

MANAGEMENT ERRORS IN ADULTS WITH CONGENITAL HEART DISEASE – PREVALENCE, SOURCES AND CONSEQUENCES

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Abstract

Aims

Improved survival has resulted in increasing numbers and complexity of adults with congenital heart disease (ACHD). International guidelines recommend specialized care but many patients are still not managed at dedicated ACHD centres. This study analysed referral sources and appropriateness of management for patients referred to our tertiary ACHD Centre over the past 3 years.

Methods and Results

We compared differences in care between patients referred from paediatric/ACHD-trained versus general adult cardiologists, according to Adherence (A) or Non-Adherence (NA) with published guidelines. NA cases were graded according to the severity of adverse outcome or risk of adverse outcome. Of 309 consecutively referred patients (28 ± 14 years, 51% male), 134 (43%) were from general cardiologists (19% highly complex CHD) and 115 (37%) were from paediatric cardiology or ACHD specialists (33% highly complex CHD). Sixty referrals (20%) were from other medical teams and of those, 31 had been lost to follow-up. Guideline deviations were more common in referrals from general compared to CHD-trained cardiologists ($p < 0.001$). Of general cardiology referrals, 49 (37%) were NA; 18 had catastrophic or major complications ($n=2,16$ respectively). By contrast, only 12 (10%) of the paediatric/ACHD referrals were NA but none of these were catastrophic and only 3 were major. Simple, moderate and highly

complex CHD patients were at increased risk of adverse outcome when not under CHD cardiology care ($p=0.04$, 0.009 and 0.002 respectively).

Conclusion

Non-adherence with guidelines was common in the ACHD population, and this frequently resulted in important adverse clinical consequences. These problems were more likely in patients who had not been receiving specialized CHD care. Configuring healthcare systems to optimise “whole of life” care for this growing population is essential.

Keywords

Congenital heart disease, transition, adult congenital heart disease, lost to follow-up, disease management

Abbreviations

ACHD - adult congenital heart disease, A - **adherent**, CHD - congenital heart disease, NA - **non-adherent**

Introduction

Delivering “whole of life” care for children born with complex medical problems is a substantial issue for all developed health care systems. Paediatric cardiologists traditionally deal with congenital heart issues, whereas adult cardiologists are trained in acquired heart diseases such as atherosclerosis and hypertension. This creates a potential problem for “whole of life” care when children with congenital heart disease (CHD), in whom there have often been enormous medical, financial and emotional investments made, transition to care as young adults.

Advances in surgical and medical care have led to rapid growth in the number and complexity of adults living with CHD, resulting in challenges to health care systems and potentially to deficiencies of care.¹ As a result, this growing patient group is at substantially increased risk of important morbidity and premature mortality.² Many of the underlying medical issues are uncommon or do not occur in adults with acquired heart disease. In recent years therefore, the need for delivery of expert care in specialized adult congenital heart disease (ACHD) centres has been recognized.^{3,4}

Current international guidelines recommend that all but the most simple congenital cardiac defects are managed, at least intermittently, by a cardiologist with ACHD training.⁴⁻⁶ When applied, this model of care has been associated with reduced mortality.^{7,8} Nevertheless, many patients are still solely under the care of general cardiologists rather than at specialized centers. The reasons for this are not well

characterized but might include geographic barriers and lack of sufficient ACHD centers.⁹

To our knowledge, the clinical consequences of the management of ACHD patients by generally trained versus CHD-trained cardiologists have not been reported. To understand the impact on patient care for this vulnerable and growing group of young adults, we sought to characterize the consequences for patient care according to compliance or otherwise with international ACHD care guidelines.^{5,6}

Methods

Study Design

Consecutive new referrals (≥ 16 years) to the major ACHD centre in Sydney, Australia from January 2013 to January 2016 were screened for inclusion. Prospectively defined exclusion criteria were uncomplicated bicuspid aortic valve disease or mitral valve prolapse. This study complies with the declaration of Helsinki. The database utilized for data collection has been approved by the Sydney Local Health District Ethics Review Committee (RPAH Zone). Individual consent waiver was granted.

