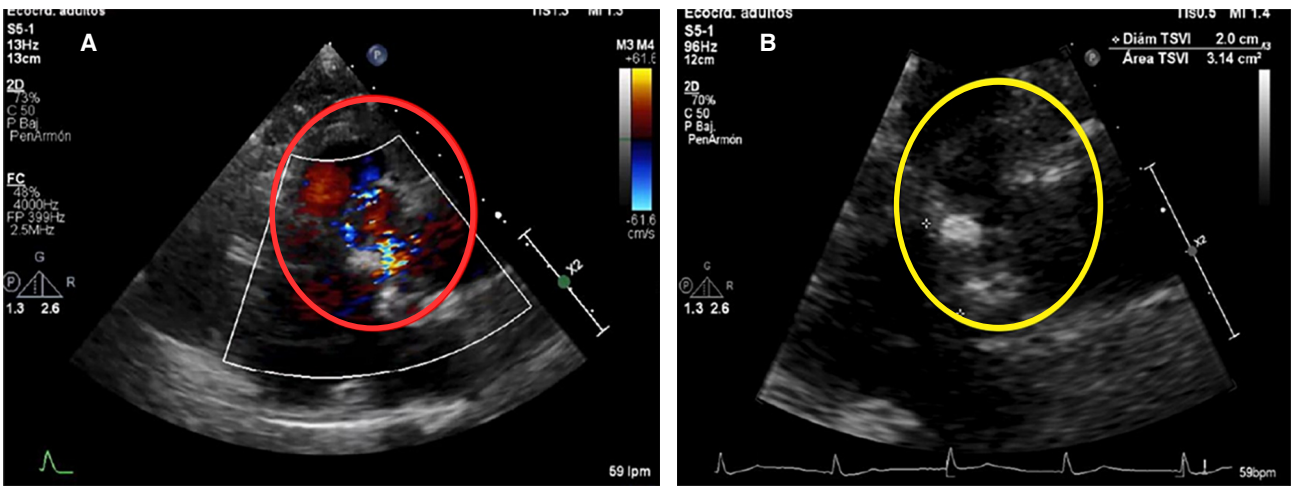

Figure 1: A) Dilatation of the sinus of Valsalva observed via color Doppler. **B)** Transthoracic echocardiogram image.

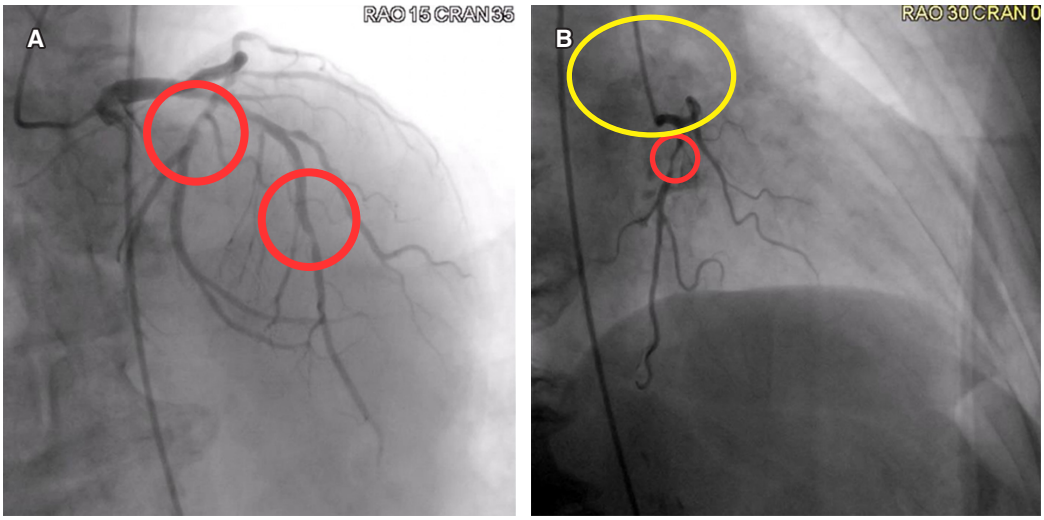

Figure 2:

A) Occlusion areas identified in the left coronary artery, specifically in its circumflex branch. **B)** The red circle delineates an occlusion area in the right coronary artery. The yellow circle identifies a slight deviation in the flow of contrast medium, caused by the dilation of the right sinus of Valsalva.

a maximal stenosis of 90%, all of this revealing triple-vessel coronary artery disease with a SYNTAX score of 22 *(Figure 2)*.

The patient was hospitalized for monitoring and was considered a candidate for Bentall and De Bono surgery with coronary artery bypass grafting (CABG), due to the presence mixed aortic valve disease. He underwent successful CABG and Bentall-De Bono operation.

