Cardiology in the Young (2017), **27**, 1764–1770
doi:10.1017/S1047951117001214

Original Article

Revision: review of non-elective hospitalisations of adults with CHD

Alexandra Soufi,[1,2] Jack M. Colman,[2] Qunyu Li,[2] Erwin N. Oechslin,[2] Adrienne H. Kovacs[2]

[1]*Cardio-Pediatric and Congenital Medico-Surgical Department, Cardiologic Hospital Louis Pradel, Lyon, France;*
[2]*Toronto Congenital Cardiac Centre for Adults, Peter Munk Cardiac Centre, University Health Network, University of Toronto, Toronto, Canada*

Abstract *Introduction:* The adult CHD population is increasing and ageing and remains at high risk for morbidity and mortality. In a retrospective single-centre study, we conducted a comprehensive review of non-elective hospitalisations of adults with CHD and explored factors associated with length of stay. *Methods:* We identified adults (⩾18 years) with CHD admitted during a 12-month period and managed by the adult CHD service. Data regarding demographics, cardiac history, hospital admission, resource utilisation, and length of stay were extracted. *Results:* There were 103 admissions of 91 patients (age 37 ± 10 years; 52% female). Of 91 patients, 96% had moderate or complex defects. Of 103 admissions, 45% were through the emergency department. The most common reasons for admission were arrhythmia (37%) and heart failure (28%); 29% of admissions included a stay in the ICU. The mean number of consultations by other services was 2.0. Electrophysiology and anaesthesiology departments were most frequently consulted. After removing outliers, the mean length of stay was 7.9 ± 7.4 days (median = 5 days). The length of stay was longer for patients admitted for heart failure (12.2 ± 10.3 days; p = 0.001) and admitted directly to the ward (9.6 ± 8.9 days; p = 0.009). *Conclusions:* Among non-electively hospitalised adults with CHD in a tertiary-care centre, management often entails an interdisciplinary approach, and the length of stay is longest for patients admitted with heart failure. The healthcare system must ensure optimal resources to maintain high-quality care for this expanding patient population.

Keywords: Adult CHD; hospitalisation; heart failure; length of stay

Received: 20 January 2017; Accepted: 11 May 2017; First published online: 10 July 2017

Approximately 90% of infants with CHD are now expected to reach adulthood.[1] The adult CHD population is thus expanding and ageing.[2] Despite increasing survival rates, adults with CHD remain at increased risk for arrhythmia, heart failure, re-operation, and premature death.[3–7] This population, particularly those with complex disease, is known to have a higher hospitalisation rate and longer hospital length of stay compared with the general adult population.[4,8–10] Higher healthcare resource utilisation has been described among elderly adults with CHD.[11] Guidelines recommend that patients with complex and moderate defects be followed-up in specialised adult CHD centres.[12–14]

A thorough description of the institutional resource utilisation for non-elective hospitalisations of adults with CHD in a North American tertiary-care centre has not been reported. We undertook an extensive review of consecutive non-elective inpatient admissions to describe inpatient care in terms of patient demographics, diagnostic and treatment history, reason for hospital admission, resource utilisation, and length of stay as well as identify factors associated with longer length of stay.

Correspondence to: A. H. Kovacs, PhD, Toronto Congenital Cardiac Centre for Adults, Peter Munk Cardiac Centre, University Health Network, 585 University Avenue, 5N-519, Toronto, ON, Canada, M5G 2N2. Tel: 416 340 4871; Fax: 416 340 5014; E-mail: akovacs@uhnresearch.ca

Methods

Sample and design

Admissions were included in this retrospective study if they met the following inclusion criteria: patient aged 18 years or older, patient with documented CHD, non-elective admission, including overnight stay, to our tertiary-care centre located in Canada in a 12-month period, and patient managed by the adult CHD service. Exclusion criteria were as follows: admission for elective procedures and admission for medical reason for which care did not involve the adult CHD service. A thorough review of multiple cross-referenced sources was undertaken to generate an accurate list of inpatients meeting inclusion/exclusion criteria and to abstract the data. Data from the first admission within the study period were used to describe the socio-demographic characteristics and medical history of patients with more than one admission. The study was approved by the institutional Research Ethics Board.

