Heart, Lung and Circulation (2019) **28**, 1427–1435
1443-9506/04/$36.00
https://doi.org/10.1016/j.hlc.2019.05.176

REVIEW

Echocardiography in Indigenous Populations and Resource Poor Settings

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The majority of global cardiovascular disease burden occurs in low- and middle-income countries (LMIC) and indigenous populations. Although common diseases, such as ischaemic heart disease, cause significant burden, there are also neglected diseases. Forgotten by many, these diseases—including rheumatic heart disease, endomyocardial fibrosis and Chagas cardiomyopathy—continue to take a tremendous toll on a large proportion of the world's population. Whilst the technology of echocardiography continues to evolve in many high-income countries, low resource countries are working out how to make this vital tool available and affordable for the most remote and poorest populations. This paper aims to highlight the neglected cardiovascular diseases and their echocardiographic features. It also highlights the latest research in relation to portable echocardiography, task shifting and disease screening. The authors make recommendations in relation to future directions, including making echocardiography an affordable and accessible tool for all.

Keywords Echocardiography • Indigenous • Rheumatic heart disease • Chagas cardiomyopathy • Endomyocardial fibrosis • Screening

Introduction

Indigenous and low-resource populations have a high burden of largely forgotten and neglected cardiovascular diseases including rheumatic heart disease (RHD), endomyocardial fibrosis (EMF) and Chagas cardiomyopathy. Echocardiography is vital to clinical diagnosis, management and further research of these conditions. Furthermore, echocardiographic screening may play a role in early disease identification. Novel strategies involving technology and task shifting are critical to improve access to echocardiography in low and middle-income countries (LMIC) and bring practical and affordable cardiovascular care to low-resource populations.

Indigenous Populations

There are over 400 million indigenous people worldwide, living across every habitable continent on the planet [1]. The largest indigenous populations are in low and middle-income countries (LMIC) [2] and many have experienced discrimination, lack of recognition or complete eradication [3]. There is no one definition for the identification of indigenous people and it may include acceptance by community, historical continuity before colonisation and strong links with land and water [4]. Although their history, culture and challenges differ, the majority of indigenous people have poorer health outcomes as compared to non-indigenous

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people from the same region [2]. The underlying causes leading to poorer health outcomes are complex and varied, relating to post-colonialism dispossession as well as geographical and socioeconomic factors.

Global Perspective of Cardiovascular Health in Indigenous and Low-Resource Populations

Cardiovascular disease remains the leading cause of disability-adjusted life years globally and accounts for approximately one-third of all deaths [5]. The majority of disease burden and deaths occur in LMIC and indigenous populations (6,7). Major cardiac conditions, such as ischaemic heart disease and heart failure, contribute substantially to the overall cardiovascular burden in low-resource settings [5], however neglected cardiovascular diseases including RHD and in certain regions Chagas cardiomyopathy and EMF are also prevalent [8,9]. Complex social, environmental, and economic factors in low-resource settings limit access to appropriate diagnosis and care [2,10] and individuals are more likely to present late and die young [11,12].

Cardiovascular Disease in the Australian and New Zealand Indigenous Populations

Cardiovascular diseases the leading cause of non-injury related mortality amongst Indigenous Australians [13]. This predominantly includes ischaemic heart disease and heart failure. Indigenous Australians are more than twice as likely to suffer a myocardial infarction than their non-Indigenous counterparts [14]. The mortality rates from heart failure are higher for Indigenous peoples than in non-Indigenous populations for both New Zealand Māori and Australian Aboriginal populations [15,16]. Australian Aboriginal people with heart failure are younger and have higher rates of other chronic diseases including diabetes, hypertension and obesity [17]. The adequate identification of early disease and instigation of management is poorer for Indigenous Australians suffering cardiovascular disease [17]. Furthermore, outcomes are worse still for those living in rural and remote locations [18].

