

RACHS-1 for the ANZPIC Registry

Information Booklet



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Risk-Adjusted Congenital Heart Surgery (RACHS-1)

Reference: K.Jenkins et al. Consensus-based method for risk adjustment for surgery for congenital heart disease. *J Thorac Cardiovasc Surg* 2002; 123: 110-8.

RACHS-1 is a published method to generate a risk-adjusted in-hospital mortality risk to be applied to children (<18yrs) undergoing surgery for congenital heart disease.

In developing the model, an 11-member national panel of paediatric cardiologists and cardiac surgeons from the USA met 1997-1998 and chose to use surgical procedure as the primary surrogate of risk and therefore divided nearly all surgical procedures for congenital heart disease into six categories of increasing predicted operative risk. Category 1 was low risk, and Category 6 the highest risk; there were very few procedures in Category 5 (see Appendix 1 for the full list of procedures in each category). They chose to use in-hospital mortality as the outcome of interest because of its overriding clinical importance, its ease of measurement, and its widespread availability in nearly all clinical databases. In further developing the model, other factors – younger age, prematurity, and the presence of a major non-cardiac structural anomaly - added to the risk of in-hospital death predicted by risk category alone. Best performance was obtained when cases with multiple procedures were placed in the risk category of the most complex procedure.

Calculation of RACHS (and RACHS risk of death%) –

$RACHS_{val} = -5.76 + 1.8871*(RCat2) + 2.7408*(RCat3) + 3.3393*(RCat4) + 4.5829*(RCat5) + 4.5369*(RCat6) + 1.0986*(AgeGrp1) + 0.6419*(AgeGrp2) + 0.5878*(nc_stan) + 0.5878*(prem) + 0.4055*(cp_sop).$

$RACHS \text{ risk of death} = e^{RACHS_{val}} / (1 + e^{RACHS_{val}})$

Example of RACHS calculation

A 6-month old child with spina bifida has been operated on for an aortic valve replacement. She was not premature.

(Therefore, AgeGrp2 = yes (code 1), major non-cardiac structural anomaly (nc_stan) = yes (code 1), RACHS category = 3 (RCat3 = 1), prematurity = no (code 0), combination of procedures = no (code 0)

$RACHS_{val} = -5.76$
 $+ 1.8871 \times 0 + 2.7408 \times 1 + 3.3393 \times 0 + 4.4829 \times 0 + 4.5369 \times 0$ (category)
 $+ 1.0986 \times 0 + 0.6419 \times 1$ (age)
 $+ 0.5878 \times 1$ (non-cardiac abnormality)
 $+ 0.5878 \times 0$ (prematurity)
 $+ 0.4055 \times 0$ (combination)
 $= -5.76 + 2.7408 + 0.6419 + 0.5878 = -1.7895$

$RACHS \text{ risk of death} = \exp(-1.7895) / (1 + (\exp(-1.7895)))$
 $= 0.1671 / (1 + 0.1671) = 0.1432$ (or 14.3%)

Coding rules and explanation of RACHS fields –

1. **AgeGrp1.** Age at ICU admission \leq 30days. Calculated centrally from Date of Birth (DOB) and Date of ICU Admission (ADM_DT). Codes: Yes=1, No=0.
2. **AgeGrp2.** Age at ICU admission between 31days - 365days (1yr). Calculated centrally from Date of Birth (DOB) and Date of ICU Admission (ADM_DT). Codes: Yes=1, No=0.
3. **RCat2, RCat3, RCat4, RCat5, RCat6.** RACHS risk categories 2, 3, 4, 5 & 6. See Appendix 1 for a list of procedures in each of the RACHS risk categories. The risk category is centrally assigned. If there are multiple procedures performed within the one operation, the procedure with the highest risk will be used in the calculation. (eg if an ASD repair (RCat1) plus an aortoplasty (RCat3) are performed in the same operation, then the higher risk category, 3, is the one used) If the only procedure is in Risk Category 1, nothing will be contributed to the RACHS calculation. Codes: Yes=1, No=0.
4. **NC_STAN.** Major non-cardiac structural anomaly. Denotes the presence of any of the structural anomalies listed in Appendix 2. Codes: Yes=1, No=0.
5. **PREM.** Prematurity. Prematurity was defined as gestational age $<$ 37 weeks. This variable is generated centrally based on the value of field GESTATION. Codes: Yes=1, No=0.
6. **CP_SOP.** Combination of cardiac surgical procedures at a single operation. When multiple procedures are performed within the same operation, this variable is included in the RACHS calculation to add a weighting for the complexity of the surgery. Codes: Yes=1, No=0.
7. Note that if the child is greater than 1 year old (365 days), or has a single procedure in risk category 1, then nothing is added to the RACHS calculation for either age or risk category.