CHD was classified as simple, moderately or highly complex in accordance with current ACC/AHA published guidelines.⁵ Each subject was classified by their most clinically important lesion, to facilitate analysis.

Referral sources were categorized as either CHD-cardiologist (paediatric or ACHD), general cardiologist, or other medical team (e.g. obstetric, general practitioner). A CHD cardiologist was defined as a cardiologist with at least 1 year of dedicated speciality training in CHD. Cardiologists without at least 1 year of formal CHD training were classified as general for the purposes of the study. Patients referred by other medical teams, who had been previously managed by a CHD-cardiologist but had been lost to any form of regular cardiology follow-up (> 3 years), were considered as “lost to follow-up”. Patients returning for review who were managed under a shared care model with our service were not considered to be a new referral and thus they were not included. Clinical notes including letters and results of investigations performed prior to referral, were retrospectively reviewed by 2 cardiologists with expertise in ACHD. For subjects who were under the care of a cardiologist, patient management at the time of referral based upon the “initial appointment” clinical notes and investigations arranged at that visit, were classified according to adherence or non-adherence with published guidelines.^{5,6,10-12} Patients referred directly when CHD was first identified were classified as “Adherent”. “Non-adherent” cases were graded according to the nature of the adverse outcome arising or the risk of adverse outcome, in accordance with local and international standards for risk assessment and classification of consequences:^{13,14}

1. Catastrophic - Death, near-death, permanent disability or loss of cardiac function with high likelihood of reducing life expectancy, inappropriate termination of pregnancy or advice to have termination.

2. Major - Permanent loss of cardiac function that poses significant risk to patient, recommended unnecessary intervention or failure to recommend necessary intervention with potential to expose patient to unnecessary risk of death or permanent loss of cardiac function, inappropriately advised against pregnancy.
3. Moderate - Less serious risk or inappropriate advice/treatment administered where the impact to patient is less serious and risk of death or permanent loss of cardiac function is unlikely.
4. Minor - failure to meet guidelines concerning investigation and treatment.

The grading of adverse outcome was agreed upon by both ACHD cardiologists. If there was uncertainty about the grade, the lowest or less important level was allocated. De-identified details of adverse events were then reviewed by an external CHD-cardiologist to minimise subjectivity. Once again, if there was disagreement, the lower grade was allocated.

New referrals who had never been under the care of any adult cardiologist were not included in analysis of compliance with clinical care guidelines. Only grade 1-3 adverse outcomes are reported in patients who had been lost to cardiology follow-up.

Statistical Analysis

Descriptive data are presented as mean \pm standard deviation. Comparisons between groups were made using Chi-squared testing for categorical variables and

Students t-testing for continuous variables. A two-sided p-value < 0.05 was considered significant. Logistic regression analyses were performed in new referrals from cardiologists to determine the predictors of adverse outcome (Grade 1-3 guideline deviation). Values produced were odds ratio, 95% confidence interval of the odds ratio, **the overall p-value and the C-statistic along with its 95% confidence interval.** Statistical analyses were performed using IBM SPSS Statistics, Version 22.0.

Results

Over the 3-year enrolment period, there were 309 consecutive referred patients who met the inclusion criteria. New referral characteristics are shown in Table 1. Simplified CHD categories are shown in Table 2. Of the non-cardiology referrers, 45 (15%) were the general practitioner/primary healthcare provider and 15 (5%) were other medical teams.

All referrals from CHD-specialists were for transition from paediatric services (108 or 94% of specialized CHD referrals, at age 20 ± 10 years, **range 16-37 years**) or relocation from other cities (5 patients).

Of patients referred from **general** cardiologists or other non-CHD trained doctors, 128 (66%) were for a specialist CHD opinion in the absence of new symptoms, 34 (17%) were for advice regarding new imaging findings, 19 (10%) were because of the

development of a new clinical problem, 10 were for advice related to pregnancy (5%) and 3 (2%) were for advice with regard to arrhythmia management.

