Risk Stratification in ACHD

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Risk Stratification

RISK: • noun
1 a situation involving exposure to danger.
2 the possibility that something unpleasant will happen.

medical-dictionary.thefreedictionary.com

RISK STRATIFICATION
The constellation of activities (e.g. lab and clinical testing) used to determine a person's risk for suffering a particular condition and need -or lack thereof- for preventive intervention

The Compact Oxford English Dictionary of Current English
Risk Stratification

Risk: A state of uncertainty where some of the possibilities involve a loss, catastrophe, or other undesirable outcome.

\[ \text{RISK} = \text{Probability of event occurring} \times \text{Impact of event} \]

Measurement of risk: A set of possibilities each with quantified probabilities and quantified losses.
Risk Management

Risk management: identification, assessment, and prioritization of risks followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events.

How to reduce risk

Prioritise

Identify

Vulnerability

Consequences
Risk Management: prevention

1. **Primary prevention**: avoids the development of a disease.

2. **Secondary prevention**: early disease detection, interventions to prevent progression of the disease.

3. **Tertiary prevention**: reduce the negative impact of established disease: restore function and reducing disease-related complications.
Risk Stratification = Cost reduction

NHS will face £15bn budget shortfall due to effects of recession managers warn

The NHS is facing its greatest financial crisis due to the recession as £15bn shortfall is forecast over five years, leading health service managers warn.

"I'll be perfectly frank with you, we need that bed!"
Percentage of Admissions Via the ED for CHD Patients by Age Category, 2000 to 2003

Requirements for Specialist ACHD centres

- MRI
- CT
- CPEX / Exercise testing / 6 min walk test
- Echo, including fetal echo and transoesophageal echocardiography (TOE)
- Diagnostic catheters
- Diagnostic electrophysiology studies
- 24 hr tapes, cardio memo, 24 hr BP
- Nurse specialist as a named point of contact
- 3 Cardiologists (full time ACHD)
- 1 interventionalist
- Imaging ACHD consultant(s): Echo and MRI
- >2 CHD Surgeons
and....

- Electrophysiologist expert in CHD and acquired heart disease: PM, EP+Ablation, ICD
- ≥ 2 WTE dedicated specialist nurses
- Cardiac and obstetric anaesthetists with ACHD expertise
- ACHD-trained Radiologist
- Clinical psychology
- Physiotherapist with knowledge of GUCH requirements
- Access to Dietetics
- 1 medical secretary per WTE GUCH cardiologist plus additional support for specialist GUCH nurses.
- Access to Social worker
- Administrator for database and liaison with national databases.
- Access to a dental team
- Links to specialist dentistry
- Support for people with learning disabilities from an appropriate specialist or agency.
- Specialist obstetric care & fetal medicine
1. Infant with congenital heart disease

Paediatric Cardiac Centre including surgery

Transition process / arrangements
Refer to standards

Transfer clinic
MDT including with Specialist GUCH cardiologist in GUCH centre
Refer to standards

Genetics service
Transplantation service
National Pulmonary hypertension service
Specialist Dental service

GUCH (ACHD) Specialist Centre
Provides:
Refer to standards
Undertakes Surgery and intervention work

GP or DGH Medical practitioner
N.B.: All patients identified MUST be referred for specialist assessment

GP Provision of ongoing care
Provision of ‘Share care under protocols agreed with specialist local or (approved DGH centre’
Manage routine cardiac medication
Monitor anticoagulation and blood chemistry
Understand the need for specialist advice regarding contraception and pregnancy care
Dental management information and care
Ensure provision of LONG TERM follow up as appropriate according to need and/or complexity of ACHD
Understand the risks of endocarditis

2. Adult presenting for the first time with a congenital condition

3. Adult presenting after losing touch with services provided when a child

4. Adult with a congenital condition self referring to specialist

5. Adult with a congenital condition presenting with a non cardiac condition (Emergency or Planned procedure)

GUCH (ACHD) LOCAL Centre
Provides:
Refer to standards

Specialist GUCH Cardiologist

N.B. All GUCH patients need to be seen at least once by a Specialist GUCH cardiologist either in the Specialist or a Local GUCH centre and receive a written care plan.
ACHD LOCAL Centres

All patients should be seen for initial consultation by a specialist GUCH Cardiologist at least once.