Data abstraction

Socio-demographic characteristics. The following data were abstracted: age at admission, sex, marital status, whether patients had children, driving time from hospital, which was determined using an online map service, employment status, documented cognitive/developmental, or psychological disorders, known current tobacco use, and documented alcohol problem or illegal drug use.

Diagnostic and treatment history. CHD were categorised as follows: simple, for example, small atrial septal defect; moderate, for example, tetralogy of Fallot and coarctation of the aorta; or complex, for example, Fontan repair, transposition of the great arteries, and double-outlet ventricle.[13] Operative history was categorised as follows: unoperated, no previous procedure; palliated, one or more previous palliative procedures but no reparative intervention; repaired, haemodynamic and/or anatomic repair; or re-operated, additional operative procedure(s) following the initial repair.[15] Details regarding subaortic ventricular morphology – right or left – and interventional history were noted. Any history of sustained arrhythmia, heart failure, stroke, or transient ischaemic attack, infective endocarditis, myocardial infarction, or transplant assessment was also documented.

Hospital admission. The following data were abstracted for each admission: the source of admission, day of admission – weekend versus weekday – and reason for admission – arrhythmia, heart failure, other cardiovascular, or other non-cardiovascular reasons. With regard to resource utilisation, the following were documented for each admission: location(s) of stay, non-adult CHD medical consultations, diagnostic investigations, main procedures and treatments, mechanical ventilation, blood transfusion, and mortality. Discharge destination and recommended outpatient clinic follow-up plan were also recorded.

Statistical analyses

Results are presented as frequencies and percentages or as means and standard deviations as appropriate. When associating variables with length of stay, we excluded four outliers for length of stay (z-scores >2). We conducted Student t-tests and correlations to investigate which factors were associated with longer length of stay. Owing to the exploratory nature of this study, a p-value of <0.05 was considered significant for all analyses. Data analyses were performed using SPSS for Windows, version 22.0 (SPSS Inc., Chicago, Illinois, United States of America, 2013).

Results

Sample and socio-demographic characteristics

In the 12-month period of study, 91 patients were under the care of the adult CHD service for a total of 103 admissions. The socio-demographic characteristics for the 91 unique patients (52% female, mean age $= 37 \pm 10$ years) are displayed in Table 1. The varying denominators in this table reflect the fact that all socio-demographic data were not available for all patients.

Diagnostic and treatment history

As presented in Table 2, 87/91 patients (96%) had moderate or complex forms of CHD. The most prevalent heart defects were univentricular anatomy/Fontan circulation (n = 21; 23%), repaired transposition of the great arteries/atrial or arterial switch procedure (n = 11; 12%), repaired tetralogy of Fallot (n = 10; 11%), and cyanotic CHD or Eisenmenger syndrome (n = 10; 11%). A total of 63 patients (69%) had a history of sustained arrhythmia, 25 patients (28%) had a history of heart failure, and 16 (18%) had previously undergone evaluation for heart and/or lung transplantation, although none had undergone transplantation.

Hospital admission

As displayed in Table 3, of 103 hospitalisations, patients were most often admitted through the emergency department (n = 46; 45%) and on weekdays (n = 80; 78%). The most common reasons for admission were arrhythmia (n = 38; 37%) and heart failure (n = 29; 28%). Other cardiovascular reasons

https://doi.org/10.1017/S1047951117001214 Published online by Cambridge University Press

Table 1. Socio-demographic characteristics.

