Angiotensin 1-7: A second window of protection in hypertensive patients

(Review article)

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Abstract

The effects of the renin-angiotensin-aldosterone system on the human body are so diverse and our knowledge about them is ever growing. Angiotensin 1-7 has been proven to play protective roles in patients with cardiovascular disorders including but not limited to hypertension.

As is the case with Africa, the prevalence of hypertension in Sudan is rising, and its complications could be delayed by pharmacologically manipulating the levels of renin-angiotensin system metabolites.

The aim of this review is to compare the advantageous and deleterious effects of Angiotensin 2 in contrast to those of Angiotensin 1-7 and to assert the well-established protective effects of Angiotensin 1-7 (systemically and locally) in hypertensive patients

Introduction

"The heart is the beginning of life, for it is by the heart the blood is moved, in which the source of all action is". Those were the words W. Harvey wrote in 1673. Corvisart in 1806 further elaborated that the cardiac muscle could change in structure due to disease. When he described "two types of dilatation, active with thick walls and increased force of contraction, and passive with thinning of the walls and a decreased force of contraction. (1)

Cardiac enlargement is considered to be a very important coping mechanism as far as compensation goes in response to increased hemodynamic load. (2)

In Africa, where morbidity and mortality such as those attributed to cardiovascular diseases are increasing every year, the economic burden is self-evident. New areas of research with clinicians being more involved in areas with a genetic background such as Renin Angiotensin Aldosterone

System (RAAS) promise novel approaches on both diagnostic and pharmacological levels, thus carrying hope for better management and intervention.

Hypertension

Hypertension is defined as the persistent elevation in blood pressure (3). The diagnosis is established based on the levels of systolic blood pressure (SBP) and/or diastolic blood pressure (DBP), and this may vary depending on the presence or absence of coexisting comorbidities (4, 5). It is very true that the numbers by which the diagnosis is based are well defined by the WHO and other entities, yet, these number may vary from population to another. Other factors may also contribute to the diagnosis, follow up and treatment of hypertension; factors like ethnicity.

Multi-Ethnic Study of Atherosclerosis (MESA) documented the distribution of treated but uncontrolled hypertension and showed hypertension to be significantly higher among ethnic groups of African Americans (35%), Chinese 33%, and Hispanics (32%) compared to Caucasians (24%) (6) The explanation for the high rates of hypertension and subsequent organ damage phenomena among African Americans is beyond comprehension. It has been suggested that socioeconomic factors play a role as well as lifestyle style, clinical factors and not to mention environmental and genetic factors that may account significantly for these differences and the response to drugs (7-13).

Hypertension is classified as primary or essential and secondary. As shown in Table 1, where the main differences between the causes of the two types are demonstrated; causes of the primary hypertension is of unknown causes (14)

Table 1: Classification and some causes of secondary hypertension

Primary (essential)	**Secondary**
UNKNOWN CAUSEs	Renovascular disease
	Reno parenchymal
	Pheochromocytoma
	Hyperthyroidism
	Drugs

RAAS over activation is considered to be a load on the cardiovascular system. Angiotensin II will increase the peripheral resistance and as Aldosterone will increase the volume of circulating blood. Both of these effects will increase pressure. .

In response to the elevated load, the heart hypertrophies as a vital mechanism for compensation, and this change is valid for some time before the overload eventually exceeds the heart capacity and the compensation becomes a failure. (2)

The renin-angiotensin system cascades

It has been traditionally accepted the classical pathway of activation of the RAAS as depicted in Figure1.

