Journal of Advanced Zoology

ISSN: 0253-7214

Volume ***44*** *Issue* ***S-3 Year 2023*** *Page* ***1:9***

Assessment the Accuracy of Risk Adjustment in Congenital Heart Surgery Score in Congenital Cardiac Centers at Dakahlya Government

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Article History

Received: 06 June 2023
Revised: 05 September 2023
Accepted: 21 September 2023

Abstract

Background: *There has been massive progress in congenital cardiac surgery outcomes analysis in the last two decades. The RACHS-1 score was developed to adjust for the huge difference in congenital cardiac pathologies when comparing the operative mortality for children undergoing paediatric congenital heart surgery.* ***Methods:*** *This prospective observational study was conducted on all patients undergoing cardiac surgery in all congenital heart surgery centers in Dakahlya Governorate, where we assessed the operative mortality post-surgery and compared it to the RACHS-1 expected mortality to assess the accuracy of using the RACHS-1 to predict mortality in our society.* ***Results:*** *This study included 559 patients in two years period, VSD was the most frequent diagnosis (13.6%), followed by Single ventricle (11.3%), then TOF (10.4%). VSD closure was the most frequent procedure (11.3%), followed by mB-T shunt (8.9%), then TOF repair (8.1%).* ***Day-30 outcome among the studied cases*** *Mortality was uncommon (7.9%), the main cause was heart in aetiology (43.2%). Mortality was significantly highest in HLHS, and then followed by TAPVD. The overall mortality according to each category was 1.2%, 3%, 8.57%, 17.39%, 0% and 57.1% for category 1, 2, 3, 4, 5 and 6.* ***Conclusion:*** *RACHS-1 is an accurate method to predict mortality early post operatively. Ventricular septal defect (VSD) was the most frequent diagnosis. VSD closure was the most frequent procedure, followed by mB-T shunt, then TOF repair, most of them were elective. The most common category of RACHS-1 was 3. HLHS, RACHS≥3, Palliation operation were significant independent factors increase the day-30 mortality.*

Keywords: *Congenital, Heart, Surgery*

1. Introduction

Tremendous Efforts are ongoing to improve the techniques and technologies available to evaluate and improve the outcomes of congenital cardiac surgeries. Patients after congenital cardiac surgeries are at risk of early mortality because of the abnormal cardiac function and arrhythmias, pulmonary vascular problems, and impaired lung function. They also frequently coexisting extracardiac abnormalities (Tabib et al., 2016).

The importance of outcomes analysis based on the fact that in the field of congenital cardiac surgery, using just mortality measurements without RA center to center (Cavalcante et al., 2016). There are major multi-institutional studies attempted to measure congenital cardiac surgery case complexity which are RACHS-1 score and the Aristotle Complexity Score (Jenkins et al., 2022).

RACHS-1 categories cardiac surgical procedures into six risk categories, based on expected early postoperative mortality, with category 1 representing the lowest risk and category 6 representing the highest risk. Along with the risk group, the RACHS-1 score adds age at time of surgery, prematurity, presence of a major noncardiac anomaly, and whether the patient is redo or not. The RACHS-1 score

showed accuracy in predicting postoperative mortality in several studies in both Europe and North America (Thiagarajam & Laussen, 2015).

2. Materials and Methods

This prospective observational study was conducted on all patients undergoing cardiac surgery in all congenital heart surgery centers in Dakahlya Governorate, where we assessed the operative mortality post-surgery and compared it to the RACHS-1 expected mortality to assess the accuracy of using the RACHS-1 to predict mortality in our society over 2 years period. 559 patients were included in this study.

Risk adjustment for congenital heart surgery (RACHS-1)

RACHS Category	Procedure	RACHS Category	Procedure
RACHS category 1	PDA >30 d	RACHS category 4	Truncus arteriosus repair
	Coarctation >30 d		Double switch
	ASD		Hypoplastic arch repair
RACHS category 2	VSD		Unifocalization
	TOF		Rastelli
	Vascular ring		ASO/VSD
	Coarctation <30 d		Konno
	AP Window		Atrial septectomy
RACHS category 3	ASO	RACHS category 5	TV repositioning in
	TOF/PA		Ebsteins anomaly <30 d
	Ross		Truncus/IAA
	ALCAPA	RACHS category 6	Norwood procedure
	DORV repair		DKS
	Coarctation/VSD		
	BTS		
	CAVC		
	PAB		

PDA indicates patent ductus arteriosus; ASD, atrial septal defect; VSD, ventricular septal defect; TOF, tetralogy of Fallot; AP, aortopulmonary; ASO, arterial switch operation; PA, pulmonary atresia; ALCAPA, anomalous left coronary artery to the pulmonary artery; DORV, double outlet right ventricle; BTS, Blalock-Tuassig shunt; CAVC, complete atrioventricular canal; PAB, pulmonary artery band; TV, tricuspid valve; DKS, Damus Kaye Stancil.