	Mean ± SD or n (%)
Age	37 ± 10 years
Female sex	47/91 (52%)
Married or living with partner	40/76 (53%)
Has ⩾1 child	34/70 (49%)
Calculated driving time from hospital	
<1 hours	57/91 (63%)
1–5 hours	21/91 (23%)
>5 hours	13/91 (14%)
Live outside the province of Ontario	8/91 (9%)
Employment status	
Employed full/part-time	38/82 (46%)
Disability	22/82 (27%)
Unemployed/not working/retired	20/82 (24%)
Student	2/82 (2%)
Documented cognitive/developmental disorder	9/91 (10%)
Documented psychological disorder	29/91 (32%)
Current tobacco use	12/71 (17%)
Documented alcohol problem	6/91 (7%)
Documented illegal drug use	4/91 (4%)

Denominators reflect the number of patients for whom data were available

Table 2. Diagnostic and treatment history (n = 91).

	n (%)
CHD complexity	
Simple (e.g. simple VSD)	4 (4%)
Moderate (e.g. tetralogy of Fallot, coarctation of the aorta)	29 (32%)
Great (e.g. Fontan physiology, transposition of the great arteries)	58 (64%)
Cardiovascular surgery history	
Unoperated	13 (14%)
Palliated	7 (8%)
Repaired	37 (41%)
Re-operated	34 (37%)
Subaortic ventricular morphology	
Right	24 (26%)
Left	67 (74%)
⩾1 adult diagnostic cardiac catheterisation	35 (38%)
⩾1 interventional cardiac catheterisation	24 (26%)
Cardiac history	
Any sustained arrhythmia	63 (69%)
Previous cardioversion	30 (33%)
Ablation	23 (25%)
Pacemaker	20 (22%)
Implantable cardioverter defibrillator	6 (7%)
Heart failure	25 (28%)
Stroke/transient ischaemic attack	10 (11%)
Infective endocarditis	8 (9%)
Myocardial infarction	2 (2%)
Transplant assessment	16 (18%)

for admission included evaluation of cardiovascular symptoms (n = 9), haemoptysis (n = 4), and infective endocarditis (n = 4).

Table 3. Hospital admission characteristics (n = 103).

	n (%)
Admission via	
Emergency department	46 (45%)
Directly to the ward	57 (55%)
Transfer from another hospital	25 (24%)
Admitted from home	24 (23%)
Admitted from clinic	8 (8%)
Day of admission	
Weekend	23 (22%)
Weekday	80 (78%)
Reason for admission	
Arrhythmia	38 (37%)
Atrial fibrillation/flutter/other supraventricular tachycardia	29 (28%)
Other arrhythmia	6 (6%)
Pacemaker/implantable cardioverter defibrillator problem	3 (3%)
Heart failure	29 (28%)
Other	36 (35%)
Other cardiovascular	32 (31%)
Other non-cardiovascular	4 (4%)

Resource utilisation

Table 4 presents the resource utilisation for all 103 admissions. During the study period, intensive care management occurred in 30 admissions (29%) and transplant assessment occurred during 15 (15%) admissions. The occurrence of intensive care management did not differ by sex, age, or defect complexity, moderate versus complex, or primary reason for admission. The mean number of consultations with other services was 2.0 ± 1.7. Electrophysiology was the service consulted most often (n = 50; 49%). A non-cardiovascular consultation occurred in 44 (43%) admissions. The mean number of consultations did not differ by sex, age, or defect complexity, moderate versus complex; however, there were more consultations for patients admitted for heart failure versus arrhythmia or other reasons (2.8 ± 2.1 versus 1.5 ± 1.0 versus 1.9 ± 1.8, respectively; p = 0.009).

Length of stay

The mean length of stay across the 103 admissions was 12.0 ± 23.2 days (with a range from 1 to 168) for a total of 1243 days; thus, a mean of 3.4 hospitalised patients per day were managed by the adult CHD service. We removed four outliers with lengths of stay ranging from 70 to 168 days, two of whom were admitted for heart failure. In the resulting sample size of 99, the mean length of stay was 7.9 ± 7.4 days, with a median of 5 days. Among these 99 admissions, the length of stay did not vary by demographic variables, sex and age, moderate versus complex defect complexity, previous cardiovascular surgery, or

https://doi.org/10.1017/S1047951117001214 Published online by Cambridge University Press