Interpretation / calculation of RACHS

- RACHS is primarily to check quality of surgery, but really will reflect the quality of all components of a multidisciplinary service including cardiology, cardiac surgery, anesthesia and intensive care (as opposed to PIM2/PIM3 which is assessing ICU care only).
- Uses in-hospital mortality.
- RACHS is evaluating surgery for congenital heart disease, so will not allocate risk for heart surgery for acquired condition (eg trauma).
- Some rare operations (eg LV to aorta conduit) are not classified in the risk categories and are therefore unable to have a RACHS score calculated.
- Similar to PIM, RACHS is not good enough to, or intended to, evaluate individual patients.

RACHS development for the Australian & New Zealand paediatric ICU population

RACHS fields were added to the ANZPIC Registry dataset at the start of 2007. Since that time, research has been undertaken to determine if the RACHS classification can be used to create a model which accurately predicts in-hospital mortality when applied to children undergoing cardiac surgery immediately prior to, or during admission to, Paediatric Intensive Care Units (PICUs) in Australia and New Zealand (ANZ). The outcome used was survival to hospital discharge.

The study had three aims: first to assess the performance of the RACHS-1 model when applied to children undergoing cardiac surgery in Australia and New Zealand; second to recalibrate the model using a recent local cohort of children; and third to investigate if the performance of the model could be improved in this setting by either removing or incorporating new risk factors.

Analysis of the ANZPIC Registry dataset showed that hospital mortality after surgery for congenital heart disease in ANZ is lower than predicted using the published RACHS model. The model did not provide a good fit for the ANZ data even after recalibration.

An alternative RACHS-ANZ model was created by forward and backward logistic regression on a development data sample. Variable selection was based on the effect of including or dropping variables based on information criteria values, discrimination and fit. All variables used formed part of the current dataset of the ANZPIC Registry. This new model demonstrated improved fit and discrimination when applied to the test data. The new version of the model, RACHS-ANZ, is accurate enough to be used to describe the risk of hospital mortality in children undergoing cardiac surgery in Australia and New Zealand.

It is hoped to have the results of this research published soon.

RACHS Q&A's

Q: Imagine a patient is admitted following Surgery 1 (Procedure A), but subsequently goes and has Surgery 2 (Procedure B). Do you just code the single surgery with the highest RACHS code (let's say Procedure B)?

A: No, code both procedures to provide an accurate record of the admission, but note that only the procedure with the highest RACHS category will be used to calculate the RACHS risk of death. You should also record that they were not combined procedures.

Q: Imagine Surgery 2 is comprised of combined Procedures B and C. Do you code both procedures (i.e. B & C), and record them as a combined procedure? If so, wouldn't this include procedure A as well?

A: Code both procedures B & C and also the combined procedures code. Procedure A won't be included in the RACHS calculation if it is the same or a lower category. Of all the procedures, the one with the highest RACHS category will be selected. There is an additional weighting if multiple procedures is coded but this doesn't influence which RACHS category is used. If the coding results in a systematic increase in the risk assessment for patients with multiple operations where a second operation is a combined procedure then this is reasonable.

Q: Does a combined procedure code carry a fixed complexity loading regardless of how many and what procedures are done, or does it calculate a new figure based on the complexity of each individual procedure?

A: It is a separate term in the logistic model - this means that all other risk factors are multiplied (due to the log transformation) by the coefficient. ie a combined procedures code will put the Risk of Death up more for RACHS 4 than 3. The coefficient for multiple procedures is relatively small though, compared with many of the other terms.

Q: Re the antenatal diagnosis of structural anomaly (AD_STAN) field – we have a few queries being generated on our data because the patient was > 1 year. Is this field only valid for under 12 months of age and therefore should be changed to 0 for those older, or do we leave as 1 and just confirm the patient's age?

A: The query is being generated because antenatal diagnosis should only be coded if the congenital anomaly diagnosed antenatal is the primary or underlying diagnosis leading to admission (eg cardiac structural anomaly or congenital diaphragmatic hernia), and that after 1 year of age, these diagnoses might be historical (eg already repaired) and not the primary reason for the admission. The query is raised based on age of the child. Please ignore the query if your coding complies with the use of the field.

