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REVIEW

Forgotten cardiovascular diseases in Africa

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Abstract Much of the global burden of cardiovascular disease is now carried by low and middle income countries. Unfortunately, many of these regions are still grappling with poverty and infection-related cardiovascular diseases, such as endomyocardial fibrosis, tuberculous pericarditis and rheumatic heart disease. In addition, Africa has its unique diseases that occur more commonly in Africans as peripartum cardiomyopathy or, almost uniquely in Africa, as subvalvular aneurysm. We present our perspective on forgotten cardiovascular disease in Africa in the context of the epidemic of cardiovascular disease due to global changes in life style.

Keywords Africa · Cardiovascular disease · Peripartum cardiomyopathy · Endomyocardial fibrosis · Submitral aneurysm

Introduction

There is an increasing awareness of a global epidemic of cardiovascular disease (CVD) that encompasses a range of conditions, from hypertension to acute coronary syndrome, stroke and chronic heart failure (CHF) with its potentially devastating impact on resources in poor countries. It is predicted that this will become the leading cause of death and disability globally by 2020 [2, 36]. It is sobering to consider that much of the global CVD burden (80%) is being carried by low and middle-income countries who, even today, are grappling with poverty-related diseases, infectious diseases and inadequate health care facilities [19, 68].

Figure 1 shows age-standardized death rates in 'developing regions' similar to those in the 'developed world'. Africa is a continent with large income inequalities, with large-scale migration of populations from rural to urban regions and there is a lack of CVD-specific training and resources and misguided attempts to transplant 'first-world' solutions without appropriate adaptation and evaluation. Limited research has been done on medical conditions that affect the cardiovascular system which are restricted to Africa or predominantly affect Africa.

However, due to the migration of Africans to other regions, physicians in the Western world increasingly come across some of these conditions, e.g. peripartum cardiomyopathy.

In this paper, we review diseases such as peripartum cardiomyopathy, submitral aneurysm, endomyocardial fibrosis, tuberculous pericarditis, and rheumatic valve disease in the context of the overall impact of an emerging 'epidemic' of CVD in resource-poor countries. These have received very little global attention and are the so-called forgotten cardiovascular diseases in Africa.

Peripartum cardiomyopathy

Peripartum cardiomyopathy (PPCM) as a form of heart failure associated with the puerperium was first described by Virchow in 1870 [64]. According to the National Heart, Lung and Blood Institute and the Office of Rare Diseases (National Institute of Health) workshop recommendations,

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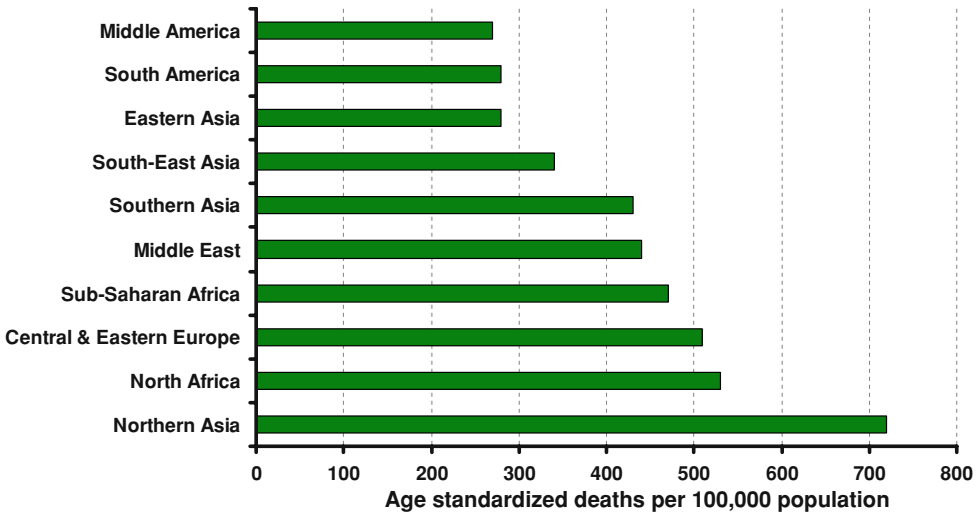

Fig. 1 Global impact of cardiovascular disease and diabetes: age standardised mortality per 100,000 population (adapted from 2)

PPCM is defined as a disorder of unknown pathogenesis in which left ventricular dysfunction and symptoms of heart failure occur between the last month of pregnancy and the first 5 months postpartum, in the absence of an identifiable cause of heart failure and in the absence of recognizable heart disease prior to the last month of pregnancy [41].