Thirty-one of the 60 non-cardiology referrals (50%, representing 10% of the entire new referral cohort) had been lost to cardiac follow-up (for ≥ 3 years). Of those, 11 were simple (35%), 15 were moderately complex (48%) and 5 were highly complex (17%) CHD patients.

Overall, care was **adherent** with current guidelines in 187 of 249 patients who had been under regular cardiology follow-up (75%). 61 patients (25%) were classified as non-**adherent** (Figure 1a). Of the patients referred from CHD-cardiologists, 12 (10%) were non-**adherent**, but no consequences were catastrophic, 3 (2%) were major, 2 (2%) were moderate and 7 (6%) were minor. In contrast, 49 (37%) **general** cardiology referrals were non-adherent; 18 (14%) had catastrophic or major issues (n=2 and 16 respectively), 17 (13%) had moderately important and 14 (10%) had minor deviations from guidelines. Deviations from guidelines were substantially more common in referrals from general compared to CHD-trained cardiology referrals ($p < 0.001$), as were catastrophic/major complications ($p = 0.002$).

The impact of CHD complexity on the rate of guideline deviation is shown in Figure 1b. In patients referred by cardiologists, no catastrophic or major adverse events occurred in patients with simple congenital heart disease. Overall, patients with complex CHD (moderately or highly complex) were more likely to have had deviations from

clinical care guidelines, compared with simple CHD patients (29% vs. 9%, $p < 0.001$). Grade 1-3 (catastrophic/major/moderate) adverse outcomes were also more common in complex CHD cases (20% vs. 6%, $p < 0.001$).

Catastrophic, major and moderate complications in new referrals from cardiologists are described in Table 3; the most common catastrophic/major adverse outcome overall occurred in the setting of free pulmonary regurgitation after repair of tetralogy of Fallot or obstructive right heart lesions.

The results of multivariable analyses for new cardiology referrals are shown in Table 4. The C-statistic for the model was 0.78 (0.72-0.85). Being under the care of a general cardiologist, age ≥ 30 years and complex CHD were independent predictors of Grade 1-3 adverse outcomes.

Thirty-one (10%) new referrals were referred back to specialized CHD care having been lost to any kind of cardiology follow-up ≥ 3 years (age at referral 29 ± 9 years, 52% female); of these, 3 (10%) had catastrophic complications, 1 (3%) had a major complication and 1 (3%) had a moderately serious complication. Catastrophic and major complications were more likely to occur in patients who had been lost to follow-up compared with those who had remained under specialized CHD care (13% vs. 3%, $p = 0.02$). Catastrophic complications in these patients included sudden death due to aortic aneurysm in repaired coarctation ($n = 1$), resuscitated cardiac arrest (ventricular tachycardia) in the setting of severe pulmonary regurgitation and right ventricular

dilatation after repair for tetralogy of Fallot (n=1) and cardiogenic shock and stroke complicating severe aortic regurgitation with left ventricular dysfunction in congenital aortic stenosis after open-valvotomy (n=1). There was one major adverse issue in a patient with very severe systemic ventricular dysfunction and ventricular tachycardia after Mustard repair and one moderate adverse outcome in a patient with severe pulmonary regurgitation after tetralogy of Fallot repair, who had severe right ventricular dilatation.

Discussion

We have found that management of adults with CHD outside specialist ACHD centres is associated with a high risk of important adverse events, and these are related to deviations from clinical care guidelines.

The great success of paediatric cardiac care in recent decades has created a challenge for healthcare systems to provide equivalent excellent levels of care for this growing population of adult survivors, who often have complex cardiac disease. This is the first study, to our knowledge, to document the rate of deviation from guidelines in the management of ACHD patients, to classify this according to the referral source and to document the clinical consequences of such deviations. Our findings support current guidelines⁴⁻⁶ that recommend expert care for such patients and emphasise the need for adequate service provision for this rapidly expanding and vulnerable population.¹

In order to optimise “whole of life” outcomes, health systems will need to be configured to provide access to specialized care for adults with CHD. In Australia and the United Kingdom, for example, guidelines have recently been published which recommend the requirement for networks of care which include specialized centres, to provide national cover.^{15,16} Each country needs to consider specific transition and ACHD care solutions, according to existing demographic, medical training and systems factors.