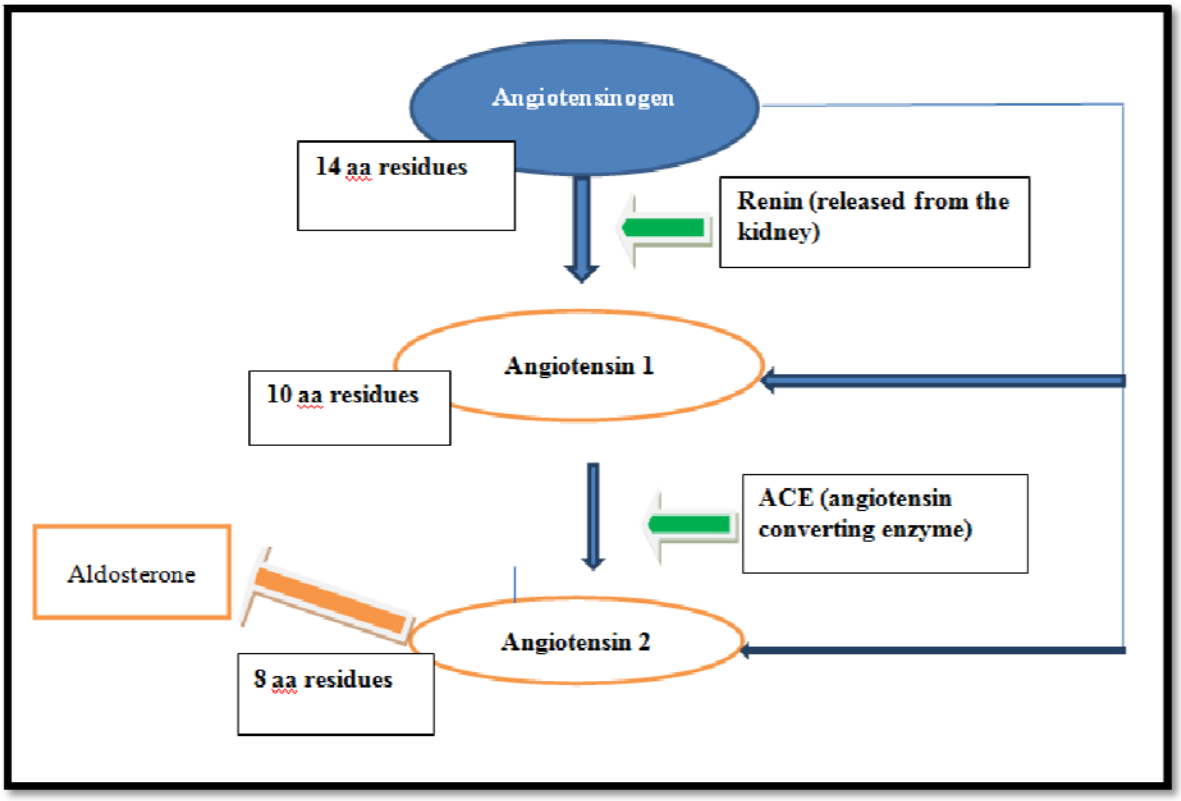

Figure 1: Scheme showing the classical cascade of activation of the renin-angiotensin system

As depicted in Figure 2, using the combination of protein chemistry and genomics a discovery has recently been made of new peptides of this system (13), specifically Angiotensin 1-7 (Ang1-7). Therefore, Ang1-7 is considered one of the most intriguing peptides for its formation could be directly from angiotensin I (Ang I) bypassing angiotensin-converting enzyme (ACE) and because it has actions which are often opposing to conventional effects of Ang II (15).