However, some authors do not adhere to this definition and are including patients that have been diagnosed with heart failure as early as 3 months of pregnancy [14]. Heart failure occurring earlier in pregnancy may be caused by previously unsuspected dilated cardiomyopathy (DCM) unmasked by the haemodynamic and hormonal stress of pregnancy; and it forms a different entity. To rule out other causes of perinatal heart failure, such as gestational hypertension, infectious, toxic or metabolic disorders and ischemic or valvular heart disease is mandatory.

Diagnosis requires echocardiographic evidence of left ventricular systolic dysfunction (ejection fraction <45%; fractional shortening <30%) [41]. Left ventricular dilatation may occur, in particular if patients present later in the post partum period. However, there are many patients presenting with normal sized ventricular chambers and impaired systolic function [47] making the description of PPCM as a form of DCM in the recently published classification of cardiomyopathies statement of the European Cardiac Society (ESC) working group on myocardial and pericardial diseases incorrect [15].

Clinical presentation, management of disease and outcome have been reviewed recently [38, 48]. Left ventricular thrombi are common (Fig. 2) and anticoagulation is necessary not only in patients presenting with thrombi, but also with an ejection fraction below 30% [49]. The few prospective studies conducted on patients with PPCM [17, 48] do not support case reports and data collected by retrospective surveys describing associations with older age, multiparity, twin pregnancy, gestational hypertension

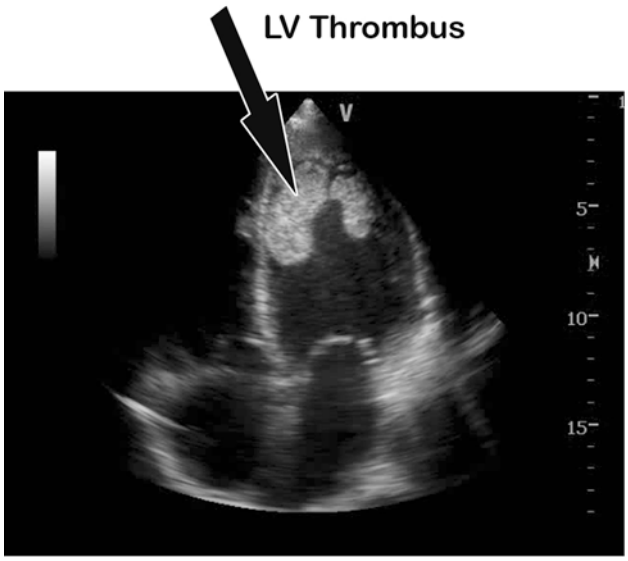

Fig. 2 Peripartum cardiomyopathy with left ventricular thrombus

and the use of tocolytic therapy. However, several studies lend support to the hypothesis that immune activation contributes to the pathogenesis of PPCM [48] as plasma levels of tumor necrosis factor (TNF)-alpha, Fas-Apo-1, a marker of apoptosis, interleukin (IL)-6 and interferon (IFN)-gamma were markedly elevated; also, a positive correlation with C-reactive protein levels, brain natriuretic peptide (BNP), left ventricular (LV) end-diastolic and/or end-systolic diameters at the time of diagnosis [48] were reported.

Recently, Denise Hilfiker-Kleiner and colleagues reported that mice with cardiac-specific deletion of signal transducer and activator of transcription-3 (STAT3-KO), developed postpartum cardiomyopathy during the first to third week postpartum [22]. In these mice, enhanced oxidative stress triggers the activation of cathepsin D, an

ubiquitous lysosomal enzyme that subsequently cleaves serum prolactin in its anti-angiogenic and pro-apoptotic 16-kDa form, which, in addition, seems to promote endothelial inflammation and impairs cardiomyocyte metabolism and contraction. Full-length 23-kDa prolactin is physiologically up-regulated post delivery and has been implicated in cardiac tissue injury and the modulation of autoimmune response [22, 24]. Reversible cardiac remodelling happens physiologically during the peripartum period without cardiomyocyte loss or injury and without triggering unwanted innate immune pathological responses [10, 58]. Unbalanced oxidative stress, activated cathepsin D and the subsequent generation of the 16-kDa prolactin were also observed in serum probes of patients with acute PPCM; this may represent a critical step in the initiation of endothelial damage, apoptosis, vasoconstriction and inflammation, leading to impaired cardiac function in PPCM. In fact, pharmacological inhibition of prolactin release has been shown to prevent PPCM in STAT3-KO mice and has proved to be beneficial in a preliminary study conducted on a small group of patients with a subsequent pregnancy in PPCM [22, 26] as well as in a few patients [23].

Roughly 23–54% of PPCM patients recover their cardiac function within 6 months [48]. The precise mechanisms leading to irreversible left ventricular dysfunction in human PPCM remain undefined.