Acute rheumatic fever and RHD also contribute substantially to morbidity and mortality, particularly in younger populations. In Australia, RHD is the greatest cause of cardiovascular inequality for Aboriginal and Torres Strait Islander people. The cumulative incidence of acute rheumatic fever in Northern Australia has been estimated at 5.7% with almost all cases occurring in young Aboriginal people living in remote communities [19]. In New Zealand the majority of cases are in Māori and Pacific Islander children between 5 and 15 years of age with prevalence rates of 31.9/100,000 and 64.5/100,000, respectively [20]. The rate of RHD in New Zealand has been estimated at 2.4% in at-risk populations [20]. This is similar to that of Indigenous Australians, with screening studies demonstrating a prevalence of RHD of 2–3% [21].

Clinical and Echocardiographic Features of Neglected Cardiovascular Diseases

Rheumatic Heart Disease

Rheumatic heart disease (RHD) is a chronic valvular heart disease resulting from rheumatic fever (RF), a systemic inflammatory reaction to group A streptococcal infections [22]. RHD is disproportionately experienced by those living in conditions of poverty, overcrowding, poor sanitation and other poor social determinants of health [23,24]. Globally, RHD is the fifth leading contributor to cardiovascular disease burden [25], with 34 million prevalent cases resulting in 345,00 deaths and 10.1 million disability-adjusted life years lost per annum [23]. Age standardised prevalence remains highest in the Oceania region, followed by Sub-Saharan Africa and South Asia [23]. Although Australia and New Zealand are considered non-endemic, their respective indigenous populations have one of the highest burdens of RHD globally [23] and are, respectively, 10–20 times more likely to die of RHD compared to non-indigenous populations in the same countries [26,27]. The *REMEDY* (Global Rheumatic Heart Disease Registry) study included people with RHD from predominantly African and Asian LMIC and demonstrated a 2-year mortality rate of 16% and a median age at death of 28 years old [22].

Acute rheumatic carditis that predominantly affects the valves, occurs in approximately 50% of cases of RF. Echocardiography is recommended in all cases where a diagnosis of RF is being considered [28]. Mitral valve involvement is most common, and is characterised by chordal elongation, annular dilatation and subsequent leaflet prolapse [29], occasionally complicated by chordal rupture. Aortic valvulitis with acute aortic insufficiency is also commonly seen, with pericardial effusion, right sided valvular regurgitation, and decreased systolic function being less common. Ten per cent (10%) of RF patients will suffer severe acute valvulitis with resultant cardiac failure.

Transthoracic echocardiography (TTE) is also the primary tool for diagnosis and monitoring of chronic RHD. The echocardiographic assessment should focus on the left-sided cardiac valves. Mitral valve disease is nearly universal, followed by aortic valve disease — most typically in addition. The tricuspid and pulmonary valves become damaged only in severe disease, and never in isolation of damage to the left-sided heart valves [30].

Posteriorly directed, eccentric mitral regurgitation is the hallmark of early RHD (Figure 1). With disease progression and fibrosis, mixed mitral valve regurgitation and stenosis

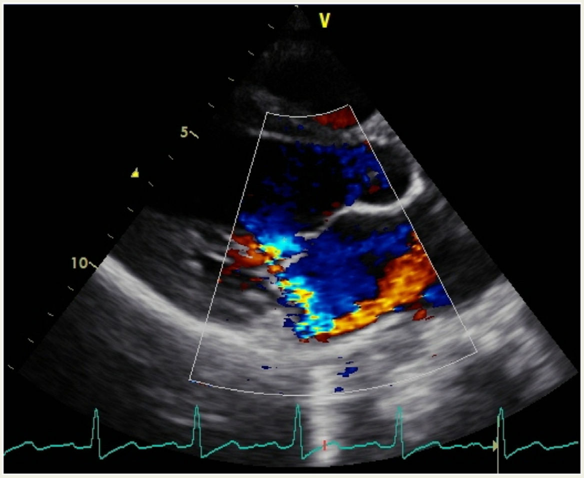

Figure 1 Eccentric posteriorly directed mitral regurgitation secondary to restricted posterior leaflet, commonly seen in rheumatic mitral valve disease.