Specialist Centres will manage all patients with complex conditions. Specialist centres will need to have in place shared care arrangements for the treatment and management non-complex lesions.

It is important that all patients are seen once by a specialist GUCH Cardiologist and clear care plans are agreed for management at the specialist centre, a local GUCH centre or by a non congenital DGH based cardiologist.

Risk stratification
Complexity

The ‘Simple’ CHD
Native
Isolated congenital Aortic Stenosis
Isolated Congenital Mitral malformations (except ‘parachute’)
Isolated ASD or PFO
Small isolated VSD
Mild Pulmonary Stenosis
PDA occlusion
ASD closure without residual shunt
VSD closure without residual shunt

Complex lesions
Valve or non-valve conduits
All cyanotic malformations
Double outlet Ventricles
Eisenmenger
Patients after Fontan operation
Mitral and Tricuspid atresia
Univentricular Heart
Aortic or Pulmonary atresia and distal pulmonary stenoses
TGV
Truncus/Hemi-truncus

The ‘Moderately Complex’
Aorto-ventricular ‘tunnel’
Total or partial anomalous vein connection
A-V septal defects
Aortic Coarctation
Ebstein
Severe RVOT obstructions
Ostium Primum ASD
PDA
Moderate-severe pulmonary insufficiency
Moderate-severe pulmonary stenosis
Aneurysm or rupture of the Valsalva Sinus
Sinus venosus ASD
Sub-aortic or Supra-aortic stenosis (no HOCM
Fallot’s Tetralogy
VSD associated with
Valvular atresia or straddling
Aortic Regurgitation or Coarctation
### Multivariate Logistic Regression Analysis for Predictors of Admission Via the ED

<table>
<thead>
<tr>
<th>Variables</th>
<th>OR</th>
<th>95%CI</th>
<th>p Value</th>
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<tbody>
<tr>
<td>Insurance source</td>
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<tr>
<td>Private insurance</td>
<td></td>
<td>2.32</td>
<td>1.97–2.73</td>
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<tr>
<td>Public insurance</td>
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<td>4.61</td>
<td>3.34–6.37</td>
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<td>Self-pay</td>
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<td>CHD complexity</td>
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<td>Noncomplex CHD</td>
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<td>Complex CHD</td>
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<td>Cardiac procedure</td>
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<td>Without procedure</td>
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<tr>
<td>With procedure</td>
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<td>0.25</td>
<td>0.19–0.33</td>
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<td>Age (yrs)</td>
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<td>0.25</td>
<td>0.19–0.33</td>
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<td>Gender</td>
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</tr>
<tr>
<td>Male</td>
<td></td>
<td>Reference</td>
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<tr>
<td>Female</td>
<td>0.8</td>
<td>0.72–0.89</td>
<td>&lt;0.001</td>
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</table>

How to risk stratify ACHD patients

1. By diagnosis
2. By previous surgery/repair
3. By age
4. By functional status
5. By exercise capacity
6. By biochemical markers
7. Imaging: residual lesions, ventricular dysfunction
8. Complications: arrhythmias, thrombosis, heart failure, hemoptysis, endocarditis
9. Pregnancy
Diagnosis/Prior surgery

High risk diagnoses/anatomies:
➲ Univentricular hearts
➲ Systemic RVs
➲ Cyanotic lesions
➲ Unrepaired lesions
➲ Palliative surgery (Fontan)
Kaplan-Meier survival curves for the eight defects

- CoA (99.3%)
- ASD (98.9%)
- Tetralogy of Fallot (98.7%)
- VSD (98.4%)
- Marfan (98.3%)
- TGA (97.1%)
- Fontan (91.8%)
- Cyanotic defect (87.4%)