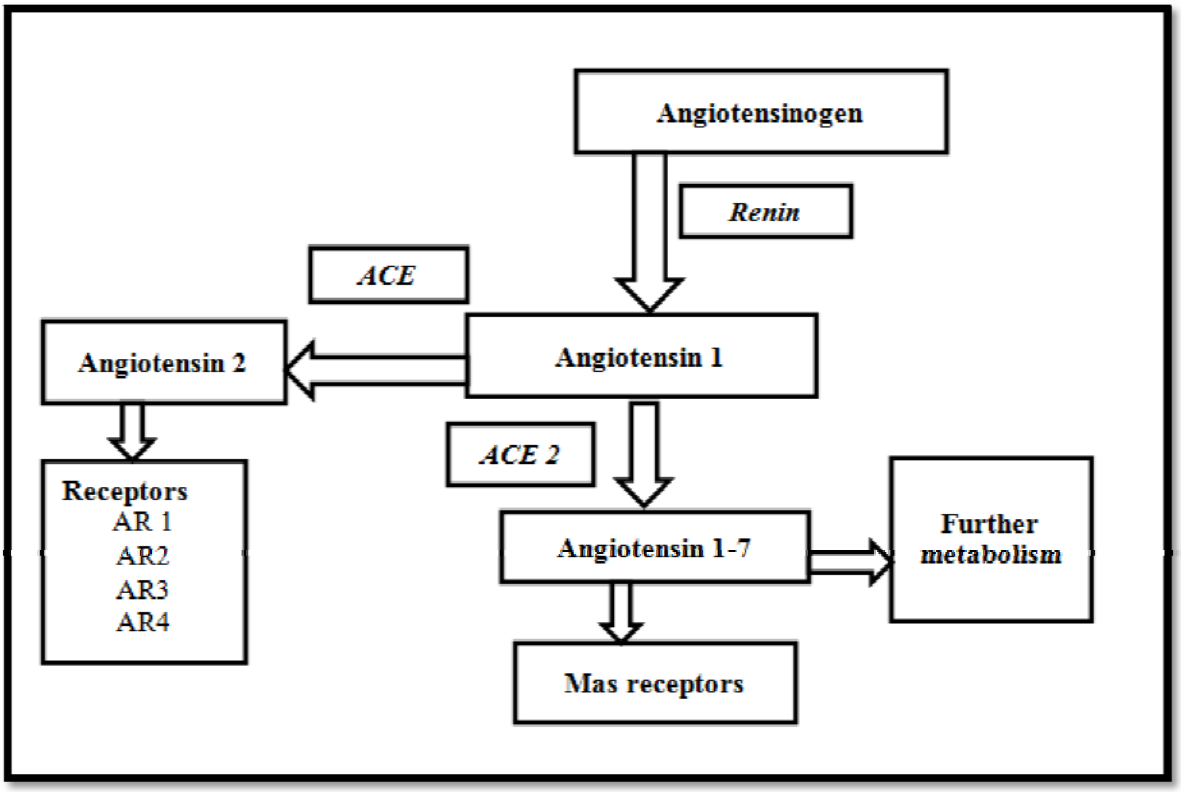

Figure 2: The alternative cascade of RAS activation

The two primary enzymes of the system long identified, ACE and angiotensin-converting enzyme 2(ACE2) have different areas of functioning. For instance, ACE produces angiotensin2 by releasing two amino acids from angiotensin 1; whereas ACE2 uses angiotensin 1-9 as a substrate to yield angiotensin 1-7.

Previous studies have displayed that Angiotensin 1-7 targets the heart and the vessels, these actions result in the so-called cardio-protection. (16, 17, 18) It has been shown that activation of intrinsic (ACE2) would improve endothelial function by decreasing the reactive oxygen species (ROS) production. (19)

ACE 2, the 40kb gene of which is located on chromosome Xp22 and contains 18 exons, many of these exons are comparable to those in the ACE gene (20). It was initially hypothesized that

disruption of the delicate balance between ACE and ACE2 would result in abnormal blood pressure control (21), ACE2 might have a protective role against increases in blood pressure, and ACE2 deficiency might lead to hypertension. The presence of ACE2 in vascular endothelial cells and smooth muscle cells (22) may lead to this conclusion.

Overwhelming evidence indicates that over-activity of systemic as well as of intra-cardiac RAAS leads to myocardial Ang II production, which contributes to the progression of heart failure.