A simultaneous dual approach was performed. The first consisted of a median sternotomy for the harvesting of the left internal thoracic artery in a caudo-cephalic direction, from its bifurcation up to the first costal arch, ensuring meticulous hemostasis of its branches through ligation. The second approach involved the dissection and procurement of the left great saphenous vein in a caudal direction. Systemic heparinization was administered, and purse-string sutures with 3-0 Prolene were placed: double sutures on the ascending aorta, and single sutures on the right atrium, right superior pulmonary vein, and the aortic root. Once an optimal activated clotting time was achieved, the aforementioned structures were cannulated, and cardiopulmonary bypass was initiated under normothermia. The ascending aorta was cross-clamped, and antegrade crystalloid cardioplegia was administered. CABG was first performed. Subsequently, a transverse aortotomy was performed, exposing both the left and right coronary ostia. The native aortic valve and ascending aorta were excised, preserving both ostia using a "button" technique. A modified Bentall procedure was performed using a 30 mm woven Dacron graft with a 27 mm aortic valve prosthesis. U-stitches with 2-0 Ethibond were placed and passed through the valved conduit. The graft was deployed using the parachute technique and secured. Coronary reimplantation was performed using 5-0 Prolene sutures for both the left and right coronary arteries. Adequate valve function and hemostasis were confirmed. The distal anastomosis of the Dacron graft to the native aorta was completed using 4-0 prolene.

Following this, the aortic cross-clamp was removed, and the patient returned to nodal rhythm, with temporary epicardial pacing leads placed. Weaning from cardiopulmonary bypass was successfully achieved on the first attempt, with stable hemodynamic parameters and adequate left heart decompression. Decannulation was performed, followed by protamine administration. Mediastinal packing was carried out for hemostasis. Chest drains were placed. Due to bleeding from the posterior surface of the pulmonary root, additional packing with two surgical rolls was required. The procedure was concluded, and the patient was transferred to the intensive care unit.

COMMENTARY

Aneurysms of the Valsalva sinuses are abnormalities of the aortic root that can be identified between the aortic valve annulus and the sinotubular junction. They may be of either congenital or acquired origin. Congenital aneurysms are associated with connective tissue disorders such as Marfan syndrome (characterized by fibrillin-1 deficiency, resulting in medial layer involvement) and Loeys-Dietz syndrome, caused by mutations in transforming growth factor beta (TGF-β) receptors. Both conditions contribute to the weakening of the tunica media. Alterations in elastin and collagen are the primary congenital causes affecting the normal histology of the Valsalva sinuses.[3,4]

Acquired forms arise from factors that lead to weakening of the tunica media and the extracellular matrix, most commonly due to ischemic processes affecting the vascular wall or conditions causing wall thickening. Infectious etiologies are

associated with propagation of infection, septic emboli, or direct invasion of the vascular wall. Likewise, non-infectious inflammatory processes, such as various forms of arteritis, are strongly associated. Valsalva sinus aneurysms frequently coexist with other pathologies such as ventricular septal defects, aortic valve disease, or infections like syphilis, endocarditis, or even trauma.[5,6]

The progression of this condition typically begins with an aneurysm that is initially asymptomatic. As the disease advances, valvular prolapse may occur, most commonly into the left ventricular outflow or inflow tract. Subsequent rupture results in a left-to-right shunt, the severity of which is proportional to the size of the rupture area. The classification proposed by Sakakibara and Konno remains the only formal system used to differentiate the various types of sinus of Valsalva aneurysms based on the affected coronary sinus and the anatomical region into which the aneurysm protrudes or ruptures *(Table 1)*.[4]

Diagnosis of this condition is primarily made using echocardiography, which is considered the gold standard. However, other diagnostic modalities, such as aortography, are also clinically valuable. Transthoracic echocardiography enables visualization of the aortic root, allowing identification of aneurysmal dilatation. It also facilitates the estimation of aneurysm size and assessment of associated abnormalities, such as aortic valve insufficiency or ventricular septal defects. On the other hand, transesophageal echocardiography provides superior imaging resolution, allowing better assessment of aneurysm extension and its effects on adjacent structures. These echocardiographic modalities have demonstrated a diagnostic accuracy of approximately 90% for ruptured sinus of Valsalva aneurysms and 75% for unruptured ones. They are also instrumental in determining the originating sinus, the severity of the condition, and the associated mechanisms contributing to the pathophysiology.[6,7]

Table 1: Classification of sinus of Valsalva aneurysms proposed by Sakakibara and Konno.