Age

Applies to all of us....but

Particularly relevant in patients with:

➲ Unrepaired lesions:
  ● Simple (e.g. ASD)
  ● Complex (e.g. univentricular, V-overloaded)

➲ Residual hemodynamic lesions

➲ Systemic RVs

➲ A-P Fontan
Mechanisms of exercise intolerance in ACHD

- Skeletal muscle abnormalities
- Detraining
- Anaemia
- Skeletal abnormalities (scoliosis)
- Arrhythmias
- Pulmonary vascular disease
- Parenchymal pulmonary disease
- Valve disease
- Outflow obstruction
- Shunting
- Endothelial dysfunction
- Pericardial disease
- Medication
- Neurohormonal activation
- Prior surgery
- Pacing

CARDIAC DYSFUNCTION

- Volume/Pressure overload
- Coronary anomalies

EXERCISE INTOLERANCE

- Anaemia
- Detraining
- Skeletal abnormalities (scoliosis)
- Skeletal muscle abnormalities
- Peripheral vascular disease
- Pericardial disease
- Pacing

FUNCTIONAL STATUS/EXERCISE CAPACITY
Exercise intolerance in ACHD

NYHA 1
NYHA 2
NYHA 3/4

Euroheart survey, Engelfriet et al, 2005
RBH ACHD Database 1999-2006: 3475pts

41.9% symptomatic patients

NYHA I
NYHA II-IV

Symptomatic (NYHA II-IV)
Asymptomatic (NYHA I)
Symptoms and prognosis in ACHD
Systemic RVs

<table>
<thead>
<tr>
<th></th>
<th>Anaerobic threshold VO2 max</th>
<th>RVEF</th>
<th>15y Mortality</th>
<th>Subsequent HF</th>
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<tbody>
<tr>
<td>Symptomatic</td>
<td>10.3 ± 2.8</td>
<td>15.2</td>
<td>34 + 4</td>
<td>47</td>
</tr>
<tr>
<td>Asymptomatic</td>
<td>13.2 ± 4.8</td>
<td>20.3</td>
<td>46 + 13</td>
<td>5</td>
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</tbody>
</table>

P value < 0.001

Patients with single RV or systemic RV have significant risk for HF accompanied by high mortality

Functional status/ Exercise capacity

Functional status:
- Easy
- Cheap
- Not reproducible
- Not accurate

Objective measures of exercise capacity
- CPET
- 6MWT
The CPET allows the simultaneous study of the responses of the cellular, cardiovascular and ventilatory systems to a known exercise stress through the measurement of the gas exchange at the airway.
Prognostic power of exercise intolerance

Biochemical Markers

Reflection of the heart failure syndrome and systemic effects of ACHD

Applicable across ACHD spectrum

Easy to measure, most are inexpensive
BNP and prognosis in ACHD

Giannakoulas et al. AJC 2010
Renal dysfunction predicts adverse outcome in ACHD

Dimopoulos et al. Circulation 2008
Anemic ACHD patients have a worse outcome

Dimopoulos et al. JACC 2009
**Hyponatremia**

Median follow-up of 4.1 years
96 deaths

Eisenmenger n=16
“Complex diagnoses” n=15
“Valvar” disease n=12
Mustard groups n=12,

Patients at risk

<table>
<thead>
<tr>
<th>Patients at risk</th>
<th>0 years</th>
<th>1 year</th>
<th>2 years</th>
<th>3 years</th>
<th>4 years</th>
<th>5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na ≤ 135mmol/l</td>
<td>156</td>
<td>142</td>
<td>125</td>
<td>113</td>
<td>92</td>
<td>72</td>
</tr>
<tr>
<td>Na &gt;135mmol/l</td>
<td>848</td>
<td>825</td>
<td>730</td>
<td>592</td>
<td>515</td>
<td>321</td>
</tr>
</tbody>
</table>

Cumulative Mortality (%)