Patients with one episode of PPCM remaining with an echocardiographic ejection fraction below 45% display an extremely high risk for a relapse [48]. Therefore, diagnosis of PPCM is important to limit the high risk of morbidity and mortality induced by a subsequent pregnancy. In addition, these women need to be counseled about the risk of relapse.

PPCM is often not diagnosed in time as many gynaecologists, physicians and even cardiologists are not aware of this disease leading to unnecessary morbidity and mortality. A recent publication by Deneux-Tharaux [12] highlights the under-reporting of pregnancy-related mortality in the United States and Europe. The study clearly shows the limitations of maternal mortality statistics based on International Classification of Diseases cause-of-death codes alone.

Thus, a higher awareness of this potentially devastating condition is urgently necessary. The Study Group on PPCM, recently established by the Heart Failure Association of the European Cardiac Society, aims to increase awareness of this condition and facilitate further research into aetiology, management and long-term prognosis.

In addition, an African registry on PPCM will be initiated 2010 in investigating the spectrum of risk factors, clinical management and outcome in eight African countries. To date, no population-based epidemiological studies on PPCM from Africa have been published. Outcome of patients with PPCM in Africa and Haiti seems to be worse than in the USA [48] making the investigation of specific risk factors and genetic background mandatory.

Subvalvular aneurysm

Submitral and, very rarely, subaortic aneurysms are of unknown etiology and have been reported predominantly from Sub-Saharan Africa [9]. Among 5,200 newly diagnosed cardiac cases evaluated from 2006 to 2008 in the Heart of Soweto Study, ten patients presented with a submitral aneurysm (unpublished data). Submitral aneurysms are thought to be false aneurysms caused by congenital defects in the posterior portion of the mitral annulus. However, other etiologies, such as tuberculosis and Takayasu's arteritis, have also been proposed [34]. The diagnosis is usually made in the second or third decade of life. Patients present typically with a history of progressive worsening exertional dyspnea. Clinical examination features signs of left-sided failure through diastolic overload by virtue of the volume or by causing mitral regurgitation. In addition, thromboembolism, arrhythmias, or compression of the left circumflex artery have been described [27].

Definitive diagnosis is made by echocardiography, CT scan or MRI (Fig. 3a).

The aneurysms typically arise from the posterior mitral annulus, can be multi-loculated and bulge into the left atrium or in an extracardiac direction. Undermining of the leaflets and papillary muscles or rupture of the aneurysm into the atrium results in severe mitral regurgitation. Surgery is indicated in all cases by ligation of the neck of the aneurysm and mitral annuloplasty (Fig. 3b).

However, larger prospective case or outcome studies have not been published.

Endomyocardial fibrosis

Endomyocardial fibrosis (EMF) remains prevalent in Sub-Saharan Africa [6], where it reaches a prevalence of nearly 20% in some endemic areas [31], despite the reduction in incidence in some parts of the world [46], and its rarity in the developed world. The etiology of EMF and the mechanisms involved are still unknown, explaining the absence of effective treatment for this disease. Several factors have been implicated, mainly hypereosinophilia, infectious agents, toxics, allergens and nutritional, among others [6].

Efforts put into research into this condition have focused on a description of its unique and controversial clinical findings, rather than investigating etiopathogenesis and