Q: In a query report we had the following error – *“Cardiac Mismatch - 2 cardiac diagnostic codes are contradictory or a combined procedure code exists”*. Can you provide me with a list of codes which are contradictory for checking purposes?

A: This query would suggest that you have used two codes for procedures which, if performed in the same operation, would have just a single code including both components which should be used instead. Please see Appendix 3 for the list of “disallowed” separate codes. If the procedures were performed in separate operations, this query should be ignored.

Q: When using (or not using) the combined procedures code (CP_SOP), some errors are being generated in the query report. It would be helpful to know what codes are being used in this check to help avoid future queries.

A: It is acknowledged that different sites may well have different practices in their cardiac surgery operations. Appendix 4 lists the codes which have been grouped together for the purposes of checking the accuracy of CP_SOP field.

Appendix 1

Individual procedures by RACHS risk category

Risk category 1

Atrial septal defect surgery (including atrial septal defect secundum, sinus venosus atrial septal defect, patent foramen ovale closure)
Aortopexy
Patent ductus arteriosus surgery at age >30 d
Coarctation repair at age >30 d
Partially anomalous pulmonary venous connection surgery

Risk category 2

Aortic valvotomy or valvuloplasty at age >30 d
Subaortic stenosis resection
Pulmonary valvotomy or valvuloplasty
Pulmonary valve replacement
Right ventricular infundibulectomy
Pulmonary outflow tract augmentation
Repair of coronary artery fistula
Atrial septal defect and ventricular septal defect repair
Atrial septal defect primum repair
Ventricular septal defect repair
Ventricular septal defect closure and pulmonary valvotomy or infundibular resection
Ventricular septal defect closure and pulmonary artery band removal
Repair of unspecified septal defect
Total repair of tetralogy of Fallot
Repair of total anomalous pulmonary veins at age >30 d
Glenn shunt
Vascular ring surgery
Repair of aorta-pulmonary window
Coarctation repair at age ≤30 d
Repair of pulmonary artery stenosis
Transection of pulmonary artery
Common atrium closure
Left ventricular to right atrial shunt repair

Risk category 3

Aortic valve replacement
Ross procedure
Left ventricular outflow tract patch
Ventriculomyotomy
Aortoplasty
Mitral valvotomy or valvuloplasty
Mitral valve replacement
Valvectomy of tricuspid valve
Tricuspid valvotomy or valvuloplasty
Tricuspid valve replacement
Tricuspid valve repositioning for Ebstein anomaly at age >30 d
Repair of anomalous coronary artery without intrapulmonary tunnel
Repair of anomalous coronary artery with intrapulmonary tunnel (Takeuchi)
Closure of semilunar valve, aortic or pulmonary
Right ventricular to pulmonary artery conduit
Left ventricular to pulmonary artery conduit

Repair of double-outlet right ventricle with or without repair of right ventricular obstruction
Fontan procedure
Repair of transitional or complete atrioventricular canal with or without valve replacement
Pulmonary artery banding
Repair of tetralogy of Fallot with pulmonary atresia
Repair of cor triatriatum
Systemic to pulmonary artery shunt
Atrial switch operation
Arterial switch operation
Reimplantation of anomalous pulmonary artery
Annuloplasty
Repair of coarctation and ventricular septal defect closure
Excision of intracardiac tumor

Risk category 4

Aortic valvotomy or valvuloplasty at age ≤30 d
Konno procedure
Repair of complex anomaly (single ventricle) by ventricular septal defect enlargement
Repair of total anomalous pulmonary veins at age ≤30 d
Atrial septectomy
Repair of transposition, ventricular septal defect, and subpulmonary stenosis (Rastelli)
Atrial switch operation with ventricular septal defect closure
Atrial switch operation with repair of subpulmonary stenosis
Arterial switch operation with pulmonary artery band removal
Arterial switch operation with ventricular septal defect closure
Arterial switch operation with repair of subpulmonary stenosis
Repair of truncus arteriosus
Repair of hypoplastic or interrupted arch without ventricular septal defect closure
Repair of hypoplastic or interrupted aortic arch with ventricular septal defect closure
Transverse arch graft
Unifocalization for tetralogy of Fallot and pulmonary atresia
Double switch