Logrank p<0.0001

HR 3.26 (2.15-4.95)

Dimopoulos et al. Eur Heart J 2009
Chronotropic incompetence: relation to mortality

Survival probability (%)

Time (days)

HRR above median (51 bpm)

HRR below median (51 bpm)

$P < 0.0001$

$n = 753$
Imaging: residual lesions, ventricular dysfunction

Ventricular dysfunction

- Both Right and Left affects prognosis
- Usually the result of:
  - Chronic P or V overload
  - Systemic RV
  - Univentricular
  - Previous surgery
  - Cryptogenic/ intrinsic ventricular disease (ToF, TGA Switch)
  - Related to disease (e.g. Marfan)
  - Previous surgery (previous decades, RV)
CCTGA: Long-term Outcome

Probability of freedom from moderate/severe RV dysfunction (n=168)

Graham T. JACC 2000;36:255
Cardiothoracic ratio

Cumulative Mortality (%)

Time (years)

CTR>55%
CTR=48-55%
CTR<48%

p<0.0001
p<0.0001
p<0.0001

Patients at risk
CTR>55%  991  858  737  602  465  333  210  100
CTR=48-55% 1064  968  849  718  583  440  322  187
CTR<48%   977   884   780   661   549   437   332   213

Dimopoulos et al. Circulation submitted 2010
Pulmonary Hypertension and cyanosis

- PH in up to 10% of ACHD pts
- Eisenmenger the extreme of the spectrum
- PH associated with:
  - Exercise intolerance
  - Reduced operability
  - RV function/ R-sided valves
  - Increased risk of procedures/pregnancy
  - Arrhythmias
  - Death
Overall mortality curve

Cumulative mortality (%) vs. time (years)

Patients at risk: 229, 197, 169, 145, 116, 92, 69, 52

Dimopoulos et al. Circulation 2010
Propensity score-adjusted Cox regression: patients within the 3rd propensity score quartile

Cumulative mortality (%)

- No advanced therapies
- Advanced therapies

HR 0.16, 95% CI: 0.04-0.71

p=0.015

Average C-statistic=0.80

Dimopoulos et al. Circulation 2010
Mortality risk of pregnancy in PAH related to CHD

Bedard, Dimopoulos, Gatzoulis, EHJ 2009
Complications

- Arrhythmias
- Thrombosis
- Heart failure
- Hemoptysis
- Endocarditis
**Fontan: Death or hospitalization according to the presence of AT**

HR 5.81, 95% CI 3.13-10.80, p<0.0001

Logrank p<0.0001

Pscore adjusted HR 5.00, 95% CI: 2.48-10.09, p<0.0001

Giannakoulas, Heart 2010
Complications

- Arrhythmias
- Thrombosis
- Heart failure
- Hemoptysis
- Endocarditis
Clinical judgement

- ACHD expertise/team/Centre
- Judicious use of investigations
- Multidisciplinary approach
- Timely patient counselling e.g.
  - Pregnancy
  - Dental/skin hygiene
  - Symptoms: report early, etc
- Timely referral to surgery/EP
Figure 2. Appropriate ICD therapy in primary and secondary prevention

Freedom from appropriate ICD therapy (%)

Time from ICD implantation (years)

Logrank P=0.1303

8.1%/year

11.5%/year

Primary Prevention

Secondary Prevention
MRI Gadolinium enhancement
Myocardial fibrosis in repaired TET

Babu-Narayan et al  Circulation 2005

Age (years)  Arhythmia (%)  Restrictive RV (%)  VO2 (ml/kg/min)  ANP (pg/ml/L)  BNP > Normal  RVESVi (ml/m2)  RVEF (%)  LVESVi (ml/m2)  LVEF (%)  LV LGE Score

< median RV LGE  > median RV LGE

p < 0.001  p < 0.001  p = 0.04  p = 0.003  p < 0.001  p = 0.04  p = 0.065  p = 0.07  NS  NS

p = 0.037  p = 0.018

p < 0.001