In our study, the most common referral source was **general** adult cardiologists; this comprised almost half of new referrals. Three quarters of those referred were moderately or highly complex CHD patients. In comparison, only 37% of new referrals were from CHD-trained cardiologists the vast majority of those whom were transitioning from paediatric to adult CHD services (71% were moderately or highly complex). These data suggest that a large number of adults with CHD are being managed outside specialized CHD centres, despite current recommendations.^{5,6} Clinically important adverse events of moderate to catastrophic severity occurred in only 4% of referrals from CHD-trained sources (none catastrophic), compared with 26% in referrals from **general** cardiologists, despite the more complex case mix for the specialist referrals (33% of highly complex patients versus 19% highly complex, amongst the **general** cardiology referrals). Thus current referral and management patterns of children born with CHD may result in suboptimal clinical outcomes, which can be catastrophic. Potential solutions to this problem are organisational and education-related.

There are three possible “fates” for children with CHD as they become adults; referral to ACHD-trained specialists; loss to follow-up; or referral to **general** adult cardiologists without specific ACHD expertise.

Our data show that when there is successful transition from paediatric cardiology to ACHD care, errors that result in adverse clinical consequences are rare. The challenge, however, is to optimise the transition of care process to minimise loss of patients. Even in the most experienced CHD centres, transition to ACHD care fails in up to 50% of cases;¹⁷ this is likely due to a combination of inadequately designed interservice transition arrangements and to patient-related factors (such as adolescent rebellion, a desire to be “normal” and/or financial constraints, especially in countries without universal health care coverage).¹⁷ Whatever the reason, loss to ACHD follow up is associated with markedly increased mortality and morbidity.¹⁸ In our study, 10% of new referrals were patients who had been lost to specialized CHD care (for ≥ 3 years). This number of complex patients lost to CHD-trained care is likely to be markedly underestimated as we do not know about ACHD patients who were never referred to an expert centre but continued to be managed by a **general** cardiologist (or physician) only, or who were under no cardiology care at all. Ten percent of our “lost to follow-up” patients had catastrophic complications, emphasising the great need for improved transition arrangements for adolescents. Potential solutions include paediatric CHD registries and mechanisms for patient recall; patient education and engagement; and provision of an adequate and trained workforce to implement such programs.^{3,17,19}

We found that many children with CHD are ultimately cared for by general cardiologists. This is also the case in many other regions, including North America and the United Kingdom.^{17,20,21} In our study, **general** cardiology care was associated with substantial non-compliance with care guidelines, often with serious consequences for the patient. Solutions to this issue include improved education in ACHD during adult cardiology training, easy access for **general** cardiologists to ACHD centres for advice (via care networks) and models of shared care, especially for rural and remote ACHD patients.

Adverse events were more common in patients with moderately or highly complex CHD **but even patients with simple CHD had an increased risk of adverse outcome**, supporting recommendations that encourage at least intermittent CHD-trained cardiology assessment for these patients.^{5,6} These data are likely to underlie the improvement in survival demonstrated in Canada, after the implementation of guidelines that recommended specialized ACHD care for patients with complex CHD.⁷ Our evidence from the Australia and New Zealand Fontan Registry has also demonstrated that non-specialized care is associated with increased risk of serious complications, in the particularly challenging group of adults with “single ventricle” hearts.⁸