develops. Morphological changes of the mitral valve include leaflet thickening, chordal shortening and commissural fusion. This is sometimes referred to as the classical ''hockey stick'' or ''dog leg'' appearance of the anterior mitral leaflet (Figure 2) [29,22]. Eventually pure mitral stenosis may ensue. Mitral stenosis severity is determined by pressure half-time and gradient across the valve and valve area by planimetry. Pressure gradient and half-time are vulnerable to confounding haemodynamics including heart rate, filling pressures and concomitant valve lesions. Therefore, it is recommended to measure planimetry as in published guidelines [30]. By TTE, this is measured at the leaflet tips including commissural opening. A mitral valve area of $<1.5\ cm^2$, pressure half time >150 ms and mean pressure gradient >10 mmHg are consistent with severe mitral stenosis [31]. Significant mitral valve disease leads to left atrial dilatation, elevated pulmonary artery pressure, and resultant tricuspid regurgitation.

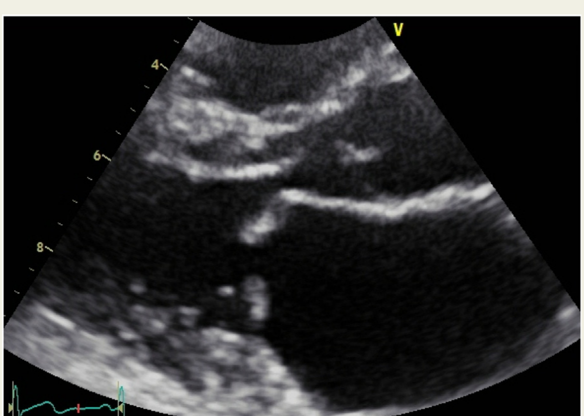

Figure 2 Rheumatic mitral valve with classical leaflet tip thickening, restricted leaflet motion and ''dog leg'' appearance of the anterior leaflet.

Early rheumatic aortic valve disease is characterised by leaflet prolapse, loss of cusp tissue height, and incomplete commissural closure. With progression of fibrosis, the cusp tips and commissures become thickened, rolled and retracted, resulting in significant mal-coaptation and aortic regurgitation [29] (Figure 3a,b). Significant scarring and calcification may eventually lead to aortic stenosis. Standard grading of the severity of mitral and aortic valve disease are employed, according to published guidelines [31].

Those with predominantly regurgitant lesions who are symptomatic or have advanced echocardiographic features require cardiac surgery, as per standard international guidelines. [31] Indications for cardiac surgery in the setting of mixed valve disease or multi-valvular lesions are less well defined [31].

Exercise stress echocardiography is useful in the evaluation of mitral stenosis where basic echocardiographic data and clinical symptoms are discordant [31]. A rise in mitral valve mean pressure gradient over 15 mmHg with exercise or 18 mmHg with dobutamine and/or pulmonary artery