Type I	Connects the right sinus of Valsalva and the right ventricular outflow tract below the pulmonary valve
Type II	Connects the right sinus of Valsalva and the right ventricle at the crista supraventricularis
Type III	
IIIa	Connects the right sinus of Valsalva and the right atrium
IIIv	Connects the posterior area of the right sinus of Valsalva and the right ventricle
IIIa+v	Connects the right sinus of Valsalva to both the right atrium and the right ventricle
Type IV	Connects the non-coronary sinus of Valsalva and the right atrium

Classification for aneurysms of the sinus of Valsalva proposed by Sakakibara and Kono according to Arenaza.[1]

Color Doppler imaging may also be utilized to visualize systolic and diastolic flow patterns, considering the physiological principle that the aorta functions as a high-pressure system. This allows for the observation of flow diversion from the aortic outflow into the aneurysmal sac. Other imaging techniques, such as magnetic resonance imaging, contrast-enhanced aortography, and computed tomography, may also be employed. Aortography, in particular, offers the advantage of evaluating other aortic regions and facilitates the inclusion or exclusion of differential diagnoses.[7,8]

The treatment of choice in these cases is always surgical intervention. According to the 2024 European Society of Cardiology (ESC) Guidelines on the diagnosis and treatment of aortic diseases, published by ESC, various surgical techniques are available to appropriately address this condition. It is crucial to emphasize that conservative measures are both ineffective and insufficient for achieving proper management of this pathology.

Based on the underlying pathophysiology of sinus of Valsalva aneurysms, ruptured cases are associated with more rapid clinical deterioration, often leading to congestive heart failure as a result of the aforementioned left-to-right shunt. Consequently, the European guidelines recommend surgical repair even for unruptured aneurysms when they are associated with malignant arrhythmias, infection, coronary artery obstruction, or obstruction of the ventricular outflow tract. Therefore, the aneurysm's rate of progression must be considered a key factor when determining the timing of surgical intervention, along with any coexisting pathologies.

In the present case, CABG was performed due to the patient's significant coronary artery disease. A Bentall and De Bono procedure was selected to address the associated aortic valve involvement and right sinus of Valsalva dilatation. In accordance with the ESC guidelines, the selected approach allowed for complete management of the coronary artery disease and correction of the aneurysmal dilation and valvular dysfunction through replacement with a prosthetic valve. Therefore, it's important to emphasize in the Need of an individualize approach to every case that allows the attendings to get a more realistic scenario while applying the knowledge and algorithms established by different type of guideline as the ones of ESC allowing to have a more punctual approach to the patient case type, and how that can be a determining factor in identifying the differences in mortality rates, and the type of surgical management that is required. It's essential to understand that identifying and classifying sinus of Valsalva aneurysms is key to achieving the right approach and the best surgical choice.

CONCLUSIONS

The coexistence of a double aortic valve lesion, right sinus of Valsalva aneurysm and ischemic cardiomyopathy is unusual. This case highlights the need for a comprehensive evaluation of the hemodynamic impact of each condition and their surgical approach. The successful outcome after a Bentall and de Bono procedure supports its role as an effective option in comparable cases.

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Coronary steal syndrome due to right coronary ostium agenesis: a case report

Síndrome de robo coronario por agenesia del ostium derecho: reporte de caso

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ABSTRACT

A single coronary artery ostium with anomalous right coronary artery (RCA) origin from collateral circulation of the left anterior descending artery is a rare variant associated with multiterritorial ST elevation myocardial infarction and high surgical complexity. We present a 54-year-old man who suffered cardiac arrest secondary to pneumonia-induced myocarditis. Cardiac Computed Tomography Angiography (CCTA) revealed a 2.6 mm LAD-RCA fistula. Stress testing showed anterior ischemia with steal syndrome, and coronary angiography confirmed the anomaly. The patient underwent successful RCA revascularization.

Keywords: coronary vessels, coronary vessel anomaly, single coronary artery, coronary steal syndrome, collateral circulation.

RESUMEN

Un ostium coronario único con origen anómalo de la arteria coronaria derecha (CD) a partir de la circulación colateral de la arteria descendente anterior izquierda (DA) es una variante rara asociada con infarto del miocardio con elevación del segmento ST multiterritorial y elevada complejidad quirúrgica. Presentamos el caso de un hombre de 54 años que sufrió paro cardiaco secundario a miocarditis inducida por neumonía. La angiotomografía coronaria reveló una fístula DA-CD de 2.6 mm. La prueba de esfuerzo mostró isquemia anterior con síndrome de robo, y la angiografía coronaria confirmó la anomalía. El paciente fue sometido a revascularización exitosa de la arteria CD.