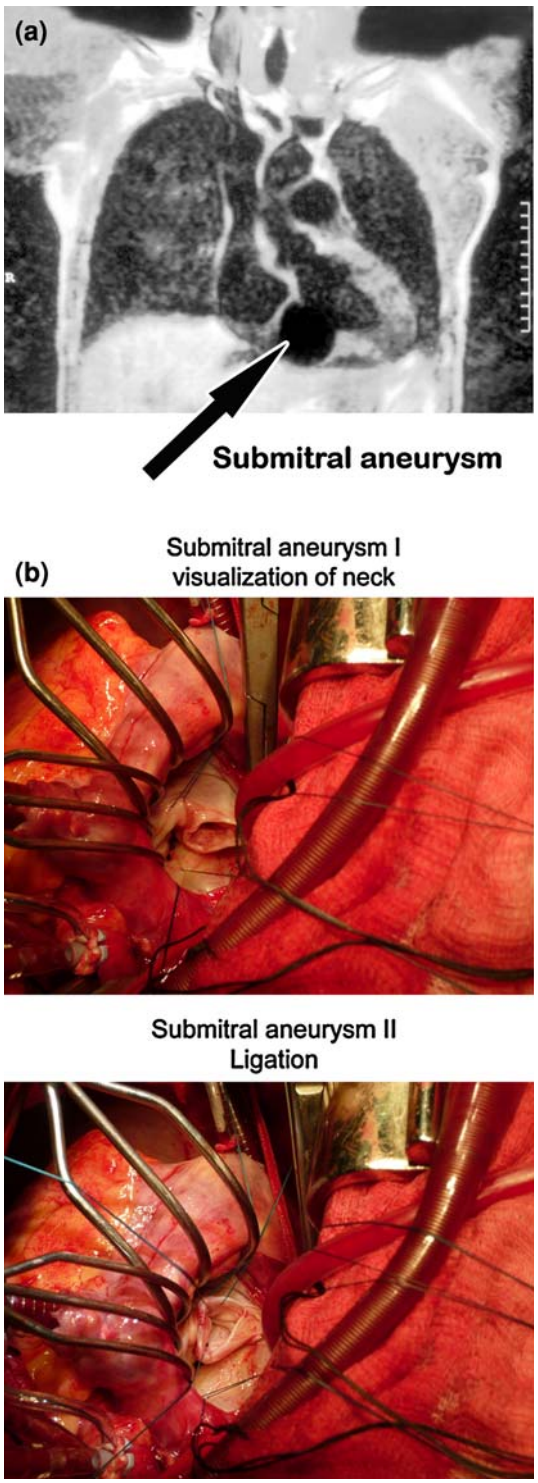

Fig. 3 **a** Submitral aneurysm (MRI). **b** Intra-operative photograph of a submitral aneurysm from epicardial surface. The neck was closed on interrupted sutures and the valve repaired with a complete ring

natural history. A considerable amount of research was undertaken prior to the dissemination of echocardiography, mostly through retrospective and hospital-based studies. A renewed interest has come through an integrated project undertaken in a rural area of Mozambique where the disease is endemic [31]. Standardized criteria and a scoring system for severity of the disease proposed in this study allowed for early detection have been used for follow-up and are being validated in ongoing prospective studies.

EMF is a condition that predominantly affects children and has a malignant course (Fig. 4). Death occurs due to acute thromboembolism and arrhythmia, or associated complications of chronic heart failure [33]. Epidemiological studies in the community have shown a large spectrum of phenotypes, with cardiac lesions being distributed in one or both sides of the heart and fibrosis predominantly affecting the valves or the mural ventricular endocardium.

Ventricular thrombosis is frequently found in early stages of EMF and is thought to be the initial endocardial lesion that evolves to fibrosis and calcification. Endocardial thickening and fibrosis interfere mainly with ventricular filling and, depending on its extension and severity, may also lead to systolic dysfunction. Aneurysmal atria are commonly found (Fig. 5).

While the diagnosis of advanced EMF in endemic areas may rely on clinical features, echocardiography is the gold standard for identification and characterization of the disease in the early stages. Echocardiography reveals the extension and the severity of structural abnormalities, as well as the hemodynamic changes, and it allows for pre-operative evaluation as well as post-operative follow-up. Where available, MRI may be used to access the extension of fibrotic lesions, the degree of myocardial involvement and the presence of thrombus or calcification.

Fig. 4 Picture of a 16-year-old boy with advanced EMF, predominantly affecting the right side of the heart. A common feature is large ascitis with little pedal edema

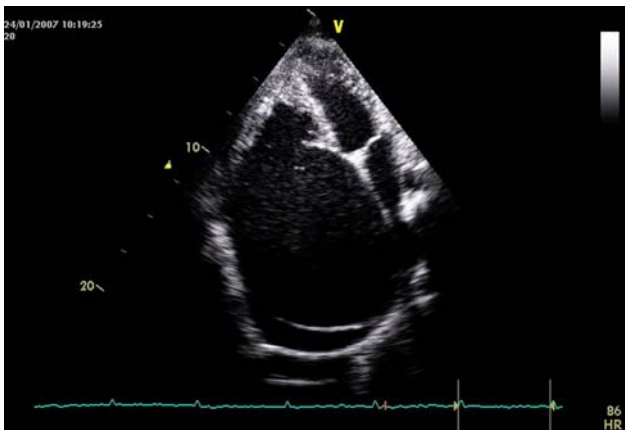

Fig. 5 Echocardiography reveals endocardial thickening, obliteration of the apex and reduction of the RV cavity size. The RA is aneurysmal with spontaneous contrast and the tricuspid annulus is dilated. The left cavities are compressed by the right side of the heart and there is pericardial effusion

The management of EMF is challenging and imposes a huge burden on health services, with patients requiring frequent admission to hospital for treatment of heart failure, arrhythmia and drainage of large effusions. The results of medical management are poor overall, but improvement in control of heart failure, arrhythmias and thromboembolic events seems to play a role in the increasing survival of patients with EMF.

Surgery, indicated in all symptomatic patients [7, 8], has traditionally been associated with high mortality and morbidity [13, 35, 61, 62], mainly due to extensive endocardial resection, permanent atrioventricular block and prosthesis-related events. Promising intermediate results have been achieved by applying tailored approaches and innovative surgical techniques as a result of a better understanding of pathophysiology [32].