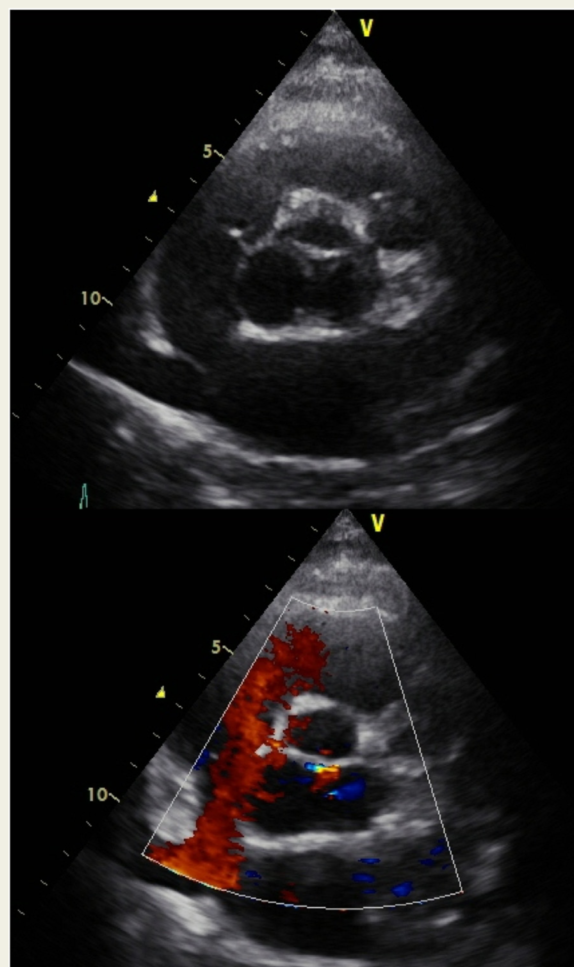

Figure 3 a & b: Rheumatic aortic valve disease. Note the cusp tip thickening and rolled edges which results in malcoaptation (3a) and subsequent regurgitation (3b).

systolic pressure >60 mmHg is associated with a poorer outcome and are indications for consideration of intervention [31]. While the majority of interventional decisions for RHD are based on the presence or absence of clinical symptoms, echocardiography plays a critical role in the selection of patients for percutaneous mitral balloon valvuloplasty. While several scoring systems exist, the Wilkins score, based on four echocardiographic criteria: leaflet thickening, leaflet mobility, calcification and subvalvular involvement [32], is most commonly employed; with a lower score reflecting a more promising outcome following percutaneous balloon dilatation [32].

Endomyocardial Fibrosis

Endomyocardial fibrosis (EMF) remains an important cause of restrictive cardiomyopathy in endemic areas, where mainly impoverished children and young adults are affected. EMF has a unique geographical distribution, with most cases found in the tropical areas of Sub-Saharan Africa, Asia and Latin America [33]. The aetiologic basis of the disease is incompletely understood, with environmental, socio-economic and genetic factors thought to play a role [33].

Both acute and chronic phases of the disease are recognised [33]. Patients in the acute phase present with fever, itching, hives, dyspnoea, periorbital oedema and eosinophilia [34]. Patients with chronic EMF present with cachexia, stunted growth, hepatosplenomegaly and marked abdominal ascites with minimal peripheral oedema. In addition, digital clubbing, male feminisation and hypoalbuminaemia are common [34].

Echocardiographic assessment, when available, is the best tool for diagnosis and staging of EMF. Endomyocardial fibrosis occurs in mainly three forms: biventricular involvement (55% of cases), followed by pure right ventricular and, rarely, pure left ventricular involvement [9]. The pathological hallmark of EMF is focal or diffuse endocardial thickening of the ventricular apices and/or the atrioventricular valves, seen as echo brightness of the endocardial surfaces, with resultant restrictive physiology and atrioventricular valve regurgitation [34]. Echocardiography may further reveal gross atrial dilatation, intramural or free thrombi, varying degrees of mitral and tricuspid regurgitation, retracted ventricles with cavity obliteration, evidence of secondary pulmonary hypertension, and sometimes large chronic pericardial effusions (Figure 4) [9,34]. Restrictive ventricular physiology, the result of fibrosis and cavity obliteration, is seen on spectral Doppler assessment of valvular inflow as tall E waves (E/A > 2), deceleration time <120 ms and isovolumic relaxation time <160 ms [35].

Endomyocardial fibrosis carries a poor prognosis. Management is focussed on symptom treatment with heart failure therapy [33]. Pericardiocentesis and paracentesis can offer temporary symptomatic relief. There may be some role for steroid therapy in the acute inflammatory, hyper-eosinophilic stage [36]. Although surgery may improve survival, it carries a high operative mortality risk and is inaccessible for the majority affected by this disease [33]. Death usually results from progressive heart failure, thromboembolism and arrhythmias [36]. There are reports that the prevalence of EMF is on the decline in once previously endemic countries, most likely due to improvements in socioeconomic conditions [37].