Statistical methods: The collected data were coded, tabulated, and statistically analyzed using IBM SPSS statistics (Statistical Package for Social Sciences) software version 28.0, International Business Machines Corporation., Chicago, USA, 2021. Quantitative data tested for normality using Shapiro-Wilk test, then if normally distributed described as mean±SD (standard deviation) as well as minimum and maximum of the range, then compared using independent t-test, and if not normally distributed described as Median (1st−3rd Interquartiles) then compared using Mann Whitney test. Qualitative data described as number and percentage and compared using Chi square test as well as Fisher's exact test for variables with small expected numbers. Logistic regression was used to find out factors affecting outcomes. The level of significance was taken at p-value <0.050 was significant, otherwise was non-significant.

3. Results and Discussion

Table (1): Demographic characteristics among the studied cases

Variables		Median (1st−3rd IQ)	Range
Age (days)		286.0 (92.0–961.0)	5.0–41399.0
Weight (kg)		7.1 (4.1–12.0)	1.9–83.0
		Mean±SD	**Range**
GA (weeks)		37.5±1.4	30.0–40.0
Birth weight (kg)		3.0±0.6	1.0–5.2
		n	**%**
Gender	**Male**	277	49.6%
	Female	282	50.4%
Age category	**Children>1y**	68	12.2%
	Infant<1y	491	87.8%
Prematurity		23	4.1%
Syndrome		50	8.9%
Down		29	5.2%
Heterotaxy		11	2.0%

William's	3	0.5%
Shone's complex	2	0.4%
DiGeorge	2	0.4%
Noonan's	1	0.2%
Cutis Laxa	1	0.2%
Bardet Biedl	1	0.2%

Total=559. IQ: Interquartiles

Table (1) shows **demographic characteristics among the studied cases**.

Table (2): Diagnosis among the studied cases

Diagnosis	n	%
ALCAPA	2	0.4
Aortic valve disease	15	2.7
AP window	2	0.4
ASD	35	6.3
AVSD	23	4.1
ccTGA	12	2.1
CoA	30	5.4
Coronary fistula	2	0.4
DORV	23	4.1
Ebsteins's anomaly	4	0.7
HLHS	8	1.4
Hypoplastic Aortic Arch	21	3.8
Interrepted aortic arch	6	1.1
LV Pseudo aneurysm	1	0.2
Mitral valve disease	21	3.8
PA, IVS	5	0.9
PA, VSD	11	2.0
PA, VSD, MAPCAs	5	0.9
PAPVR	3	0.5
PAVSD	15	2.7
PDA	16	2.9
RVOTO	11	2.0
SAM	4	0.7
Single ventricle	63	11.3
TAPVD	10	1.8
TGA, IVS	37	6.6
TGA, VSD	10	1.8
TGA, VSD, PS	10	1.8
TOF	58	10.4
Truncus Arteriosus	13	2.3
Vasclar ring	7	1.3
VSD	76	13.6

Table (2) shows VSD was the most frequent diagnosis (13.6%), followed by Single ventricle (11.3%), then TOF (10.4%)

Table (3): Procedure among the studied cases

Procedure		
ALCAPA repair	2	0.4
Aortic valve repair	9	1.6
AP window repair	2	0.4
Arch reconstruction	27	4.8
Arterial switch	36	6.4
ASD closure	33	5.9