Basic research on EMF is urgently needed. Integration of its results with the findings from epidemiological studies on follow-up, genetic predisposition and etiological factors, will hopefully uncover the natural history and identify new therapeutic targets and measures for prevention and control of this condition.

Rheumatic heart disease

Acute rheumatic fever (RF) continues to be a major health problem and chronic rheumatic valvular disease, the sequel to rheumatic fever, is a very common cause of cardiovascular mortality and morbidity in Africa—both being commonly encountered in their most virulent forms. RF/RHD leads to disability and premature death, and is a serious problem in surviving adults; thus imposing a substantial burden on the families, the health system and communities [16].

RHD is amongst the major contributors to the etiology of heart failure in Africa, where it remains the most common form of acquired cardiovascular disease in children and but data on incidence and prevalence are lacking [60]. Hospital-based studies show that RHD accounts for 6.6–34.0% of cardiovascular disease-related hospital admissions or echocardiographic examinations performed in institutions across Africa [4, 5, 18, 21, 25, 40, 45, 51]. Epidemiological studies using clinical screening followed by echocardiographic confirmation showed a prevalence of RHD in schoolchildren varying between 6.2% and 14/1,000 [1, 3, 28, 39].

More recently, a large-scale study performed in an urban area of Mozambique studied 2,710 children, randomly selected from primary schools using echocardiographic screening, detecting prevalence of 30.4/1,000 [29], and highlighting the inadequacy of clinical screening for optimizing the diagnosis of sub-clinical and potentially treatable children with RHD.

The diagnosis of active rheumatic carditis and chronic heart valve disease has its particularities, since the strict adherence to the Jones criteria results in under-diagnosis and lack of treatment of patients with recurrent episodes of rheumatic fever [37]. The diagnosis of carditis by the Jones criteria can be difficult when carditis is the isolated manifestation of the disease or when the rheumatic activity occurs on pre-existing RHD—a common scenario in Africa. The high prevalence of RF/RHD contrasts with limited access to medical care and echocardiography and first attacks are rarely witnessed by health personnel. Most patients present with recurrences and established valvular lesions and are primarily diagnosed by auscultation. A minority of patients reach health units with cardiologists and/or echocardiography with established chronic heart valve disease and its complications (Fig. 6), the most common being: valvular cardiomyopathy, secondary pulmonary hypertension, functional tricuspid regurgitation, atrial fibrillation, thromboembolism, infective endocarditis.

Management in Africa consists mainly of medical therapy to control recurrences of carditis, heart failure, arrhythmias and other complications, such as bacterial endocarditis and thromboembolism. Severe gastrointestinal bleeding is a risk when using aspirin in children, while the high prevalence of parasitic infections and tuberculosis precludes steroid therapy in many patients. Percutaneous mitral dilatation, closed-heart mitral commissurotomy and open-heart surgery (although necessary for the treatment of chronic symptomatic rheumatic valve disease) are rarely performed, since they are not readily available. Valvuloplasty is always attempted, even at the risk of sub-optimal results, owing to its advantages in avoidance of anticoagulation and allowance for growth in the young female and deprived population.

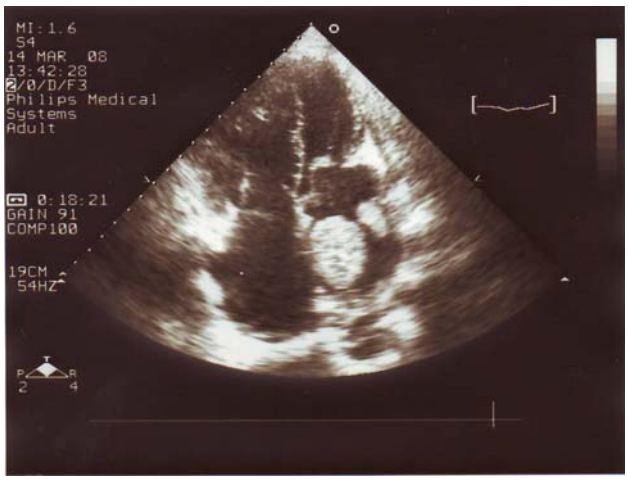

Fig. 6 Mitral stenosis due to RHD. Notice the restriction of movement of the anterior mitral leaflet, which has a nodular aspect in its free border. There is deficient opening of the valve in diastole. Thrombi are present in the left atrium and there is moderate dilatation of the right cavities