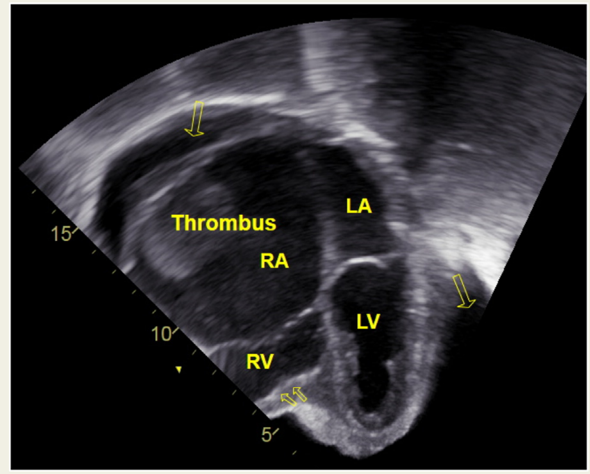

Figure 4 Right ventricular endomyocardial fibrosis. Short Arrows: RV apical fibrosis with reduced RV cavity and RV does not reach the apex. Tall Arrows; Pericardial effusion.
Abbreviations: LA; left atrium, RA; right atrium, LV; left ventricle, RV; right ventricle.

Chagas Cardiomyopathy

Charles Darwin is quoted to have said ''Even ill-health, though it has annihilated several years of my life, has saved me from the distractions of society and amusement''. Throughout his life he was plagued by bouts of considerable illness. Although no formal diagnosis was able to be made at the time, it has since been hypothesised that he may have suffered from Chagas disease. Caused by the protozoan *Trypanosoma cruzi*, Chagas disease remains one of the most prevalent infectious diseases in Latin American, and has become a health problem in non-endemic countries [38]. This disease is most commonly transmitted to humans by infected triatomine bugs. In the last decades, strategies targeting vector and transmission control have led to substantial decline in global prevalence, currently estimated at 6 million persons [39].

Chagas disease evolves through acute and chronic phases. The acute phase usually occurs 1–2 weeks following vector-borne transmission, and often is asymptomatic or presents as a nonspecific febrile illness. After 8–12 weeks, the acute clinical manifestations disappear and the disease enters the chronic phase, generally starting with a long period of clinical latency called indeterminate form, which lasts decades or throughout life [40]. After this period, 20-40% of the patients progress to clinically manifest disease, most commonly cardiomyopathy, at a rate of 1.85–7% annually [39].

Chagas cardiomyopathy is the most severe manifestation of the disease, resulting in substantial disability and mortality. Clinical presentation varies widely according to the degree of myocardial dysfunction, which can be asymptomatic or manifest by heart failure, cardiac arrhythmias, thromboembolism events or sudden death [40].

Chagas cardiomyopathy is characterised by a chronic myocarditis that involves all cardiac chambers and the conduction system [39]. Echocardiography is the most commonly used imaging modality for assessment of patients with Chagas disease, allowing the classification of patients according to left ventricular function [41]. In early stages of cardiac involvement, echocardiography may demonstrate segmental left ventricular wall motion abnormalities, mainly in inferior, and inferolateral walls. Left ventricular apical aneurysms are a typical finding in patients with Chagas cardiomyopathy and can be helpful in making the aetiologic diagnosis in dilated cardiomyopathy (Figure 5) [41]. Aneurysm morphology is variable, ranging from small (like a 'hollow punch') lesion to large aneurysms, hardly distinguishable from those seen with myocardial infarction. Thrombi can be associated with aneurysms and are important risk factors for thromboembolic events, mainly stroke [41].

The treatment of Chagas cardiomyopathy focusses on parasite-specific therapy and management of heart failure, arrhythmias, stroke and systemic embolism [39]. Anti-parasitic therapy (nifurtimox or benznidazole) is indicated for patients with acute infection, children, congenital infection, and reactivation due to immunosuppression.

Chagas cardiomyopathy is associated with an ominous prognosis with higher mortality risk compared with other cardiomyopathy of similar severity [40]. The most important predictors of death are the New York Heart Association functional class, left ventricular systolic dysfunction and non-sustained ventricular tachycardia, which reflect severity of the myocardial damage [40]. Left ventricular diastolic dysfunction, left atrial enlargement, decreased left atrial contractility and right ventricular dysfunction are also independent echocardiographic predictors of mortality and adverse outcomes [41].