AVSD Repair	14	2.5
BDG	24	4.3
Bilateral PA Banding	1	0.2
CoA repair	30	5.4
Cone repair	4	0.7
CORONARY artery fistula closure	2	0.4
DORV Repair	16	2.9
Double switch	8	1.4
Fontan	12	2.1
LV aneurysm repair	1	0.2
M Aortic valve replacement	1	0.2
M Mitral replacement	6	1.1
mBT shunt	50	8.9
Mitral Valve repair	15	2.7
modified-Konno	1	0.2
Mustard	7	1.3
Nikaidoh	5	0.9
Norwood	7	1.3
PA banding	39	7.0
PA, VSD repair	8	1.4
PAPVR repair	3	0.5
PAVSD repair	14	2.5
PDA Ligation	16	2.9
Rastelli	3	0.5
Ross	5	0.9
RV-PA conduit placement	1	0.2
RVOTO repair	9	1.6
SAM resection	3	0.5
Senning	3	0.5
TAPVD repair	10	1.8
TOF repair	46	8.3
Truncus arteriosus repair	12	2.1
Unifocalization	3	0.5
Vascular ring division	7	1.3
VSD closure	63	11.3
Yasui Operation	1	0.2

Table (3) shows VSD closure was the most frequent procedure (11.3%), followed by mB-T shunt (8.9%), then TOF repair (8.1%).

Table (4): Day-30 outcome among the studied cases

Variables		**N**	**%**
Mortality	**Death**	44	7.9%
	Survival	515	92.1%
Causes of mortality	**Neurological complications**	4	9.1%
	Cardiac complications	19	43.2%
	Pulmonary complications	10	22.7%
	MOF	7	15.9%
	Shunt Problems	4	9.1%

Table (4) shows **Day-30 outcome among the studied cases**. Mortality was uncommon (7.9%), the main cause was heart in aetiology (43.2%).

Table (5): Comparison showing effect of demographic characteristics on day-30 mortality

Variables		Mortality (n=44)	Survival (n=515)	p-value
Age (Days)		59.0 (25.0–954.0)	299.0 (110.0–973.0)	⌂**0.002***
Weight (kg)		4.1 (3.0–11.1)	7.5 (4.5–12.0)	⌂**0.002***
Gender	**Male**	17 (38.6%)	260 (50.5%)	#0.131
	Female	27 (61.4%)	255 (49.5%)	
GA (weeks)		37.1±1.2	37.5±1.4	^0.057
Birth weight (kg)		2.8±0.5	3.0±0.6	^0.056
Prematurity		3 (6.8%)	20 (3.9%)	§0.414
Syndrome		3 (6.8%)	47 (9.1%)	§0.787
Down		1 (2.3%)	28 (5.4%)	§0.719
Heterotaxy		1 (2.3%)	10 (1.9%)	§0.598
William's		0 (0.0%)	3 (0.6%)	§0.999
Shone's complex		0 (0.0%)	2 (0.4%)	§0.999
DiGeorge		1 (2.3%)	1 (0.2%)	§0.151
Noonan's		0 (0.0%)	1 (0.2%)	§0.999
Cutis Laxa		0 (0.0%)	1 (0.2%)	§0.999
Bardet Biedl		0 (0.0%)	1 (0.2%)	§0.999

^Independent t-test. ⌂Mann Whitney test. #Chi square test. §Fisher's Exact test. *Significant

Table (5) shows Cases dead by day-30 significantly had lower age and weight.

Table (6): Comparison according to day-30 mortality regarding Diagnosis

Diagnosis	Mortality (n=44)	Survival (n=515)
ALCAPA	1 (50.0%)	1 (50.0%)
Aortic stenosis	0 (0.0%)	1 (100.0%)
Aortic valve disease	0 (0.0%)	14 (100.0%)
AP window	0 (0.0%)	2 (100.0%)
ASD	1 (2.9%)	34 (97.1%)
AVSD	1 (4.3%)	22 (95.7%)
ccTGA	2 (16.7%)	10 (83.3%)
CoA	0 (0.0%)	30 (100.0%)
Coronary fistula	0 (0.0%)	2 (100.0%)
DORV	1 (4.3%)	22 (95.7%)
DTGA	0 (0.0%)	1 (100.0%)
Ebsteins's anomaly	0 (0.0%)	4 (100.0%)
HLHS	4 (57.1%)	3 (42.9%)
Hypoplastic Aortic Arch	2 (9.5%)	19 (90.5%)
Interrepted aortic arch	0 (0.0%)	6 (100.0%)
LV aneurysm	0 (0.0%)	1 (100.0%)
Mitral valve disease	2 (9.5%)	19 (90.5%)
PA, IVS	1 (20.0%)	4 (80.0%)
PA, VSD	2 (18.2%)	9 (81.8%)
PA, VSD, MAPCAs	0 (0.0%)	5 (100.0%)
PAPVR	0 (0.0%)	3 (100.0%)
PAVSD	1 (6.7%)	14 (93.3%)
PDA	0 (0.0%)	16 (100.0%)
RVOTO	0 (0.0%)	11 (100.0%)
SAM	0 (0.0%)	4 (100.0%)
Single ventricle	9 (14.8%)	54 (85.2%)
TAPVD	3 (33.3%)	7 (66.7%)