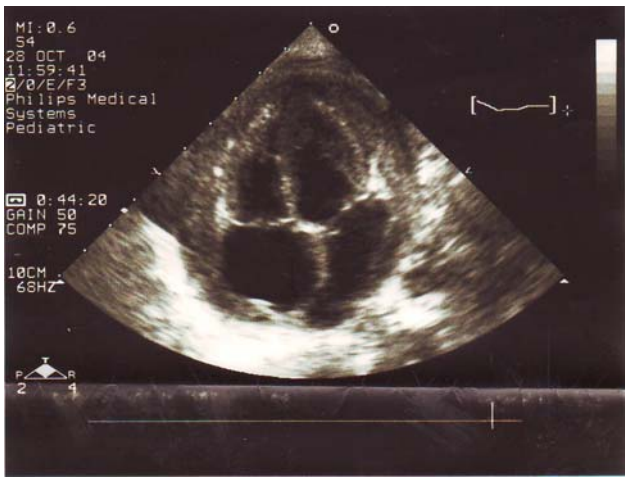

Fig. 7 Tuberculous pericarditis. The myocardium shows an abnormal structure with areas of increased echoes. There is a large amount of fibrin surrounding the epicardium with little effusion. Both the epicardium and parietal pericardium are thickened

African medical specialists subscribe to the Drakensberg Declaration on Prevention and Control of RHD in Africa [30]. Known as the ASAP approach, it calls for a comprehensive strategy based on the pillars of awareness-raising, surveillance, advocacy and prevention to be applied in all African countries.

Demonstration sites have been identified and large-scale studies using echocardiographic screening are under way. Whilst the last evaluation by experts on RHD (held in 2000) [16] agreed that there was insufficient data to support revision of the Jones criteria and reaffirmed the guidelines for clinical diagnosis iterated in the 1992 statement [11], there is a need for dissemination of these criteria to health care providers in African countries and an evaluation of the cost-effectiveness of echocardiographic screening in these particular settings [37].

Tuberculous pericarditis

Pericardial involvement is the most important form of cardiac tuberculosis, which occurs in approximately 1% of patients suffering from active tuberculosis, but myocardial involvement is also a well-recognised condition [56]. Tuberculoma of the myocardium is rarely reported intra-vitam [57]. Tuberculous pericarditis is accompanied by inflammatory response that results in significant morbidity and mortality due to effusive and constrictive disease in spite of appropriate chemotherapy [30]. In Sub-Saharan Africa, pericardial tuberculosis is frequently diagnosed in HIV sero-positive patients, in whom there seems to be a preponderance of myopericardial rather than purely pericardial disease. The syndrome of effusive–constrictive pericarditis is commonly seen in Africa (Fig. 7).

Clinical signs and symptoms of pericarditis vary and, in most instances, are non-specific. In areas of high prevalence of both HIV and tuberculosis, clinical features have a higher diagnostic efficiency than pericardial biopsy [42] since there is a decrease in the sensitivity of the histopathological examination that occurs when tuberculosis and HIV co-exist. Chest X-ray (CXR) also plays an important role in identifying large pericardial effusions and calcifications on the border of the cardiac silhouette; these can be used as a screening tool in areas with difficult access to echocardiography. When available, the echocardiographic examination shows pericardial effusion with variable amounts of fibrin strands. The definitive diagnosis of tuberculous pericarditis, however, requires isolation of the *Tubercles bacillus* from pericardial fluid, which can be difficult in resource-poor areas.

In the absence of clear contra-indication for corticosteroids, these drugs are used as adjunctive therapy [55]. Studies performed in Africa show that tuberculous pericardial effusion responds well to closed pericardiocentesis followed by tuberculous chemotherapy, irrespective of the HIV status [43]; in additions although intrapericardial and systemic corticosteroids were well tolerated, they do not improve the clinical outcome of patients [43, 44].

Surgery is needed for resection of the pericardium in patients with calcific constrictive pericarditis and after a 6–8 week trial of anti-tuberculosis treatment in patients with persistent signs of constriction.

Lack of agreement concerning their effectiveness in reducing mortality using steroids in tuberculous pericarditis has fueled the establishment of a multi-center

randomised clinical trial in African patients (the IMPI project, led by Professor Mayosi's team at Cape Town University in South Africa). This project involves several African countries and aims at achieving a more accurate description of TB pericarditis in HIV-infected and immuno-competent patients. To assess the impact of using adjunctive corticosteroids in tuberculous pericarditis, 185 consecutive patients with suspected pericardial tuberculosis from 15 hospitals in Cameroon, Nigeria and South Africa were studied. Of these, 109 (58.9%) patients received steroids with a significant variation of corticosteroid use, ranging from 0 to 93.5% per centre ($P < 0.0001$). The presence of clinical features of HIV infection was an independent predictor of the non-use of adjunctive corticosteroids ($P < 0.005$) [65]. A multi-centre pilot trial of adjunctive prednisone and Mycobacterium immunotherapy in tuberculous pericarditis is under way.