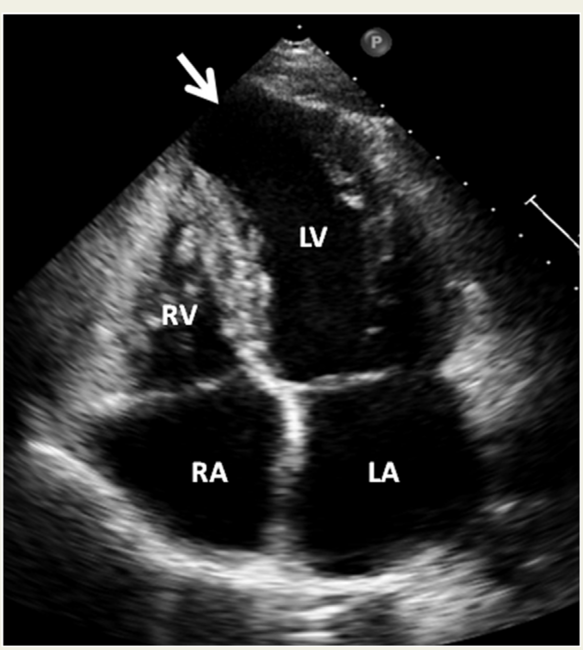

Figure 5 Chagas Cardiomyopathy. Arrow; Apical aneurysm.
Abbreviations: RV; right ventricle, LV; left ventricle, RA; right atrium, LA; left atrium.

Echocardiography and RHD Screening

Echocardiographic screening has been most widely explored for early detection of RHD, as most patients show substantial latency between first insult (rarely recognised RF) and diagnosis at time of advanced valvular disease. In paediatric populations, where most echocardiographic screening research has focussed, echocardiography provides far superior sensitivity and specificity for RHD detection compared to cardiac auscultation [21]. As RHD disproportionally affects women in their reproductive years [22], leading to poor outcomes in resource limited settings [42], echocardiographic screening may also play a role in improving maternal outcomes. Though still a nascent area of research, a pilot study in Uganda uncovered a 1.5% prevalence of largely occult RHD among pregnant women, with substantial population attributable risk of maternal, fetal, and neonatal mortality [43].

Evidence-based criteria for echocardiographic diagnosis of RHD were published in 2012 by the World Heart Federation [29], and have improved standardisation of epidemiological study and research across populations (Table 1). These guidelines have shown high sensitivity and adequate specificity in endemic and non-endemic populations [44,45].

The clinical impact of RHD screening is not fully understood. It is possible that early detection of RHD could limit progression of valvular disease, with regular penicillin prophylaxis preventing further streptococcal exposure. Currently, a randomised controlled trial, the GwokO Adunu pa Lutino (GOAL) trial, is underway in Northern Uganda to further explore this impact (Clinicaltrial.gov NCT03346525). There are also important implementation challenges to consider, including appropriate resource allocation, cost of equipment including echocardiography machines, adequately trained personnel, and ability of current health systems to deal with the increased workload that would be generated by screening programs. A complete discussion regarding the benefits and challenges of screening programs for RHD is outside the scope of the paper.

Access to Echocardiography in Rural and Remote Settings–A Case Example

The Northern Territory cardiology specialist outreach service is one of the most successful programs of its kind and has significantly improved access to echocardiography and specialist care for Indigenous Australians living in remote communities. This outreach model of care is founded on a

Table 1 Modified from Reményi B et al., World Heart Federation criteria for echocardiographic diagnosis of rheumatic heart disease—an evidence-based guideline, Nat Rev Cardiol 2012; 9: 297–309 [29].