Risk category 5

Tricuspid valve repositioning for neonatal Ebstein anomaly at age ≤30 d
Repair of truncus arteriosus and interrupted arch

Risk category 6

Stage 1 repair of hypoplastic left heart syndrome (Norwood operation)
Stage 1 repair of nonhypoplastic left heart syndrome conditions
Damus-Kaye-Stansel procedure

Appendix 2

RACHS-1 Major noncardiac structural anomalies

ICD10 code	Diagnosis
740.0	Anencephalus
740.1	Craniorachischisis
740.2	Iniencephaly
741.0	Spina bifida, with hydrocephalus
741.9	Spina bifida, without mention of hydrocephalus
742.0	Encephalocele
742.1	Microcephalus
742.2	Reduction deformities of brain
742.3	Congenital hydrocephalus
742.4	Other specified anomalies of brain
742.5x	Other specified anomalies of spinal cord
742.9	Unspecified anomaly of brain, spinal cord, and nervous system
748.0	Choanal atresia
748.2	Web of larynx
748.3	Other anomalies of larynx, trachea, and bronchus
748.4	Congenital cystic lung
749.0x	Cleft palate
	749.1x Cleft lip
	749.2x Cleft palate with cleft lip
750.3	Tracheoesophageal fistula, esophageal atresia and stenosis
751.1	Atresia and stenosis of small intestine
751.2	Atresia and stenosis of large intestine, rectum, and anal canal
751.4	Anomalies of intestinal fixation
751.61	Biliary atresia
753.0	Renal agenesis and dysgenesis
753.15	Cystic kidney disease, renal dysplasia
753.2	Obstructive defects of renal pelvis and ureter
753.5	Exstrophy of urinary bladder
756.6	Anomalies of diaphragm
756.7	Anomalies of abdominal wall

Appendix 3

Disallowed Combinations of cardiac codes

Description	1970 Repair of hypoplastic or interrupted arch without VSD closure
May NOT be combined with:	
Description	1971 Repair of hypoplastic or interrupted arch with VSD closure
Or	1915 VSD repair
Or	1913 ASD and VSD repair
Or	1916 VSD closure and pulmonary valvotomy or infundibular resection
Or	1917 VSD closure and pulmonary artery band removal
Suggested alternative	1971 Repair of hypoplastic or interrupted arch with VSD closure
Description	1940 Repair of anomalous coronary artery without intrapulmonary tunnel
May NOT be combined with:	
Description	1941 Repair anomalous coronary art. with intrapulmonary tunnel (Takeuchi)
Description	1901 ASD surgery (including ASD secundum, sinus venosus ASD, patent foramen ovale closure)
May NOT be combined with:	
Description	1915 VSD repair
Suggested alternative	1913 ASD and VSD repair
Description	1914 ASD primum repair
May NOT be combined with:	
Description	1915 VSD repair
Suggested alternative	1913 ASD and VSD repair
Description	1908 Pulmonary valvotomy - valvuloplasty
May NOT be combined with:	
Description	1915 VSD repair
Suggested alternative	1916 VSD closure and pulmonary valvotomy or infundibular resection
Description	1910 Right ventricular infundibulectomy
May NOT be combined with:	
Description	1915 VSD repair
Suggested alternative	1916 VSD closure and pulmonary valvotomy or infundibular resection
Description	1952 Atrial switch operation
May NOT be combined with:	
Description	1915 VSD repair
Suggested alternative	1964 Atrial switch operation with VSD closure

Description 1953 Arterial switch operation
May NOT be combined with:
Description 1915 VSD repair
Suggested alternative 1967 Arterial switch operation with VSD closure

Description 1952 Atrial switch operation
May NOT be combined with:
Description 1911 Pulmonary outflow tract augmentation
Or 1910 Right ventricular infundibulectomy
Suggested alternative 1965 Atrial switch operation with repair of sub PS

Description 1953 Arterial switch operation
May NOT be combined with:
Description 1911 Pulmonary outflow tract augmentation
Or 1910 Right ventricular infundibulectomy
Suggested alternative 1968 Arterial switch operation with repair of sub PS

Description 1952 Atrial switch operation
Or 1964 Atrial switch operation with VSD closure
Or 1965 Atrial switch operation with repair of sub PS
May NOT be combined with:
Description 1953 Arterial switch operation
Or 1966 Arterial switch operation with pulmonary artery band removal
Or 1967 Arterial switch operation with VSD closure
Or 1968 Arterial switch operation with repair of sub PS
OrSuggested alternative 1974 Double switch