Post-injury heart remodeling or remodeling in response to high or increasing wall stress is a major player in the progression of cardiac physiology deterioration which eventually leads to heart failure (23, 24)

It is widely accepted that Ang-(1-7) may counteract the negative remodeling processes inflicted by Ang II on the cardiac tissues. The suggested mechanisms are binding to the Mas receptor to activate a sequence of events leading to vasodilation and anti-hypertrophic effects (25)

Li Lin and colleagues from the Department of Cardiovascular Medicine, East Hospital, China, have investigated the effect of both metabolites on the heart of mice. Angiotensin 1-7 inhibited the cardiac fibrosis induced by Ang II in vivo. (26) Increased cardiomyocyte autophagy and myocardial fibrosis have been suspected to be vital in the transition from adaptive hypertrophy to maladaptive and eventually to heart failure (27, 28).

Li Lin et al 2016 demonstrated that treating mice with angiotensin II has advanced effects on heart remodeling. These effects include the increased left ventricular (LV) anterior wall , LV posterior wall , and LV internal dimension at end-diastole (26). Furthermore, mice treated with angiotensin II shows a decreased LV fractional shortening Gross heart size, and heart weight to body weight ratio (HW/BW) were also increased by treatment with Ang II (26). They also documented that: these effects were reversed by Angiotensin 1-7 by activating the Mas receptor

in their experiment. They even went a step further in investigating the oxidative process in the heart. They used an indicator called MDA for lipid peroxidation to estimate the oxidative stress. Ang II increased the process, while Ang 1-7 reduced it.

Therapeutic intervention targeting the RAAS

Several drugs are in use, which targets the RAAS metabolites in order to treat hypertension. Many of them are known like the ACE inhibitors and its receptor blockers. New agents like direct renin inhibitors and mineralocorticoid receptor antagonists have been used.

Several clinical trials have been using these agents such as Heart Outcomes Prevention Evaluation (HOPE) (29). The Microalbuminuria, Cardiovascular (MICRO-HOPE), and Renal Outcomes in HOPE) (30)

It is well documented that African-Americans have a unique reaction to RAAS blockers in comparison to Caucasians. An explanation for this is a variety of mechanisms, including salt sensitivity, low renin, and high aldosterone levels (31- 35).

Table2 demonstrates some of the differences between Angiotensin 2 and Angiotensin 1-7

Table 2: Some of the biological differences between the angiotensin 1-7 and angiotensin 2

	Angiotensin 1-7	Angiotensin 2
1	7 aa	8 aa
2	Produced by ACE 2	Produced primarily by ACE 1
3	Acts on Mas receptors	Acts on Angiotensin receptors
4	Induces reverse remodeling [26]	Induces pathological remodeling [26]
5	Anti-apoptotic effect [36]	Induces apoptosis in the infarction area

Conclusion:

Understanding the functioning of Angiotensin 1-7 in hypertension may optimize current therapies and ultimately guide the development of new therapeutic strategies. Finding new means to stimulate the production of Angiotensin 1-7 will lead to better protection of the heart and perhaps other organs from damage. Taking into account DNA variations will affect the design and selection of drugs affecting the system

In Africa, and specifically in Sudan, where the highest interethnic variations exist worldwide; it will not come as a surprise to find different and novel genes involved in the physiology of hypertension. This wide genetic diversity mandates a research into the genetic portfolio of these populations and applies them to our subpopulations such as whole genome sequencing and other molecular diagnostic tools in order to reveal the DNA variants in our country. Identifying these variants in our subpopulations will evidently lead to a more individualized approach to treating

different patients with elevated blood pressure. The choice of drugs acting on the metabolites of RAAS will; ultimately, change the outcome for patients with HTN, and cardiovascular disease resulting in reduced incidence of heart failure.

Summary

Ang II is not the sole active metabolite of the system. It exerts its actions by binding to receptors distributed throughout the body, heart, vessels, brain and other organs. Ang 1-7 is another active metabolite and it has the Mas receptors with various distributions. Ang 1-7 could be produced by ACE2 and by bypassing ACE1. Ang 1-7 counteracts the effects of Ang II on heart and vessels in particular through many mechanisms (biochemical, physiological and structural reverse remodeling). Bearing in mind the genetic diversity among different ethnic groups, a population-based approach in treating hypertension should have priority eventually.

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