TGA, IVS	4 (11.1%)	32 (88.9%)
TGA, VSD	1 (10.0%)	9 (90.0%)
TGA, VSD, PS	0 (0.0%)	10 (100.0%)
TOF	3 (5.2%)	55 (94.8%)
Truncus Arteriosus	3 (23.1%)	10 (76.9%)
Vasclar ring	0 (0.0%)	7 (100.0%)
VSD	2 (2.6%)	74 (97.4%)

Percentages were taken from rows (per diagnosis). §Fisher's Exact test. *Significant
Table (6) shows Mortality was significantly highest in HLHS, then followed by TAPVD

Table (7): Comparison according to day-30 mortality regarding procedure

Procedure	Mortality (n=44)	Survival (n=515)	p-value
ALCAPA repair	1 (50.0%)	1 (50.0%)	
Aortic valve repair	0 (0.0%)	9 (100.0%)	
AP window repair	0 (0.0%)	2 (100.0%)	
Arch reconstruction	2 (7.4%)	25 (92.6%)	
Arterial switch	3 (8.3%)	33 (91.7%)	
ASD closure	1 (3.0%)	32 (97.0%)	
AVSD Repair	1 (7.1%)	13 (92.9%)	
BDG	1 (4.2%)	23 (95.8%)	
Bilateral PA Banding	0 (0.0%)	1 (100.0%)	
CoA repair	0 (0.0%)	30 (100.0%)	
Cone repair	0 (0.0%)	4 (100.0%)	
CORONARY artery fistula closure	0 (0.0%)	2 (100.0%)	
DORV Repair	1 (6.3%)	15 (93.8%)	
Double switch	1 (12.5%)	7 (87.5%)	
Fontan	4 (33.3%)	8 (66.7%)	
LV aneurysm repair	0 (0.0%)	1 (100.0%)	
M Aortic valve replacement	0 (0.0%)	1 (100.0%)	
M Mitral replacement	1 (16.7%)	5 (83.3%)	
mBT shunt	7 (14.0%)	43 (86.0%)	
Mitral Valve repair	1 (6.7%)	14 (93.3%)	**§<0.001***
modified-Konno	0 (0.0%)	1 (100.0%)	
Mustard	0 (0.0%)	7 (100.0%)	
Nikaidoh	0 (0.0%)	5 (100.0%)	
Norwood	4 (57.1%)	3(42.9%)	
PA banding	2 (5.1%)	37 (94.9%)	
PA, VSD repair	1 (12.5%)	7 (87.5%)	
PAPVD repair	0 (0.0%)	3 (100.0%)	
PAVSD repair	1 (7.1%)	13 (92.9%)	
PDA Ligation	0 (0.0%)	16 (100.0%)	
Rastelli	0 (0.0%)	3 (100.0%)	
Ross	0 (0.0%)	5 (100.0%)	
RV-PA conduit placement	0 (0.0%)	1 (100.0%)	
RVOTO repair	0 (0.0%)	9 (100.0%)	
SAM resection	0 (0.0%)	3 (100.0%)	
Senning	1 (33.3%)	2 (66.7%)	
TAPVD repair	3 (30.0%)	7 (70.0%)	
TOF repair	2 (4.4%)	44 (95.6%)	
Truncus arteriosus repair	3 (25.0%)	9 (75.0%)	
Unifocalization	0 (0.0%)	3 (100.0%)	
Vascular ring division	0 (0.0%)	7 (100.0%)	

VSD closure	2 (3.2%)	61 (96.8%)
Yasui Operation	0 (0.0%)	1 (100.0%)

Percentages were taken from rows (per procedure). §Fisher's Exact test. *Significant

Table (7) shows Mortality was significantly highest in Norwood, followed by Fontan 33.3% then TAPVD repair 30%.