Description 1953 Arterial switch operation
Or 1966 Arterial switch operation with pulmonary artery band removal
Or 1967 Arterial switch operation with VSD closure
Or 1968 Arterial switch operation with repair of sub PS
May NOT be combined with:
Description 1964 Atrial switch operation with VSD closure
Or 1965 Atrial switch operation with repair of sub PS
Suggested alternative 1974 Double switch

Description 1977 Norwood (Stage 1 repair of hypoplastic left heart syndrome)
Or 1978 Stage 1 repair of nonhypoplastic left heart syndrome conditions
May NOT be combined with:
Description 1979 Damus-Kaye-Stansel procedure

Appendix 4

Linked Cardiac Surgical Procedures

If there are multiple cardiac procedures coded, logic checks are attempting to differentiate between multiple components of one larger cardiothoracic procedure (ie associated procedures) versus multiple procedures (ie not associated procedures). In the following list, any descriptors coloured in blue will be followed by a list of procedures which have been deemed to be associated with it, and which therefore would NOT be classed as multiple procedures if the codes appeared together. Procedures listed outside of these accepted sub-procedures would assume multiple procedures and would generate a query if the CP_SOP field is not set to “yes” (code 1).

<i>Code</i>	<i>Description</i>
1901	<i>ASD surgery (including ASD secundum, sinus venosus ASD, patent foramen ovale closure)</i>
1902	<i>Aortopexy (RC 1)</i>
1903	<i>PDA surgery >30d of age (RC 1)</i>
1904	<i>Coarctation repair >30d of age (RC 1)</i>
1903	PDA surgery >30d of age
1905	<i>Partially anomalous pulmonary venous connection surgery</i>
1901	ASD surgery (including ASD secundum, sinus venosus ASD, patent foramen ovale closure)
1903	PDA surgery >30d of age
1914	ASD primum repair
1906	<i>Aortic valvotomy - valvuloplasty >30d of age (RC 2)</i>
1907	<i>Subaortic stenosis resection (RC 2)</i>
1908	<i>Pulmonary valvotomy - valvuloplasty (RC 2)</i>
1909	<i>Pulmonary valve replacement (RC 2)</i>
1910	<i>Right ventricular infundibulectomy</i>
1911	Pulmonary outflow tract augmentation
1911	<i>Pulmonary outflow tract augmentation (RC 2)</i>
1912	<i>Repair of coronary AV fistula (RC 2)</i>
1913	<i>ASD and VSD repair</i>
1901	ASD surgery (including ASD secundum, sinus venosus ASD, patent foramen ovale closure)
1914	ASD primum repair
1915	VSD repair
1914	<i>ASD primum repair (RC 2)</i>
1915	<i>VSD repair (RC 2)</i>
1916	<i>VSD closure and pulmonary valvotomy or infundibular resection</i>
1908	Pulmonary valvotomy - valvuloplasty
1910	Right ventricular infundibulectomy

1911 Pulmonary outflow tract augmentation
1915 VSD repair

1917 *VSD closure and pulmonary artery band removal*

1915 VSD repair

1918 *Repair of unspecified septal defect (RC 2)*

1919 *Total repair of tetralogy of Fallot*

1908 Pulmonary valvotomy - valvuloplasty
1910 Right ventricular infundibulectomy
1911 Pulmonary outflow tract augmentation
1915 VSD repair
1916 VSD closure and pulmonary valvotomy or infundibular resection

1920 *Repair of total anomalous pulmonary veins >30d of age*

1901 ASD surgery (including ASD secundum, sinus venosus ASD, patent foramen ovale closure)
1914 ASD primum repair
1915 VSD repair

1921 *Glenn shunt – Extracardiac Component (code intra cardiac components separately)*

1922 *Vascular ring surgery (RC 2)*

1923 *Repair of AP window*

1903 PDA surgery >30d of age

1924 *Coarctation repair ≤30d of age*

1903 PDA surgery >30d of age

1925 *Repair of pulmonary artery stenosis (RC 2)*

1926 *Transection of pulmonary artery (RC 2)*

1927 *Common atrium closure*

1901 ASD surgery (including ASD secundum, sinus venosus ASD, patent foramen ovale closure)

1928 *Left ventricular to right atrial shunt repair (RC 2)*

1929 *Aortic valve replacement (RC 3)*

1930 *Ross procedure*

1906 Aortic valvotomy - valvuloplasty >30d of age
1908 Pulmonary valvotomy - valvuloplasty
1909 Pulmonary valve replacement
1926 Transection of pulmonary artery
1929 Aortic valve replacement
1958 Aortic valvotomy - valvuloplasty ≤30d of age

