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Age-Related Decline in Renal Blood Flow Could Be a Beneficial and Compensatory Mechanism

Authors' Contribution:

Study Design A

Data Collection B

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Funds Collection G

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Aging is a time-dependent process affecting all organs and tissues in the human body. The process of aging in the kidney is characterized by structural and functional changes, of which the main feature is a reduction in size, a decreased number of functioning glomeruli, and vascular changes. These changes result in functional deterioration, mainly involving a decrease in renal blood flow and the glomerular filtration rate. Additionally, impaired regulation of electrolyte and water homeostasis due to structural changes in the tubulo-interstitial system can occur. A reduced glomerular filtration rate does not necessarily result in serious clinical complications, and other selected parameters of kidney function may remain within reference value ranges in the elderly. Aging is also accompanied by decreased perfusion of other organs, including the heart and brain, which can induce more serious conditions in the elderly, including cardiac insufficiency or impairment of mental function. Thus, the decrease in renal blood flow in the aging kidney could be regarded as a compensatory mechanism to maintain perfusion of other organs and therefore, it could be also treated as being a beneficial reordering of blood-flow allocation.

MeSH Keywords:

Aging • Glomerular Filtration Rate • Kidney Function Tests

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Background

Aging is a time-dependent process that affects all organs and tissues in the body. The process of aging in the kidney is characterized by structural and functional changes such as reduction in size, a decreased number of functioning glomeruli, and vascular changes [1,2]. These changes result in functional deterioration, consisting primarily of reduced renal blood flow and a decrease in the glomerular filtration rate (GFR) [3,4]. Effective renal plasma flow (ERPF) exhibits a steady decline with age due to an increase in renal vasculature resistance. It is observed mainly in the renal cortex, whereas the medullary flow is relatively well preserved [5]. Rule et al. established that GFR showed a 6.3 ml/min/1.73 m² decline with each decade of age [6]. However, data regarding the degree of GFR decline per year is inconsistent and varies from 0.4 to 2.6 ml/min per year among different studies [5].

Additionally, impaired regulation of electrolyte and water homeostasis due to structural changes in the tubulointerstitial system may occur. These disturbances are aggravated by altered kidney responsiveness to the renin-angiotensin system (RAS). The RAS is suppressed with age; serum concentrations of renin and aldosterone in elderly people are lower, and the responsiveness to stimuli usually activating the RAS becomes less well-defined with increasing age [7]. Electrolyte and water deteriorations predispose to acute kidney injury [5].

Aging is also accompanied by a decrease in the perfusion of other organs. For instance, mean cerebral blood flow across the entire gray matter of the brain decreases with age in healthy individuals. The decline differs in various regions of the brain. Cerebrovascular reactivity also decreases with age. It has been shown that aging, even in the absence of Alzheimer's disease or other degenerative illness, is associated with memory, language, and/or motor dysfunction [8]. Cardiac output also decreases with age at a rate of about 1% per year. The average cardiac output at the age of 20 years is 6.49 l/min, and at the age of 82 years it is 3.87 l/min. Some of this decrease is associated with the decrease in body size and some with the decrease in heart rate, but about half of the decrease is

associated with the reduction in blood volume pumped per beat per unit of body size. The relationship between cardiac output and age is statistically significant. Cardiac index, stroke volume, and stroke index also decrease with age [9]. The comparison between cardiac output, cerebral blood flow, and renal blood flow are presented in Table 1.

We should consider what would happen if the kidneys do not undergo the normal aging process, but renal blood flow is preserved. Our own data indicate that the average renal blood flow at the age of 20 to 29 years is approximately 1000 ml/min and is higher in men than women [3]. At ≥65 years, the average renal blood flow is approximately 550 ml/min. When the renal blood flow is preserved in elderly people, other organs' perfusion would further decrease because about 450 ml of extra blood per minute would be still directed to the kidneys instead of other organs, including the brain and heart. Such a situation could result in greater cardiac insufficiency or impairment in mental function due to cerebral insufficiency.

The decrease in renal blood flow could be treated as a compensatory mechanism for maintaining perfusion of other organs, including heart and brain, which are critical for survival. Thus, the decrease in renal blood flow could be treated as a beneficial blood allocation, comparable to the phenomenon observed in physical exercise. Both cardiac output and index start to decline around the age of 30 to 40 years, similar to cerebral blood flow and renal blood flow [1,9,10]. It should be pointed out that the decrease in GFR resulting from decreased renal blood flow is lower than the extent of renal perfusion decrease, and this GFR decrease does not present any serious clinical consequences. The main renal function parameters normally remain within normal reference value ranges despite the aging process [3]. The decreased activity of RAS could also contribute to this compensating phenomenon, thereby preventing exaggerated cardiac afterload. However, there may still be some deterioration in an aging kidney, presenting as an increased risk of hypovolemia and electrolyte disturbances.

Table 1. Comparison between CO, CBF, and ERBF in young and elderly adults.

Parameter		Young adults, age [years] (value)		Elderly adults, age [years] (value)		App. % of decrease
CO [L/min]		34.1	(6.57)	65.4	(4.29)	35%
CBF [ml/100 g/min]		30±7	(57.0±8)	64±8	(46±9)	20%
RBF [ml/min]	Women	30–39	(846.9±161.8)	60–69	(611.7±123.3)	28%
	Men	30–39	(1109.0±268.5)	60–69	(874.0±324.9)	21%

CO – cardiac output, L/min [9]; CBF – cerebral blood flow; ERBF – effective renal blood flow, ml/min [3].

Conclusions

We do not intend to regard kidney aging as being beneficial to the body. However, we would like to suggest that the renal aging process has another side that could be beneficial and protect an individual from exaggerated decrease in heart and brain blood flow.

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Conflict of interest

None.