Table (8): Comparison according to day-30 mortality regarding Operation characteristics

Variables		Mortality (n=44)	Survival (n=515)	p-value
Urgency	**Elective**	29 (65.9%)	406 (78.8%)	
	Emergency	3 (6.8%)	18 (3.5%)	#0.129
	Urgent	12 (27.3%)	91 (17.7%)	
Procedure type	**Repair**	25 (56.8%)	383 (74.4%)	
	Palliation	19 (43.2%)	132 (24.7%)	**§0.030***
RACHS	**1**	1 (2.3%)	82 (15.9%)	**§<0.001***
	2	5 (11.4%)	158 (30.7%)	
	3	18 (40.9%)	192 (37.3%)	
	4	16 (36.4%)	76 (14.8%)	
	5	0 (0.0%)	4 (0.8%)	
	6	4 (9%)	3 (0.6%)	

#Chi square test. §Fisher's Exact test. *Significant

Table (8) shows Cases dead by day-30 significantly had more frequent palliation and RACHS 3. Calculating overall mortality according to each category was 1.2%, 3%, 8.57%, 17.39%, 0% and 57.1% for category 1, 2, 3, 4, 5 and 6

Table (9): Operation characteristics among the studied cases

Variables		n	%
Urgency	**Elective**	435	77.8%
	Emergency	21	3.8%
	Urgent	103	18.4%
Procedure type	**Repair**	408	73.0%
	Palliation	151	27%
RACHS score	**1**	83	14.8%
	2	163	29.2%
	3	210	37.6%
	4	92	16.5%
	5	4	0.7%
	6	7	1.3%

Table (9) shows **Operation characteristics among the studied cases**. Operations were mainly elective (77.8%) and patients for repair (73.0%).

Table (10): Regression model for factors affecting day-30 mortality

Factors	β	SE	p-value	OR (95% CI)
HLHS	1.84	0.83	**0.027***	6.30 (1.23–32.12)
RACHS≥3	1.01	0.49	**0.039***	2.73 (1.05–7.12)
Palliation operation	0.84	0.38	**0.027***	2.32 (1.10–4.91)
Constant	-3.92	0.43	**<0.001***	

β: Regression coefficient. SE: Standard error. OR: Odds ratio. CI: Confidence interval. *Significant

HLHS, RACHS≥3, Palliation operation were significant independent factors increase the likelihood of 30-day mortality.

This prospective observational study was conducted on 559 patients underwent cardiac surgery in all congenital heart surgery centers in Dakahlya Governorate, which were followed for 30 days as regards operative mortality.

Comparing our results to the RACHS-1 we showed mortality of 1.2%, 3%, 8.57%, 17.39%, 0% and 57.1% for category 1, 2, 3, 4, 5 and 6, respectively while The RACHS-1 score ranges from 1–6 (mortality rates were 0.4% in category 1, 3.8% in 2, 8.5% in 3, 19.4% in 4, and 47.7% in 6) so we showed higher mortality in both category 1 and 6 otherwise the rest of the results were very similar which mean we had a very good outcome that could be compared to the standard care worldwide even better than other big centers as shown in a big Brazilian study which showed a mortality of 1.8%, 5.5%, 14.9%, 32.5% and 68.6% for category 1, 2, 3, 4 and 6, respectively (Cavalcante et al., 2016)**.**

Regarding demographic data, the median (1st−3rd IQ) age of the studied group was 286.0 (92.0–961.0) Days, most of them were infants (87.2%) and females (50.4%). The median (1st−3rd IQ) weight was 7.1 (4.1–12.0) Kg. Only 5.2% of patients were Down syndrome.

While; a Brazilian retrospective date analysis done by **Cavalcante et al., (2016)** that were conducted on 3201 surgeries. Of these, 3071 were classified according to the RACHS-1 score and 130 procedures could not be categorized by the score. Of the patients, 1643 (51.7%) were male, aged less than 1 year of age 1523 (47.5%) and 2281 (71.1%) used CPB. The median weight was 8 kg (4 to 17.8 kg). Only 5.5% had trisomy 21.

As regard diagnosis among the studied cases, the current study detected that ventricular septal defect (VSD) was the most frequent diagnosis (13.6%), followed by Single ventricle (11.3%), then tetralogy of Fallot (TOF) (10.4%).

An investigation used the cardiovascular surgery patients in the Trichotomous Outcome Prediction in Critical Care database collected by the Child Health and Human Development Collaborative Pediatric Critical Care Research Network. The overall sample contained 10,078 patients, of whom 1550 underwent a cardiac surgery. Of the cardiac interventions, 1199 (77.4%) had 2-ventricle anatomy and 351 (22.6%) were single-ventricle patients. A total of 871 (56.2%) were acyanotic and 679 (43.8%) were cyanotic (Berger et al., 2017).