1931 *Left ventricular outflow tract patch (RC 3)*

- 1932** *Ventriculomyotomy (RC 3)*
- 1933** *Aortoplasty (not arch) (RC 3)*
- 1934** *Mitral valvotomy - valvuloplasty (RC 3)*

1935 *Mitral valve replacement*

1934 Mitral valvotomy - valvuloplasty

1936 *Valvectomy of tricuspid valve*

1937 Tricuspid valvotomy - valvuloplasty

1937 *Tricuspid valvotomy - valvuloplasty (RC 3)*

1938 *Tricuspid valve replacement*

1936 Valvectomy of tricuspid valve

1937 Tricuspid valvotomy - valvuloplasty

1939 *Tricuspid valve repositioning for Ebstein anomaly >30d of age*

1936 Valvectomy of tricuspid valve

1937 Tricuspid valvotomy - valvuloplasty

1940 *Repair of anomalous coronary artery without intrapulmonary tunnel (RC 3)*

1941 *Repair anomalous coronary art. with intrapulmonary tunnel (Takeuchi) (RC 3)*

1942 *Closure of semilunar valve, aortic or pulmonary*

1906 Aortic valvotomy - valvuloplasty >30d of age

1908 Pulmonary valvotomy - valvuloplasty

1943 *Right ventricular to pulmonary artery conduit (RC 3)*

1944 *Left ventricular to pulmonary artery conduit (RC 3)*

1945 *Repair of double-outlet right ventricle with or without repair of*

1903 PDA surgery >30d of age

1915 VSD repair

1911 Pulmonary outflow tract augmentation

1910 Right ventricular infundibulectomy

1946 *Fontan procedure (RC 3)*

1947 *Repair of transitional or complete atrioventricular canal with or*

- 1914 ASD primum repair
- 1934 Mitral valvotomy - valvuloplasty
- 1935 Mitral valve replacement
- 1937 Tricuspid valvotomy - valvuloplasty
- 1938 Tricuspid valve replacement
- 1903 PDA surgery >30d of age

1948 *Pulmonary artery banding (RC 3)*

1949 *Repair of tetralogy of Fallot with pulmonary atresia*

- 1909 Pulmonary valve replacement
- 1910 Right ventricular infundibulectomy
- 1911 Pulmonary outflow tract augmentation
- 1915 VSD repair
- 1916 VSD closure and pulmonary valvotomy or infundibular resection
- 1919 Total repair of tetralogy of Fallot

1950 *Repair of cor triatriatum*

- 1927 Common atrium closure

1951 *Systemic to pulmonary artery shunt (RC 3)*

1952 *Atrial switch operation*

- 1901 ASD surgery (including ASD secundum, sinus venosus ASD, patent foramen ovale closure)
- 1903 PDA surgery >30d of age

1953 *Arterial switch operation*

- 1901 ASD surgery (including ASD secundum, sinus venosus ASD, patent foramen ovale closure)
- 1903 PDA surgery >30d of age

1954 *Reimplantation of anomalous pulmonary artery (RC 3)*

1955 *Annuloplasty (RC 3)*

1956 *Repair of coarctation and VSD closure*

- 1903 PDA surgery >30d of age
- 1904 Coarctation repair >30d of age (?VAD)
- 1924 Coarctation repair ≤30d of age

1957 *Excision of intracardiac tumour (RC 3)*

1958 *Aortic valvotomy - valvuloplasty ≤30d of age (RC 4)*

1959 *Konno procedure*

- 1903 PDA surgery >30d of age
- 1906 Aortic valvotomy - valvuloplasty >30d of age
- 1929 Aortic valve replacement
- 1958 Aortic valvotomy - valvuloplasty ≤30d of age

1960 *Repair of complex anomaly (single ventricle) by VSD enlargement (RC 4)*

1961 *Total repair of anomalous pulmonary veins ≤30d of age*

- 1901 ASD surgery (including ASD secundum, sinus venosus ASD, patent foramen ovale closure)
- 1903 PDA surgery >30d of age