Palabras clave: *vasos coronarios, anomalía de las arterias coronarias, arteria coronaria única, síndrome de robo coronario, circulación colateral.*

Abbreviations:
CCTA = Cardiac computed tomography angiography
LVEF = Left ventricular ejection fraction
RCA = Right coronary artery
STEMI = ST-Elevation myocardial infarction

A single coronary ostium with an anomalous origin of the Right Coronary Artery (RCA), arising from collateral circulation of the left anterior descending artery represents an uncommon variation of a single coronary artery.[1] Although it generally has a benign prognosis, it can potentially

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present as an ST-Elevation Myocardial Infarction (STEMI) affecting the anterior, inferior, and right ventricular regions simultaneously. The management of STEMI in anomalous coronary arteries can pose frequent surgical challenges, requiring interventional cardiologists and thoracic surgeons to be familiar with these unusual coronary patterns, as they may necessitate innovative and adaptable technical approaches.[2]

We present the case of a 54-year-old man with a two-week clinical course characterized by cough, orthopnea, progressive exertional dyspnea, and lower limb edema, complicated by septic shock secondary to community-acquired pneumonia, which led to septic myocarditis and a post-cardiac arrest state. After the patient was stabilized, a coronary CT angiography was performed, revealing a 2.6 mm fistula originating from the left anterior descending artery, located between its mid and proximal segments, with apparent communication toward the right coronary artery. An exercise stress test demonstrated exercise-induced angina and a steal phenomenon in the anterior wall. Subsequently, a diagnostic coronary angiography was performed to more precisely delineate the coronary anatomy and confirm collateral circulation from the left anterior descending artery.

CASE REPORT

A 54-year-old man with no significant past medical history developed a rapidly evolving cardiopulmonary syndrome. Initial complaints included a two week-history of cough, orthopnea, progressively worsening dyspnea on moderate exertion, and lower extremity edema. This presentation was complicated by septic shock secondary to community-acquired pneumonia, which precipitated septic myocarditis, a subsequent post–cardiac arrest state, and acute kidney injury classified as Kidney Disease: Improving Global Outcomes (KDIGO) stage IIIB. Initial laboratory workup revealed atrial fibrillation and an elevated brain natriuretic peptide level of 1160 pg/ml. Following prompt resuscitation with vasopressors and broad-spectrum antibiotic therapy. A transthoracic echocardiogram revealed generalized biventricular hypokinesia with a markedly reduced Left Ventricular Ejection Fraction (LVEF) of 20%. Initial intensive management included vasopressors for hemodynamic stabilization, dobutamine to enhance cardiac output, and furosemide for decongestion. Atrial fibrillation was controlled with amiodarone, digoxin, and anticoagulation. The resulting clinical improvement reflected a modest improvement in systolic function with an LVEF rising to 30%. However, there remained evidence of a dilated left ventricle with eccentric hypertrophy, hypokinesia in the inferoseptal, basal, and mid segments, and biatrial enlargement. A stress test was performed, which demonstrated exercise-induced angina and a steal phenomenon in the anterior wall. In parallel with these echocardiographic findings, a Cardiac Computed Tomography Angiography (CCTA) was performed as part of the heart failure workup. The CCTA revealed a 2.6 mm fistula originating from the left anterior descending artery, located between the mid and proximal thirds, with apparent communication to the right coronary artery, in addition to cardiac chamber dilation and LVEF of 30% *(Fig. 1)*. Subsequently, a diagnostic coronary angiography was performed to delineate the coronary anatomy further and confirm the collateral circulation from the left anterior descending artery *(Fig. 2)*. The patient underwent cardiac surgery, including right coronary artery revascularization, closure of anomalous collateral vessels, mitral valve repair with a full semi-rigid ring, and left atrial appendage exclusion *(Fig. 3)*. Given the complexity of the procedure, an intra-aortic balloon pump was placed intraoperatively. Postoperatively, the patient showed clinical improvement

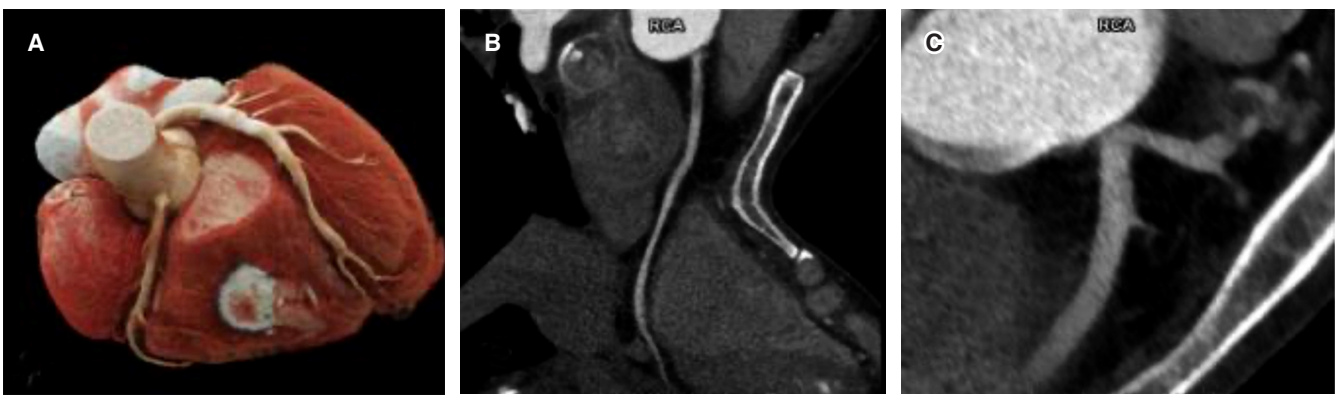

Figure 1: A) Overview of coronary vessels course. **B)** Anatomical course of the anomalous right coronary artery. **C)** CCTA showing absent right coronary artery ostium and the proximal segment of the right coronary artery.