Concerning procedure among the studied cases, VSD closure was the most frequent procedure (11.3%), followed by mB-T shunt (8.9%), then TOF repair (8.1%). Operations were mainly elective (77.8%), for total repair (73.0%). Furthermore, the most common category of RACHS was 3 (210\37.6%).

With reference to Day-30 outcome among the studied cases, mortality was uncommon (7.9%), the main cause was heart failure in etiology (43.2%).

According to NATIONAL CONGENITAL HEART DISEASE AUDIT (NCHDA), in Newcastle Freeman Hospital, 30-day mortality for RACHS-1 1 and 2 categories were 2.4% in patient > 16 yrs underwent congenital heart procedure. While in Leicester Glenfield Hospital, it was 1.9%. The 30-day mortality rate in Glasgow Royal Hospital for Children was 1.5%. Bristol Royal Hospital for Children, Southampton Wessex Cardiothoracic Centre, Dublin Our Lady's Children's Hospital and Liverpool Alder Hey Hospital revealed similar rate of mortality. Likely, **Miyata et al. (2014)** reported that outcome rates of congenital heart surgery were 1.7% for 30-day mortality.

A satisfactory 30-day mortality rate can be attributed to the adequate provision of resources for hospitalization care, such as postoperative intensive care, and is reflected by long-term hospitalization that lasts on average one month because mortality might be related with prolonged stay.

Comparison according to day-30 mortality, cases dead by day-30 significantly had lower age and weight. Mortality was significantly highest in HLHS, then ALCAPA also this result is not accurate as we had only 2 cases, followed by TAPVD, Mortality was significantly highest in Norwood (57.1%), followed by Fontan and Senning (33.3% for each). Cases dead by day-30 significantly had more palliative procedures and RACHS 3. So, HLHS, RACHS≥3, Palliation operation and Open surgery were significant independent factors increase the likelihood of day-30 mortality.

The National Institute for Cardiovascular Outcomes Research (NICOR) and audit at UK regarding **Norwood procedure in HLHS** quotes a 33% mortality early post-operatively and that was in **Birmingham Children's Hospital** which is one of the biggest centers who dealt with HLHS with great success up to Fontan and 45% mortality between stage one and two so our result of 57% mortality

early postoperatively is not a bad result compared to the biggest centers who deal with HLHS and this is for many reasons, **firstly** this is the start of a learning curve which shows good result compared to the 100% mortality of HLHS if left not treated, **secondly** in centers who don't do this procedure regularly our results almost the same in spite of the availability of ECMO and NO in these centers, **thirdly** in Birmingham children hospital we used to classify HLHS into 2 groups with one group who has high risk of mortality due to multiple risk factors which include ; severe TR, restrictive atrial septum and very small ascending aorta less than 2mm, In our study 2 of the cases who died were from the high risk group so I believe with better selection of the cases and more cases to be done this will improve the learning curves and eventually the results.

Study limitation

There were some limitations that had to be disclosed in this study. **First,** this study was done in centers in Dakahlya only and we need to involve more centers all across Egypt to get more accurate results that we can use to formulate a model that can be generalized all across Egypt. This would require a comprehensive database across multiple institutions to accurately capture all essential variables. **Second,** we did not compare RACHS 1 with other risk stratification score in cardiac surgery to detect its efficiency. **Finally,** the sample size of this study was relatively small in comparison to similar study. The number of cases in category 5 AND 6 are small so in order to have more accurate results we need more cases although these 2 categories have rare cases also. One of the limitations also was that 20 patients were lost in follow up.

4. Conclusion

RACHS-1 is an accurate method to predict mortality early post operatively. Ventricular septal defect (VSD) was the most frequent diagnosis. VSD closure was the most frequent procedure, followed by mB-T shunt, then TOF repair, most of them were elective. The most common category of RACHS was 3. 30-day mortality was 7.9%. Patients dead by day-30 had lower age and weight. Mortality was significantly highest in HLHS, followed by TAPVD; Mortality was significantly highest in Norwood, followed by Fontan and Senning. Cases dead by day-30 significantly had more frequent palliation and RACHS ≥3. HLHS, RACHS≥3, Palliation operation were significant independent factors increase the day-30 mortality.

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