The commonest “errors” we observed were related to underestimation of pulmonary regurgitation, a common late consequence of repaired tetralogy of Fallot or right heart obstruction. In this setting delayed treatment of pulmonary regurgitation exposes patients to risks of adverse cardiac remodelling, ventricular arrhythmia and

death, in the setting of severe right ventricular dilatation.²² This observation is consistent with data from the United Kingdom that demonstrated the proportion patients with repaired tetralogy of Fallot who received pulmonary valve replacement was much lower in those receiving general follow-up compared with those with specialized CHD care.²⁰ When considered as proportion of lesion-type, high numbers of adverse events were also noted from non-compliance in relation to unrepaired intracardiac shunts, repaired coarctation or interrupted aortic arch, Ebstein's anomaly, repaired atrioventricular septal defect, Mustard/Senning repair for transposition of the great arteries and complex single ventricle patients.

Based on prevalence estimates from developed countries, there are likely at least 2000 CHD children per million children aged 8 to 18 years, who will require adult care for severe CHD, over the next 10 years.¹ Our data suggest that care at a specialized ACHD Centre rather than by **general** cardiologists could avoid approximately 40 000 adverse events over 10 years, in developed countries alone (that is, approximately 400 adverse clinical events for every 2000 patients who transition to adult care). This number would be even greater if adults with CHD who are already under **general** cardiology care and less severe CHD patients were to be included.

Limitations

A limitation of this study is potential selection bias. We only studied those patients who were eventually referred to an ACHD Centre; those lost to follow up

entirely would not have been included. Thus the true picture of late adverse clinical outcomes has likely been underestimated in our study. Another potential limitation is the methodology used for interpretation of the severity of adverse outcomes related to non-compliance with published guidelines. We attempted to minimise subjectivity or bias by using internationally recognized tools to grade adverse outcome,¹³ down-grading any adverse event when a consensus was not achieved between specialist assessors and including an external, blinded assessor. It is likely that advancing age is associated with an increased incidence of cardiac complications and, since general cardiology referrals were older on average, this may have biased the results. On multivariable analysis, however, we found that referral from a general cardiologist was predictive of adverse outcome independent of patient age at the time of referral. Our data is from a single ACHD centre in Australia and practices may differ internationally, but our outcomes for patients with some of the most complex congenital heart disease are excellent by international standards²³ and the issues we have highlighted are supported by recent data from North America and the United Kingdom.^{17,18,20} The reasons for non-compliance with guidelines may not simply be related to physician-related factors; patients may decline intervention or be non-compliant with medical recommendations. To address this issue, care was classified as **adherent** if the physician had proposed guideline-directed management, even if the plan was not implemented. Also, clinical status could have changed between the last review prior to referral and the first review at our centre, however this should have been equally likely, from any referral source (CHD trained or general). Finally, we acknowledge that “guidelines” only guide management decisions, which sometimes require modification according to individual patient factors.

Conclusions

The rapidly expanding ACHD population is at risk of a complex array of issues that require specialized care.²⁴ We have found that a significant proportion of the ACHD cohort had received care that was not **adherent** with guidelines, and that this led frequently to adverse consequences which were far more common in referrals from general cardiologists than in referrals from practitioners with CHD training and expertise; with over one quarter of patients from “non-specialists” having adverse clinical events. Patients who were lost to any kind of cardiology follow-up were at a similarly increased risk of major or catastrophic complications. Optimising health care systems to enable adequate access to specialized ACHD service provision for this growing population is essential.

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Figure Title and Legend:

Figure 1) a and b Guideline Deviations in New Adult Referrals to a Specialized Congenital Heart Disease Centre: Incidence, Clinical Implications and Impact of Complexity. Statistical comparison reported for combined analysis of moderate to catastrophic complications

Table Titles**Table 1**

New Referrals and Frequency of Non-Compliance with Clinical Guidelines

Abbreviations: CHD - congenital heart disease, TGA - transposition of the great arteries

Table 2: Congenital Heart Defect Categories with Grade 1-3 Adverse Outcomes Referred from Cardiologists - Frequency and Issue

Table 3

Predictors of Grade 1-3 Adverse Outcomes in Referrals from Cardiologists

Abbreviations: CHD - congenital heart disease