Table 4. Resource utilisation (n = 103).

	n (%) or mean ± SD
Intensive care management for part of the admission	30 (29%)
Services consulted	
⩾1 cardiovascular consultation	77 (75%)
⩾1 non-cardiovascular consultation	44 (43%)
Total number of services consulted	2.0 ± 1.7
Non-adult CHD physician consultations	
Electrophysiology	50 (49%)
Cardiac anaesthesiology	32 (31%)
Interventional cardiology	22 (21%)
Congenital heart surgery	19 (18%)
Heart failure	17 (17%)
Infectious disease	15 (15%)
Heart and/or lung transplant	15 (15%)
Neurology	7 (7%)
Vascular surgery	6 (6%)
Endocrinology	6 (6%)
Hepatology/gastroenterology	7 (7%)
Pulmonary hypertension	5 (5%)
Haematology	5 (5%)
Nephrology	5 (5%)
Respirology	4 (4%)
Allied health consultations	35 (34%)
Respiratory therapy	17 (17%)
Nutrition	11 (11%)
Social work	7 (7%)
Physiotherapy	6 (6%)
Psychology	3 (3%)
Investigations	
Transthoracic echocardiography	52 (50%)
Thorax CT	33 (32%)
Cardiac catheterisation	19 (18%)
Cardiac MRI	11 (11%)
Electrophysiology study	8 (8%)
ECG	5.4 ± 11.5
Chest X-ray	2.4 ± 4.5
Procedures and treatments	
Heart failure management	31 (30%)
Cardioversion	17 (17%)
Arrhythmia medical management	15 (15%)
Pacemaker implantation	9 (9%)
Electrophysiology ablation	8 (8%)
Percutaneous cardiovascular intervention	8 (8%)
Cardiac reoperation	5 (5%)
Infective endocarditis treatment	5 (5%)
Mechanical ventilation	15 (15%)
Blood transfusion	11 (11%)

documented psychological disorder. Length of stay also did not differ significantly between the four most common diagnoses – Fontan circulation, repaired transposition of the great arteries, repaired tetralogy of Fallot, and cyanotic CHD/Eisenmenger syndrome. Length of stay was longer for patients admitted for heart failure versus arrhythmia or other reasons (12.2 ± 10.3 versus 5.8 ± 4.4 versus 6.8 ± 6.1, respectively; p = 0.001). Length of stay was also longer when patients were admitted directly to the ward versus via the emergency department (9.6 ± 8.9 versus 5.7 ± 4.0; p = 0.009). Follow-up analyses revealed that patients admitted directly to the ward versus emergency department did not differ with regard to age, sex, defect complexity, primary reason for admission, or NYHA class (all p-values >0.05) (Fig 1).

Discharge planning

There were seven deaths across the 103 hospitalisations, and therefore information regarding discharge planning was available for 96 admissions. The majority of patients were discharged back to their homes (n = 93; 97%). Only two patients were transferred to other hospitals, and one was transferred to a rehabilitation facility; we do not have data regarding the length of stay at these other facilities. Among the 75 discharged patients with known planned outpatient clinic follow-up, appointments were on average scheduled for 7.4 ± 8.2 weeks and occurred at a mean of 9.3 ±11.9 weeks after discharge.

Discussion

Complex medical management

The adult CHD population, which is increasing in numbers, morbidity, and complexity, will continue to challenge allocated inpatient and outpatient resources in any adult CHD centre.[2,16,17] This study highlights the fact that complex patients require complex management.