The emergence of CVD in resource-poor countries

A major driver of the rising burden of CVD in resource-poor countries is the various stages of epidemiologic transition that mark dramatic social, environmental and economic changes, accompanied by parallel changes in the risk status and pattern of illness within the affected communities [3, 67, 68]. As described in recent reports from the Heart of Soweto Study in South Africa [50, 53], the paradox of improved economic conditions leading to a rise in unhealthy lifestyles and the emergence of so-called 'affluent' forms of CVD (predominantly non-communicable forms of disease secondary to underlying hypertension and atherosclerosis diabetes) has joined the traditional killers of infectious disease and malnourishment to pose multiple threats to vulnerable communities [54] For example, although human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDS) is the leading overall cause of death in Sub-Saharan Africa, CVD is the second leading killer overall and the leading cause of death among young adults aged 30 years and older, who are in their most productive years of life [19, 20].

One of the most crippling aspects of an increasing prevalence of CVD, due to expanded pathways to CV dysfunction (i.e. from an infectious basis to dyslipidemia and hypertension due to a salt and fat-rich diet), is its financial impact from an individual to a whole society perspective. In high-income countries, the cost of treating advanced forms of heart disease has increased exponentially with the ageing of high-risk populations. While it is difficult to estimate the monetary burden of CVD without accurate economic indicators, it is clear that CVD is beginning to have the same negative impact on health care resources and loss of productivity in low-to-middle income countries; the lesson from high-income countries being, of course, that prevention is far more cost-effective in the absence of cheap and readily applicable treatment and management options [54].

Unfortunately, there is clear disparity in the amount of government resources devoted to minimizing the burden of CVD within the developing world relative to the historical killers of malnourishment and infection; a situation that reflects the wide-spread apathy towards tackling non-communicable diseases at a global level [54].

This global phenomenon has the potential to severely impact the economic viability of many countries in whom (tragically) economic productivity and prosperity is reliant on those who survive malnourishment and infection in childhood only to die due to affluent forms of CVD, paradoxically due to their ability to afford an unhealthy lifestyle.

The Heart of Soweto Study

It is within the above context that we have studied the emergence of advanced forms of CVD (predominantly heart disease) in Soweto, South Africa [52]. Soweto has one of the largest urban concentrations of black Africans on the continent. Unfortunately, each phase of this ongoing project has confirmed our worst fears in terms of the CV risk profile of this community in epidemiological transition, and the likely consequences in terms of deadly forms of advanced disease. Through a monthly series of Heart Awareness Days we undertook community screening of voluntary adult participants in Soweto (>1,500 subjects in total) and found that only 22% of participants had no risk factor for CVD [59]. Moreover, awareness rates of heart disease and its risk factors leading to coronary artery disease, hypertension or diabetes were extremely low. The most prevalent CV risk factor, by far, was obesity (43%)—up to 70% were overweight; an observation that is consistent with other community-based surveys in the region, with far more obese women than men (23 vs. 55%; OR 0.24 95% CI 0.19–0.30: $P < 0.001$). A further 33% of subjects in the Heart Awareness Days recorded elevated blood pressure, whilst 13% of participants recorded an elevated (non-fasting) total blood cholesterol level with minimal difference between men and women observed in this regard. Consistent with the importance of our findings, in relation to the weight profile of participants, being either overweight or obese was significantly associated with elevated blood pressure and raised cholesterol levels [59].

In addition to monitoring risk factors at the community level, within the constraints of limited resources and a chaotic township environment that prevented a more