2012 World Heart Federation Criteria for Echocardiographic Diagnosis of RHD [29]

Echocardiographic criteria for individuals aged ≤20 years Definite RHD (either A, B, C or D):

- A) Pathological MR and at least two morphological features of RHD of the MV
- B) MS mean gradient, ≥4 mmHg
- C) Pathological AR and at least two morphological features of RHD of the AV
- D) Borderline disease of both the AV and MV

Borderline RHD (either A, B, or C):

- A) At least two morphological features of RHD of the MV without pathological MR or MS
- B) Pathological MR
- C) Pathological AR

Normal echocardiographic findings (all of A, B, C, and D):

- A) MR that does not meet all four Doppler echocardiographic criteria (physiological MR)
- B) AR that does not meet all four Doppler echocardiographic criteria (physiological AR)
- C) An isolated morphological feature of RHD of the MV (for example, valvular thickening) without any associated pathological stenosis or regurgitation
- D) Morphological feature of RHD of the AV (for example, valvular thickening) without any associated pathological stenosis or regurgitation

Echocardiographic criteria for individuals aged >20 years Definite RHD (either A, B, C, or D):

- A) Pathological MR and at least two morphological features of RHD of the MV
- B) MS mean gradient, ≥4 mmHg
- C) Pathological AR and at least two morphological features of RHD of the AV, only in individuals aged <35 years
- D) Pathological AR and at least two morphological features of RHD of the MV

Abbreviations: AV, atrioventricular; RHD, rheumatic heart disease; AR, aortic regurgitation; MR, mitral regurgitation; MS, mitral stenosis; MV, mitral valve.

multidisciplinary, patient centred, sustainable and cost-effective design. The service is provided through a government and private sector partnership. The outreach team includes a cardiologist, echocardiographer, clinical nurse consultant, Aboriginal health practitioner and junior doctor in training. A single cardiologist is assigned to specific communities in order to provide continuity of care.

Patient and family education and engagement is provided by the clinical nurse consultant and Aboriginal health practitioner, complementing the cardiology consultation. The frequency and the duration of each trip is determined based on various factors including referral volume, population size and disease burden. Over 200 outreach cardiology visits are provided each year across the Northern Territory. These visits directly reduce the need for patients to travel to major towns for treatment, which is often associated with substantial social and emotional burden for patients and their family. This model of care has significantly improved access to echocardiography, and to paediatric and adult cardiology services for populations living in remote regions of Australia.

Improving Access to Echocardiography in Resource Poor Settings–Task Shifting

Unfortunately, for the majority of the world's population living in resource-limited locations, access to echocardiography or trained technicians, particularly outside of major urban centres, is scarce. For example, Malawi has 0.19 physicians per 1,000 people and no in-country paediatric cardiologist [46]. The Northern region of Uganda, with a population of more than 37 million people, is served by a single paediatric cardiologist with monthly outreach to the regional referral hospital [47]. In order to improve access to important diagnostic echocardiography in these settings, utilisation of hand-held echocardiography and a shift in service provision is necessary.

Cost and portability of echocardiographic equipment are important considerations to improve access to care in low-resource settings. Less expensive hand-held devices have been employed for both screening and clinical outreach

[48,49] with generally good results. In Brazil, the Programa de RastreamentO da VAlvopatia Reumática (PROVAR) program has successfully used hand-held echocardiography in primary care settings to decrease wait times for specialty consultation [50]. Limited functionality of these devices remains an important consideration (Table 2), in most cases requiring confirmatory follow-up assessment for comprehensive evaluation.

Task shifting has been utilised in many low-resource settings to provide necessary aspects of health care [51,52]. Though in early stages, research in task-shifting of echocardiography in low-resource settings shows promise. In Fiji, nurses utilising basic portable echocardiographic equipment were able to detect RHD with a sensitivity of 84% and specificity of 85% [53]. Similar results were replicated in New Caledonia [54] and Uganda [55]. Rwanda has employed a more extensive, integrated program, utilising cardiovascular nurses in dedicated non-communicable disease clinics to extend care in rural areas, including focussed echocardiography and simplified diagnostic and treatment algorithms for heart failure. In a study of this program, the performance of nursing staff following a 2-month training program was evaluated [56]. In 81% of cases reviewed by a physician, the nursing staff appropriately identified heart failure, demonstrating the potential feasibility of decentralisation and task-shifting to improve cardiovascular service provision [56].