Approximately 3000 patients were followed-up in the outpatient clinic the year of data collection; thus, we estimate a 3% rate of non-elective hospitalisation among patients followed-up at our clinic. Among non-elective hospitalisations at our tertiary-care centre, most inpatients had moderate or complex CHD; Fontan circulation, repaired transposition of the great arteries, and repaired tetralogy of Fallot were most common. Arrhythmia and heart failure are common CHD complications known to be associated with emergency hospital admissions[18–20] and our study further documented these as the two most common reasons for non-elective admissions. Arrhythmias and heart failure manifest especially complex behaviour within this population and require unique expertise to understand their presentation and treatment.[21] As supraventricular arrhythmias are common following Fontan and atrial switch procedures,[22–24] it is not surprising that half of the patients in this study had consultations from the electrophysiology service. With regard to heart failure, this represents a different process in single-ventricle physiology or in a patient after atrial switch procedure with a subaortic right ventricle compared with that which occurs in heart failure associated with acquired heart disease.[22,25,26]

https://doi.org/10.1017/S1047951117001214 Published online by Cambridge University Press

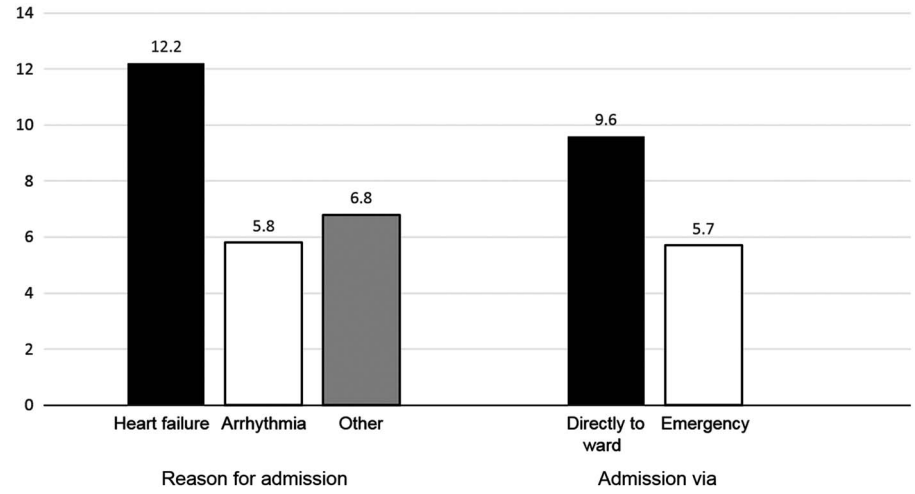

Figure 1.
Length of stay (days).

The care of adults with complex CHD admitted to hospital under an adult CHD service demands consultation and collaboration with a variety of healthcare providers as previously shown.[18] Almost half of the admissions required consultation with non-cardiovascular medical specialties, and approximately one-third included allied health consultations. We found that approximately half of non-elective admissions began in the emergency department, and that one-third of patients in this study were managed in an ICU for a portion of their hospitalisation. The observation that cardiac anaesthesiology was actively involved in one-third of the hospital admissions underscores the importance of collaboration with cardiac anaesthetists with expertise in complex CHD anatomy and pathophysiology and the fragile pathophysiology of CHD patients.

Length of stay considerations

After removing outliers, the mean length of stay in this study was 8 days, with a median of 5 days, and was significantly longer in patients admitted with heart failure. A focus on length of stay is certainly not unique to the CHD community. Within the acquired heart disease population, heart failure is the most frequent admitting diagnosis and also associated with longer length of stay.[27] The 29 patients in our study who were admitted for heart failure had an average length of stay of 12 days, which is longer than that reported for all acute hospitalisations due to heart failure in Canada (9.2 days).[28] They also had a higher number of consultations during their hospitalisations. Longer length of stay among heart failure patients has been associated with greater co-morbidities and disease severity,[29] although the ability to risk stratify remains limited.[29] The adult CHD community might wish to draw upon strategies targeting length of stay within the general heart failure population, such as the provision of post-discharge ambulatory care.[30] Close outpatient follow-up can facilitate earlier identification of cardiac destabilisation and planned weekday admissions. Advanced practice nurses play a key role in the acquired heart disease population as well as the adult CHD population by identifying patient care needs, providing ongoing tailored education, maintaining regular telephone follow-up while promoting self-care capacity and coordinating care with all concerned care providers.[31–33]

Although length of stay was longer among patients admitted directly to the ward versus via the emergency department, we did not detect any other significant differences between the two groups. We hypothesise, based on our clinical experiences, that patients admitted directly to the ward might have had more challenging healthcare needs not captured by disease complexity or the NYHA class because they were either transferred from another hospital, which did not have the resources to provide complex adult CHD treatment, or were admitted from home or the clinic, in which case we would have tried to optimise treatment on an outpatient basis if possible.