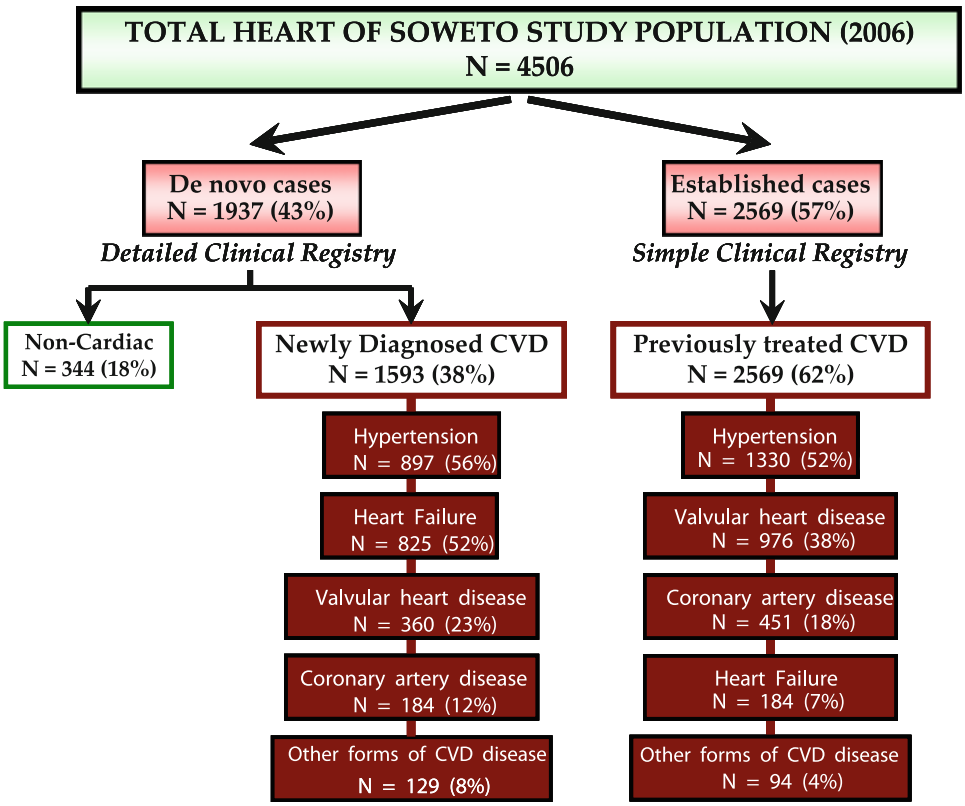

Fig. 8 Profile of the 2006 Heart of Soweto Cohort [50]

orthodox approach to risk surveillance, we established an advanced clinical registry for all patients attending the Cardiology Unit of the Baragwanath Hospital, which services Soweto and the surrounding communities [50]. In 2006, this registry captured a combination of demographic, clinical, investigative and treatment data from 4,162 new and returning patients. The majority of new presentations ($n = 1{,}593/38\%$ of all cases) were subjected to a systematic screening program with an echocardiograph.

Overall, we found a broad range of CVD (predominantly advanced heart disease) in the 1,593 new cases that comprised mainly black Africans (85%) and women (60%); the latter being slightly younger than men (mean age 53 ± 16 vs. 55 ± 15 years: $P = 0.031$), with almost a quarter of cases aged <40 years. Consistent with our community findings, the prevalence of modifiable CV risk factors was high, with 56% of cases diagnosed with hypertension (47% of whom were also obese) and almost two-thirds having multiple risk factors. Compared to the rest of the cohort, black Africans were far more likely to be diagnosed with heart failure (HF) (OR 2.36, 95% CI 1.74–3.21: $P < 0.0001$), but were far less likely to be diagnosed with coronary artery disease (OR 0.10, 95% CI 0.07–0.14: $P < 0.0001$).

Apart from the 310 cases (19%) with a primary diagnosis of hypertension (HT), most were 'late' clinical presentations with established heart disease and multiple etiologies. The four most common diagnoses overall were HT (total of 897 cases, 56%), HF (844 cases, 53%), valvular heart disease/dysfunction (360 cases, 23%) and coronary artery disease (165 cases, 10%)—see Fig. 8.

The most common forms of HF were hypertensive HF [281 (33%)], idiopathic dilated CMO [237 (28%)] and, surprisingly, right HF [225 (27%)]. Black Africans had less ischemic CMO (adjusted OR 0.12, 95% CI 0.07–0.20), but more idiopathic and other causes of CMO (adjusted OR 4.80, 95% CI 2.57–8.93).

Summary

In summary, there is ample evidence to suggest that the burden of CVD is already having a profound effect on the health of vulnerable populations in low-to-middle income countries of the world. The phenomenon of epidemiological transition has certainly contributed to the rise of CVD and will no doubt feed a sustained epidemic of non-communicable forms of CVD for the foreseeable future. Unfortunately, in resource-poor countries, there is often limited scope to respond to this growing problem.

There is, however, still time to implement cost-effective primary and secondary prevention programs in low-to-middle income countries in order to truncate the type of epidemic seen in high-income countries [63]. It is

encouraging to see that the World Health Organization (WHO) has developed an action plan that advocates key strategies for limiting the impact on non-communicable diseases (WHO 2009 [66]). In addition, the National Heart, Lung and Blood Institute (NHLBI) in partnership with the United Health Group, one of the world's largest well-being companies, has increased its commitment to reducing the global burden of chronic disease by supporting a collaborative global network of centres of excellence in low-income and middle-income countries throughout the world.

At the same time, research into etiology, diagnosis and management of specific forms of cardiovascular diseases common in African needs to be done.

This could be achieved by applying a practical and systematic approach in order to:

a. Properly understand the under-researched diseases;
b. Building clinical and research capacity using available resources;
c. Developing flexible surveillance programs; and
d. Evaluate the impact of any implemented strategies from a local perspective.

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