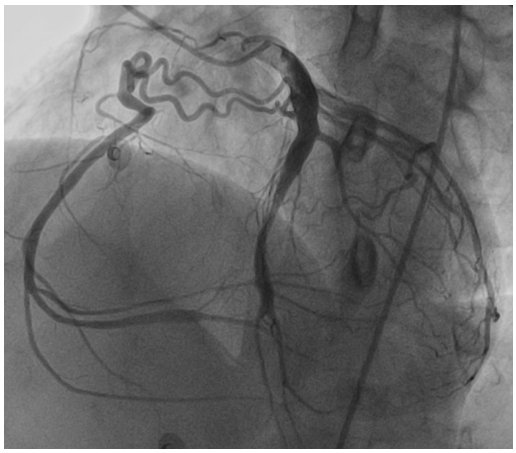

Figure 2: Coronary angiography delineating the coronary anatomy and confirm the collateral circulation from the left anterior descending artery.

in the intensive care unit and was discharged home in hemodynamically stable condition.

COMMENTS

Anomalous origin of the right coronary artery is a rare congenital anomaly first described in 1948 by White and Edwards,[3] its prevalence is between 0.026 and 0.25% of the general population. An anomalous origin of the right coronary artery can lead to angina pectoris, myocardial infarction, or sudden death, in the absence of atherosclerosis.[4] The interarterial course of the anomalous RCA between the aorta and pulmonary artery predisposes it to mechanical compression, kinking, and stretching, particularly during exertion when diastolic expansion of the great vessels occurs, ischemia is primarily attributed to the intramural course rather than the ostial location.[4] The diagnosis of coronary artery anomalies relies on multiple imaging modalities, including echocardiography, cardiac magnetic resonance imaging, and CCTA. Among these, CCTA stands out as an excellent complementary technique for evaluating congenital coronary anomalies due to its superior spatial and temporal resolution. With a temporal resolution of just 66 ms, CCTA enables high-quality imaging even at elevated heart rates, surpassing some of the limitations of the cardiac magnetic resonance imaging. This modality provides high-resolution visualization of distal coronary vessels, allowing for detailed 3D reconstruction of the coronary anatomy and its relationship with extracardiac structures and the sternum. Additionally, it facilitates the detection of calcified or stenotic coronary segments while enabling the simultaneous assessment of ventricular function and associated cardiovascular abnormalities using a single imaging dataset.[5,6] Despite advancements in non-invasive imaging techniques, cardiac catheterization remains a critical diagnostic modality. Its advantages lie in the ability to comprehensively evaluate the entire course and distribution of the coronary arteries. Selective angiography is particularly valuable in detecting small, discrete occlusions or interruptions of the coronary artery, where collateral circulation reconstitutes the vessel. Additionally, direct catheter-based imaging provides superior assessment of distal flow distribution and vessel patency, overcoming limitations associated with non-invasive methods. Intravascular ultrasound allows for direct visualization of coronary artery wall architecture, while fractional flow reserve enables quantitative evaluation of flow alterations across coronary stenoses.[6] Various surgical techniques have demonstrated favorable outcomes, with reimplantation emerging as an option that provides anatomic correction while avoiding long-term complications associated with coronary artery bypass grafting. Although unroofing is widely performed, studies have reported cases of persistent ischemia, suggesting the need for an individualized approach based on the patient's anatomical characteristics. Despite technical challenges, reimplantation has shown excellent mid-term outcomes by eliminating the intramural segment and associated stenotic disease, achieving anatomic correction while circumventing the late complications of conduit failure associated with bypass grafting, positioning itself as an effective strategy in the management of this condition.[7]

CONCLUSIONS

This case highlights the varied presentation of coronary anomalies and emphasizes the importance of prompt multimodal imaging and personalized surgical management, including revascularization of the RCA and mitral valve repair, to optimize outcomes in complex anatomical settings.