Unique psychosocial considerations

Our observation that one-third of inpatients had a known history of psychological problems is consistent with research conducted in outpatient clinics.[34,35] As very few inpatients in this study received inpatient mental health services, it is important to determine optimal strategies to assess and provide treatment when appropriate. Indeed, hospitalisations can present additional psychosocial challenges for adults with CHD. Adults admitted to hospitals with acquired

https://doi.org/10.1017/S1047951117001214 Published online by Cambridge University Press

heart disease are typically in their seventh or eighth decades of life, whereas in our study the mean age of adult CHD inpatients was 37 years. Most hospitalised adults with CHD are thus at a very different stage in their lives than patients hospitalised with acquired heart disease; in our study, almost half of them were employed and had, presumably younger, children.

Further, unlike general cardiovascular patients for whom appropriate medical care is more readily available, adult CHD programmes are typically housed within tertiary-care centres that are often located at a significant distance from the patient's home,[36] thereby increasing the risk of social isolation during hospitalisation. Indeed, one in seven patients in this study lived over 5 hours' driving distance from the hospital; therefore, when caring for hospitalised adults with CHD, it is important to be mindful of potential psychosocial challenges and to develop strategies to optimise overall health care.

Study limitations

This study overcame some of the challenges of administrative databases and national registries, which may include inaccuracies and incomplete data;[37,38] however, the study sample was limited to non-elective hospitalisations in a single, large, Canadian supra-regional centre, and therefore the results may not be easily generalisable to community hospitals or hospitals without a dedicated adult CHD inpatient service. Results of this study are also most generalisable to other tertiary-care centres in Canada or other countries with universal health care. We were unable to determine the extent to which insurance coverage might impact non-elective hospitalisations. In addition, our focus was care provided by the adult CHD service at a tertiary care hospital. We do not have overall length of stay data on the three patients who were transferred to other hospitals or a rehabilitation facility. We also do not have data from our institution regarding resource use and length of stay of non-CHD patients or CHD patients admitted to other services. Further, data were analysed for a 1-year period only. We did not analyse changes in admissions over time, and therefore we do not know whether rates are increasing.

Conclusions

The population of adults with complex CHD continues to expand and remains at high risk for cardiovascular morbidity and mortality, thus requiring specialised care in both outpatient and inpatient settings. This is the first study to provide a thorough description of the nature of non-elective inpatient care for adults with CHD, and revealed heart failure and arrhythmia as the most common reasons for admission. The involvement of many subspecialists confirms CHD as a complex, multisystem disease that calls for interdisciplinary collaboration. Length of stay was longest for patients admitted with heart failure, and future studies should investigate whether it might be possible to reduce unnecessary length of stay while concurrently maintaining high-quality clinical care. Researchers may wish to draw upon strategies with proven effectiveness among adults with heart failure due to acquired heart disease. Finally, a comprehensive approach to inpatient management entails acknowledging complexities in both medical and psychosocial aspects of care.

Acknowledgements

The authors acknowledge the assistance provided by Nathan Ing and Vincent Maquin.

Financial Support

The authors acknowledge the French Federation of Cardiology for supporting the first author, Dr Alexandra Soufi, and the University Health Network Allied Health Research Committee for providing additional support for this study.

Conflicts of Interest

None.

Ethical Standards

The authors assert that all procedures contributing to this study comply with the ethical standards of the relevant national guidelines on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008, and has been approved by the University Health Network Research Ethics Board.