1962 *Atrial septectomy (RC 4)*

1963 *Repair of transposition-VSD sub PS (Rastelli)*

- 1903 PDA surgery >30d of age
- 1915 VSD repair
- 1932 Ventriculomyotomy
- 1943 Right ventricular to pulmonary artery conduit

1964 *Atrial switch operation with VSD closure*

- 1901 ASD surgery (including ASD secundum, sinus venosus ASD, patent foramen ovale closure)
- 1903 PDA surgery >30d of age
- 1915 VSD repair
- 1952 Atrial switch operation

1965 *Atrial switch operation with repair of sub PS*

- 1901 ASD surgery (including ASD secundum, sinus venosus ASD, patent foramen ovale closure)
- 1903 PDA surgery >30d of age
- 1911 Pulmonary outflow tract augmentation
- 1952 Atrial switch operation

1966 *Arterial switch operation with pulmonary artery band removal*

- 1901 ASD surgery (including ASD secundum, sinus venosus ASD, patent foramen ovale closure)
- 1903 PDA surgery >30d of age
- 1953 Arterial switch operation

1967 *Arterial switch operation with VSD closure*

- 1901 ASD surgery (including ASD secundum, sinus venosus ASD, patent foramen ovale closure)
- 1903 PDA surgery >30d of age
- 1915 VSD repair
- 1953 Arterial switch operation

1968 *Arterial switch operation with repair of sub PS*

- 1901 ASD surgery (including ASD secundum, sinus venosus ASD, patent foramen ovale closure)
- 1903 PDA surgery >30d of age
- 1911 Pulmonary outflow tract augmentation
- 1953 Arterial switch operation
- 1914 ASD primum repair

1969 *Repair of truncus arteriosus*

- 1915 VSD repair
- 1926 Transection of pulmonary artery
- 1951 Systemic to pulmonary artery shunt

1970 *Repair of hypoplastic or interrupted arch without VSD closure*

- 1904 Coarctation repair >30d of age (?VAD)
- 1924 Coarctation repair ≤30d of age

1971 *Repair of hypoplastic or interrupted arch with VSD closure*

- 1915 VSD repair
- 1904 Coarctation repair >30d of age (?VAD)
- 1924 Coarctation repair ≤30d of age

1972 *Transverse arch graft*

- 1970 Repair of hypoplastic or interrupted arch without VSD closure
- 1971 Repair of hypoplastic or interrupted arch with VSD closure
- 1904 Coarctation repair >30d of age (?VAD)
- 1924 Coarctation repair ≤30d of age

1973 *Unifocalization for tetralogy of Fallot - pulmonary atresia (RC 4)*

1974 *Double switch*

- 1952 Atrial switch operation
- 1953 Arterial switch operation
- 1964 Atrial switch operation with VSD closure
- 1965 Atrial switch operation with repair of sub PS
- 1966 Arterial switch operation with pulmonary artery band removal
- 1967 Arterial switch operation with VSD closure

1975 *Tricuspid valve repositioning for neonatal Ebstein ≤30d of age*

- 1936 Valvectomy of tricuspid valve
- 1937 Tricuspid valvotomy - valvuloplasty

1976 *Repair of truncus arteriosus and interrupted arch*

- 1915 VSD repair
- 1926 Transection of pulmonary artery
- 1951 Systemic to pulmonary artery shunt
- 1969 Repair of truncus arteriosus
- 1970 Repair of hypoplastic or interrupted arch without VSD closure
- 1971 Repair of hypoplastic or interrupted arch with VSD closure

1977 *Norwood (Stage 1 repair of hypoplastic left heart syndrome)*

- 1903 PDA surgery >30d of age
- 1926 Transection of pulmonary artery
- 1943 Right ventricular to pulmonary artery conduit
- 1951 Systemic to pulmonary artery shunt

1978 *Stage 1 repair of nonhypoplastic left heart syndrome conditions*

- 1903 PDA surgery >30d of age
- 1926 Transection of pulmonary artery
- 1943 Right ventricular to pulmonary artery conduit
- 1951 Systemic to pulmonary artery shunt

1979 *Damus-Kaye-Stansel procedure*

- 1903 PDA surgery >30d of age
- 1926 Transection of pulmonary artery
- 1943 Right ventricular to pulmonary artery conduit
- 1951 Systemic to pulmonary artery shunt