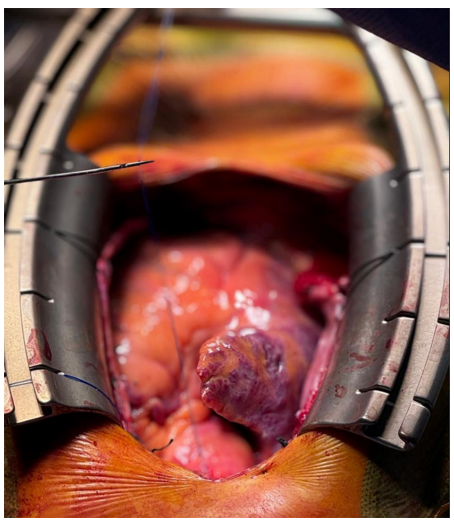

Figure 3: Coronary artery revascularization.

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Management of pulmonary bullae by thoracotomy versus minimally invasive approach

Tratamiento de las bullas pulmonares mediante toracotomía frente a abordaje mínimamente invasivo

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ABSTRACT

The most common causes of bullous emphysema include smoking, exposure to biomass, and α-1 antitrypsin deficiency. Symptoms include progressive dyspnea, productive cough, decreased exercise tolerance, and wheezing. Surgical management options include thoracotomy or video-assisted thoracoscopy. When choosing the ideal approach for each patient, the extent and location of the bullae, comorbidities, and risk of recurrence, among other factors, must be considered. We present two surgical cases: a 45-year-old woman with a history of biomass exposure and a giant bulla causing acute respiratory distress, successfully treated with thoracotomy; and a 25-year-old man who developed a spontaneous pneumothorax with associated subpleural cysts at high altitude, managed via video-assisted thoracoscopic bullectomy.

Keywords: pulmonary bullae, bullous emphysema, chronic obstructive pulmonary disease, thoracotomy, video-assisted thoracoscopy.

RESUMEN

Las causas más comunes de enfisema bulloso incluyen el tabaquismo, la exposición a biomasa y la deficiencia de α-1 antitripsina. Los síntomas incluyen disnea progresiva, tos productiva, disminución de la tolerancia al ejercicio y sibilancias. Las opciones de tratamiento quirúrgico incluyen toracotomía o videotoracoscopia. Al elegir el abordaje ideal para cada paciente, se deben considerar la extensión y la ubicación de las bullas, las comorbilidades y el riesgo de recurrencia, entre otros factores. Presentamos dos casos quirúrgicos: una mujer de 45 años con antecedentes de exposición a biomasa y una bulla gigante que le causó dificultad respiratoria aguda, tratada con éxito mediante toracotomía; y un hombre de 25 años que desarrolló un neumotórax espontáneo con quistes subpleurales asociados con gran altitud, tratado mediante bullectomía videotoracoscópica.

Palabras clave: *bullas pulmonares, enfisema bulloso, enfermedad pulmonar obstructiva crónica, toracotomía, toracoscopia videoasistida.*

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Pulmonary bullae are air-filled spaces larger than 1 cm in the lung parenchyma.[1] They form as a result of the loss of distal lung architecture, causing airflow limitation due to tissue destruction and enlargement of the alveolar spaces beyond the terminal bronchioles. These lesions most commonly affect the upper lobe.[2] This clinical condition is called bullous emphysema.[3,4]

A giant bulla is defined as one that affects 30% or more of a hemithorax. These giant bullas can form slowly as they gradually fill with air, or they can enlarge rapidly and progress to become tension bullae.[2,5]

There are three types of bullous emphysema:[6]

- **Type I:** isolated bullae.
- **Type II:** subpleural bullae.
- **Type III:** generalized bullae affecting the entire lung.

The most common causes of bullous emphysema include smoking, exposure to biomass,[7] and α-1 antitrypsin deficiency.[3] Exposure to tobacco smoke causes the destruction of alveolar walls and permanent dilation of air spaces by inducing oxidative stress due to the presence of free radicals.[8] In relation to exposure to biomass, people exposed to this pollutant have a 2.44 odds ratio (95% CI, 1.9-3.33) of developing COPD.[9] Exposure to biomass is more common in women who perform domestic tasks in rural areas, such as preparing food on wood-burning stoves, in whom the relative risk of COPD was estimated at 3.2 (95% CI, 2.3-4.8).[9]

On the other hand, α-1 antitrypsin deficiency is a hereditary condition characterized by decreased plasma and tissue levels of alpha-1 antitrypsin. This protein protects lung tissue against elastases produced by neutrophils during inflammatory processes, participating in the modulation of the immune system and tissue repair.[10]

The clinical manifestations of bullous emphysema include progressive dyspnea, productive cough, decreased tolerance to physical activity, and wheezing. Physical examination usually reveals signs of pulmonary hyperinflation, such as decreased chest expansion and decreased breath sounds.[11,12] As the disease progresses, complications such as respiratory failure, spontaneous pneumothorax,[13] or infections may occur.[14]

On chest X-rays, pulmonary bullae appear as unilateral hyperlucency like that seen in pneumothorax. In addition, contralateral mediastinal shifts similar to that of a tension pneumothorax may occur.[15]

CASE DESCRIPTION

Case 1: this is a 45-year-old woman who presents to the emergency department complaining of sudden pain in the left hemithorax and dyspnea with oxygen saturation of 70%, she denies fever or cough, with a relevant history of prolonged exposure to biomass smoke as she has been cooking her food on a wood stove for 25 years; She also has systemic hypertension diagnosed a year ago and is being treated with metoprolol and enalapril.