References

1. Moons P, Bovijn L, Budts W, Belmans A, Gewillig M. Temporal trends in survival to adulthood among patients born with congenital heart disease from 1970 to 1992 in Belgium. Circulation 2010; 122: 2264–2272.
2. Marelli AJ, Ionescu-Ittu R, Mackie AS, Guo L, Dendukuri N, Kaouache M. Lifetime prevalence of congenital heart disease in the general population from 2000 to 2010. Circulation 2014; 130: 749–756.
3. Warnes CA. The adult with congenital heart disease: born to be bad? J Am Coll Cardiol 2005; 46: 1–8.
4. Verheugt CL, Uiterwaal CS, van der Velde ET, et al. The emerging burden of hospital admissions of adults with congenital heart disease. Heart 2010; 96: 872–878.
5. Oechslin EN, Harrison DA, Connelly MS, Webb GD, Siu SC. Mode of death in adults with congenital heart disease. Am J Cardiol 2000; 86: 1111–1116.
6. Nieminen HP, Jokinen EV, Sairanen HI. Causes of late deaths after pediatric cardiac surgery: a population-based study. J Am Coll Cardiol 2007; 50: 1263–1271.

7. Verheugt CL, Uiterwaal CS, van der Velde ET, et al. Mortality in adult congenital heart disease. Eur Heart J 2010; 31: 1220–1229.
8. Mackie AS, Pilote L, Ionescu-Ittu R, Rahme E, Marelli AJ. Health care resource utilization in adults with congenital heart disease. Am J Cardiol 2007; 99: 839–843.
9. Opotowsky AR, Siddiqi OK, Webb GD. Trends in hospitalizations for adults with congenital heart disease in the U.S. J Am Coll Cardiol 2009; 54: 460–467.
10. Cedars A, Benjamin L, Vyhmeister R, et al. Contemporary hospitalization rate among adults with complex congenital heart disease. World J Pediatr Congenit Heart Surg 2016; 7: 334–343.
11. Tutarel O, Kempny A, Alonso-Gonzalez R, et al. Congenital heart disease beyond the age of 60: emergence of a new population with high resource utilization, high morbidity, and high mortality. Eur Heart J 2014; 35: 725–732.
12. Silversides CK, Marelli A, Beauchesne L, et al. Canadian Cardiovascular Society 2009 Consensus Conference on the management of adults with congenital heart disease: executive summary. Can J Cardiol 2010; 26: 143–150.
13. Warnes CA, Williams RG, Bashore TM, et al. ACC/AHA 2008 guidelines for the management of adults with congenital heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (writing committee to develop guidelines on the management of adults with congenital heart disease). Circulation 2008; 118: e714–e833.
14. Baumgartner H, Bonhoeffer P, De Groot NM, et al. ESC guidelines for the management of grown-up congenital heart disease (new version 2010). Eur Heart J 2010; 31: 2915–2957.
15. Gatzoulis MA, Hechter S, Siu SC, Webb GD. Outpatient clinics for adults with congenital heart disease: increasing workload and evolving patterns of referral. Heart 1999; 81: 57–61.
16. O'Leary JM, Siddiqi OK, de Ferranti S, Landzberg MJ, Opotowsky AR. The changing demographics of congenital heart disease hospitalizations in the United States, 1998 through 2010. JAMA 2013; 309: 984–986.
17. Islam S, Yasui Y, Kaul P, Marelli AJ, Mackie AS. Congenital heart disease hospitalizations in Canada: a 10-year experience. Can J Cardiol 2016; 32: 197–203.
18. Kaemmerer H, Bauer U, Pensl U, et al. Management of emergencies in adults with congenital cardiac disease. Am J Cardiol 2008; 101: 521–525.
19. Kaemmerer H, Fratz S, Bauer U, et al. Emergency hospital admissions and three-year survival of adults with and without cardiovascular surgery for congenital cardiac disease. J Thorac Cardiovasc Surg 2003; 126: 1048–1052.
20. Koh AS, Yap BT, Le Tan J. Emergency admissions in Asians with adult congenital heart disease. Int J Cardiol 2011; 151: 54–57.