Although Indigenous populations within Australia and New Zealand face a similar disease burden to populations within low-and-middle income countries, the approach to service provision differs significantly. It is imperative that quality of care and service is consistent across locations. Service provision should thus include specialists accompanied by cardiac specific nurses, technicians and Indigenous health workers. A team-based model enables comprehensive care. There remain substantial workforce shortfalls in areas of highest need, including rural and remote Australia [57]. The report on the audit of health workforce in rural and regional Australia demonstrated that the number of specialists per 100,000 people in regional and remote locations were 38 and 16 per 100,000, respectively, as compared to 122 per 100,000 in major cities. A 2011 external report for the Northern Territory Top End Health Service demonstrated a shortfall in workforce for regional and rural areas, suggesting that the current service required several more full-time equivalent positions for both cardiologists and cardiac trained nursing staff. Although this report is limited to the Northern Territory of Australia, it likely reflects unmet need in other rural and remote regions of Australia. To compensate, upskilling of regional and remote medical staff, including rural trained generalists or physicians, supported by centrally located sub-specialists may enable improvement in service provision. The role of limited echo performed by health workers needs to be well designed, including comprehensive training, understanding of skill limitations and well supported by experts in order to provide high quality, uncompromising care. Although there have been prior echo screening studies performed within Australia and New Zealand, this has not become part of clinical practice and remains predominantly a research tool. There is currently work underway to design a comprehensive training program for health workers, nurses and doctors to perform limited screening echocardiography for the identification of RHD in high prevalence

Table 2 Comparison of standard portable echocardiogram (STAND) and handheld echocardiogram (HAND). Modified from Nascimento B et al., Rheumatic heart disease echocardiographic screening: approaching practical and affordable solutions, Heart 2016;102: 658–664 [48].

	STANDARD ECHO	HAND-HELD ECHO
Cost (US$)	60,000–100,000	7,000
Weight (kg)	10–15	0.390
Size	Large laptop	Large smart-phone
Display resolution (pixels)	800 × 600	320 × 240
Image sector	90 degrees	75 degrees
Colour Doppler	Yes	Yes
Spectral Doppler	Yes	No
Transducers	Multiple	Single
Frequency	Multiple	Single
Battery charge time (min)	120	60
Battery life (scan time) (min)	45	90
Overheat tendency	Rare	Common
Patient information	Multiple data fields	Limited data fields
Measurements	Multiple (linear, volume, Doppler)	Linear only
File format	Any, DICOM compatible	.jpg, .mpg, .wav, DICOM compatible
File size (MB)	25–100/study	1–2/study
File transfer	Wired/wireless/manual, network	Wired, manual
Offline viewing	Compatible with DICOM viewer	Proprietary software

populations. The utility of this approach in rural and remote Australia is currently being tested in research settings.

Future Directions

Urgent attention is needed to improve the lives of millions of people world-wide suffering cardiovascular diseases of poverty, the diagnosis and management of which are hampered due to resource limitations in many of the affected regions. Access to affordable technology — echocardiography — is critical to this goal. The last decade has provided critical research and technological developments that have extended the reach of echocardiography, however, most people living in resource poor settings still lack access. Task shifting has shown substantial promise in its ability to provide echocardiographic and diagnostic facilities in remote and resource-limited areas. Further investment in specific training programs design, relevant to location and disease burden, is necessary. This would enable expansion of task shifting whilst importantly maintaining quality of care.

Disease screening is challenging, particularly in resource limited regions. However, cumulative evidence supports echocardiographic screening for RHD in specific populations, such as the Indigenous population of Northern Australia where rates of up to 5% have been documented. Whilst echocardiography screening for RHD is currently considered to be a research tool, in the near future, through coordinated services involving specialist and primary care, it may become a clinical reality. As further evidence of the sensitivity of hand-held screening by non-experts develops, community screening will become less burdensome on the limited specialist services available in these regions. Echocardiographic screening is our best weapon to detect RHD in those high-risk individuals who developed RHD without a clinically documented episode of RF. Early implementation of secondary prophylaxis is known to be the most cost-effective method of halting disease progression and allowing for disease resolution.

Coordinated investment and partnership between governmental, non-governmental organisations and industry are needed to develop effective, affordable, and sustainable solutions that bring echocardiography to the world.

Acknowledgements and funding

Nil.

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