During the physical examination, a decrease in respiratory thoracic movements is detected, with abolished pulmonary sounds and tympanic percussion in the left hemithorax. A follow-up chest X-ray was taken, revealing the presence of a giant bulla covering approximately 90% of the left hemithorax *(Fig. 1)*.

The thoracic surgery department was consulted and the patient was scheduled for a posterior thoracotomy with muscle preservation. The surgical procedure was performed successfully, removing all of the tissue affected by the bulla. A size 24 drainage tube was left in place and a follow-up chest X-ray was taken 15 days after the surgery, showing favorable clinical progress *(Fig. 2)*.

Case 2: a 25-year-old male patient, previously healthy, with no known significant personal medical history, non-smoker, no exposure to biomass, no previous history of lung disease or chest procedures. During a trip to a mountainous area (higher altitude above sea level), he presented with sudden onset of dyspnea, initially mild, which worsened with altitude. This was accompanied by stabbing-like chest pain, located in the left hemithorax, without radiation, which increased with deep inspiration.

A chest X-ray was performed, which reported a left pneumothorax in the apical region of the superior lobe. Subsequently, a chest CT scan was performed, confirming left pneumothorax in the upper lobe and the presence of bilateral subpleural cysts in the lung apices and left lung base, all less than 1 cm in size, and left basal subsegmental atelectasis *(Fig. 3)*.

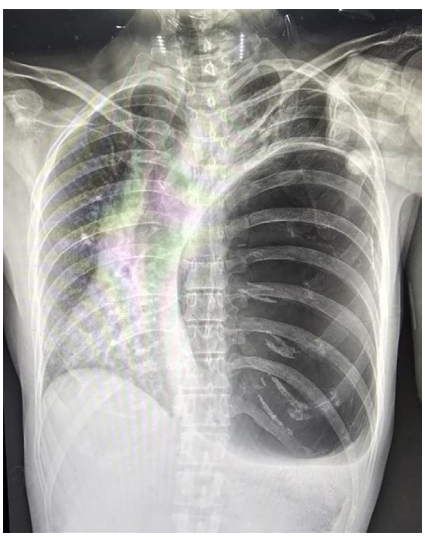

Figure 1:

Anteroposterior chest X-ray showing the presence of a giant bulla occupying 90% of the left hemithorax.

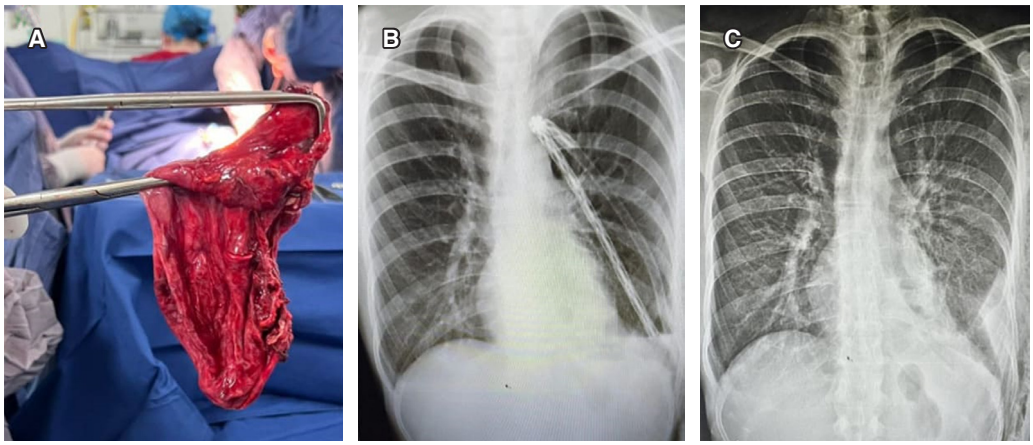

Figure 2:

A) Resection of the giant pulmonary bulla. **B)** Anteroposterior chest X-ray immediately after the surgical procedure. Placement of a size 24 Kardia Spiral pleural tube. **C)** Anteroposterior chest X-ray taken 15 days after the surgical procedure showing adequate re-expansion of the lung tissue with a favorable clinical outcome.