21. Khairy P, Van Hare GF, Balaji S, et al. PACES/HRS expert consensus statement on the recognition and management of arrhythmias in adult congenital heart disease: developed in partnership between the Pediatric and Congenital Electrophysiology Society (PACES) and the Heart Rhythm Society (HRS). Endorsed by the governing bodies of PACES, HRS, the American College of Cardiology (ACC), the American Heart Association (AHA), the European Heart Rhythm Association (EHRA), the Canadian Heart Rhythm Society (CHRS), and the International Society for Adult Congenital Heart Disease (ISACHD). Heart Rhythm 2014; 11: e102–e165.
22. Warnes CA. Transposition of the great arteries. Circulation 2006; 114: 2699–2709.
23. Sridhar A, Giamberti A, Foresti S, et al. Fontan conversion with concomitant arrhythmia surgery for the failing atriopulmonary connections: mid-term results from a single centre. Cardiol Young 2011; 21: 665–669.
24. Aboulhosn J, Williams R, Shivkumar K, et al. Arrhythmia recurrence in adult patients with single ventricle physiology following surgical Fontan conversion. Congenit Heart Dis 2010; 5: 430–434.
25. Horer J, Herrmann F, Schreiber C, et al. How well are patients doing up to 30 years after a mustard operation? Thorac Cardiovasc Surg 2007; 55: 359–364.
26. Cedars A, Joseph S, Ludbrook P. Heart failure in adults who had the Fontan procedure: natural history, evaluation, and management. Curr Treat Options Cardiovasc Med 2013; 15: 587–601.
27. Albert K, Sherman B, Backus B. How length of stay for congestive heart failure patients was reduced through six sigma methodology and physician leadership. Am J Med Qual 2010; 25: 392–397.
28. Information CIfH. Hospital Morbidity Database. 2013–2014.
29. Whellan DJ, Zhao X, Hernandez AF, et al. Predictors of hospital length of stay in heart failure: findings from Get With the Guidelines. J Card Fail 2011; 17: 649–656.
30. Dusemund F, Steiner M, Vuilliomenet A, et al. Multidisciplinary assessment to personalize length of stay in acute decompensated heart failure (OPTIMA II ADHF). J Clin Med Res 2012; 4: 402–409.
31. Carrington MJ, Stewart S. Bridging the gap in heart failure prevention: rationale and design of the Nurse-led Intervention for Less Chronic Heart Failure (NIL-CHF) study. Eur J Heart Fail 2010; 12: 82–88.
32. Washburn SC, Hornberger CA. Nurse educator guidelines for the management of heart failure. J Contin Educ Nurs 2008; 39: 263–267.
33. Moons P, De Geest S, Budts W. Comprehensive care for adults with congenital heart disease: expanding roles for nurses. Eur J Cardiovasc Nurs 2002; 1: 23–28.
34. Kovacs AH, Saidi AS, Kuhl EA, et al. Depression and anxiety in adult congenital heart disease: predictors and prevalence. Int J Cardiol 2009; 137: 158–164.
35. Bromberg JI, Beasley PJ, D'Angelo EJ, Landzberg M, DeMaso DR. Depression and anxiety in adults with congenital heart disease: a pilot study. Heart Lung 2003; 32: 105–110.
36. Beauchesne LM, Therrien J, Alvarez N, et al. Structure and process measures of quality of care in adult congenital heart disease patients: a pan-Canadian study. Int J Cardiol 2012; 157: 70–74.
37. Welke KF, Karamlou T, Diggs BS. Databases for assessing the outcomes of the treatment of patients with congenital and paediatric cardiac disease – a comparison of administrative and clinical data. Cardiol Young 2008; 18 (Suppl 2): 137–144.
38. Zomer AC, Uiterwaal CS, van der Velde ET, et al. Mortality in adult congenital heart disease: are national registries reliable for cause of death? Int J Cardiol 2011; 152: 212–217.