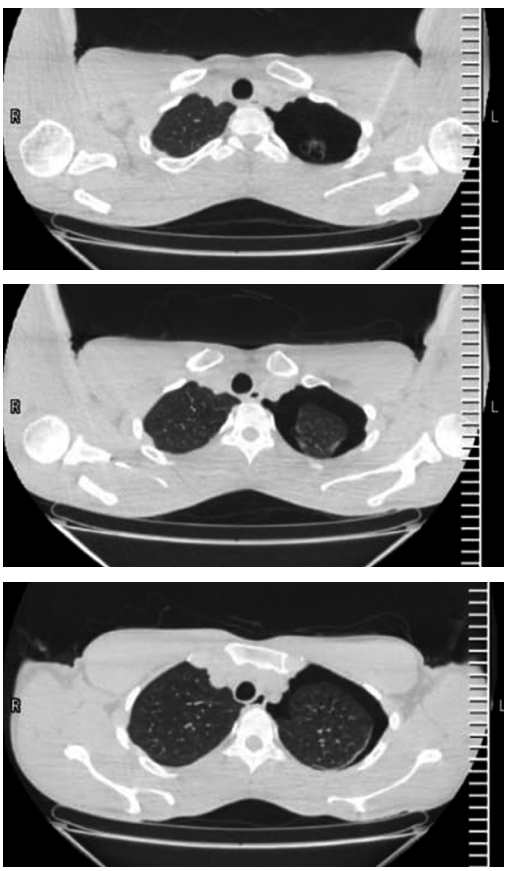

Figure 3: Axial chest tomography showing left pneumothorax predominantly affecting the upper lobe, bilateral apical subpleural cysts, and left basal cysts.

Regarding the surgical management of this patient, due to the size of the lesions, a minimally invasive approach was chosen using *video*-assisted thoracoscopic bullectomy with linear resection *(Fig. 4)*.

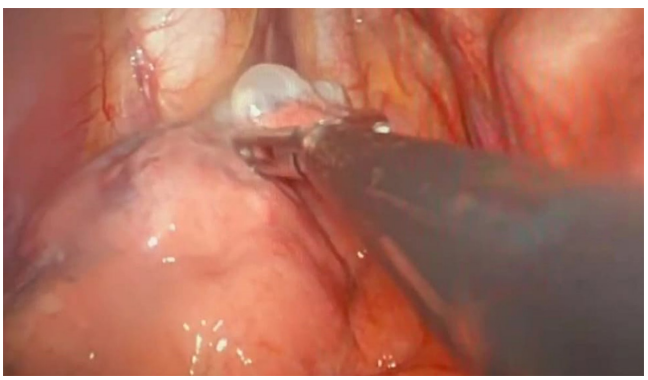

Figure 4: Minimally invasive approach using video-assisted thoracoscopic bullectomy with linear resection.

COMMENT

There are two surgical approaches to treating pulmonary bullae: an open approach using thoracotomy and a minimally invasive approach by thoracoscopy.

Thoracotomy is the preferred approach for emergency cases or for extensive defects affecting a large part of the lung tissue.[16] Another indication for thoracotomy is the presence of pachypleuritis, since when it is extensive (> 2 cm), open surgery is recommended. In addition, other researchers mention that recurrences are less frequent with thoracotomy than with video-assisted surgery.[17] Thoracotomy requires the use of selective bronchial intubation to allow airway management, favoring left or right lung collapse to facilitate surgical access to the affected lung.[18] However, the disadvantage is a longer recovery time due to tissue manipulation and a higher risk of infection.[19]

The video-assisted thoracoscopy approach has the benefit of being both a diagnostic and therapeutic procedure, widely used in the management of pleural effusions, lung biopsies,

or pneumothorax management.[20,21] This procedure has many advantages, such as shorter recovery time, reduced use of postoperative analgesics, and lower incidence of complications.[22] In addition, several authors mention that this type of approach is particularly effective in pediatric patients, minimizing intraoperative bleeding, achieving more cosmetic results, and shortening hospital stays.[23] Other authors mention that minimally invasive approaches in pediatrics provide a better quality of life in psychological and physical terms.[24] However, one of the possible disadvantages of this approach includes a longer duration of the surgery[25] and probably a higher total cost of the surgical procedure.[26]

CONCLUSIONS

Choosing the type of surgical approach for the treatment of pulmonary bullae remains controversial since several factors must be considered, such as the size of the lung flaw, as well as the patient's age, presence of comorbidities, risk of recurrence, among others. However, the best approach in managing this pulmonary pathology will always be the individualized treatment, where treatment and management are tailored to the characteristics of each patient.

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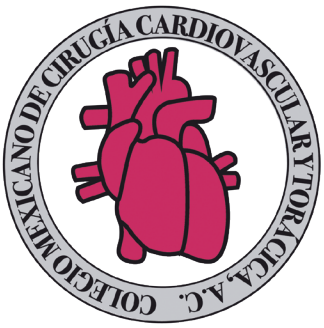

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