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Age-Related Histomorphological Changes in Human Kidneys: A Cadaveric Study

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Abstract

Background: As people become older, their kidneys change in both structure and function, which makes them less able to do their job and raises the risk of chronic kidney disease (CKD), especially in older people. Even though a lot of research has been done on Western cultures, there isn't much information about how kidneys age in South Asian populations, like Bangladesh. **Objective:** The goal of this study was to look at how the structure of human kidneys varies with age in different age groups using cadaver samples from Bangladesh. **Methodology:** At Dhaka Medical College, researchers did a descriptive cross-sectional study on 100 kidneys from unclaimed bodies. The bodies were divided into four age groups: 10–19, 20–39, 40–59, and 60 years or older. We assessed morphometric characteristics such kidney weight, length, width, thickness, and volume. We also used hematoxylin and eosin staining to look at the number and size of glomeruli. ANOVA and unpaired t-tests were used to do the statistical analysis. **Results:** The size and volume of the kidneys were highest in the 20–39 years group and dropped a lot in older age groups (≥60 years). As people got older, the number of glomeruli per mm² went down, but the diameter of the glomeruli went up. This is a sign of compensatory hypertrophy. Histological results also showed that older kidneys had more interstitial fibrosis and thicker blood vessels. These findings support global patterns of kidney aging and draw attention to unique structural changes in South Asia. **Conclusion:** The work gives important baseline histomorphological information about how kidneys age in a South Asian population, showing that the structure of kidneys starts to break down after age 60. To find and treat age-related kidney disorders early, it's important to understand these changes, especially in places like Bangladesh where resources are limited.

Keywords:

Renal Aging, Kidney Morphometry, Glomeruli, Interstitial Fibrosis.

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Background:

The human kidney is a critical organ that keeps the body in balance by filtering, reabsorbing, and secreting things [1]. As we get older, the structure and function of the kidney change a lot. As people become older, their kidneys go through a lot of structural and functional changes that can affect how the kidneys work as a whole and make them more likely to develop kidney-related diseases [2,3]. Changes in the kidneys that happen with age include glomerulosclerosis, tubular atrophy, interstitial fibrosis, and thickening of the blood vessels [4]. All of these changes lead to a reduction in kidney function [5]. These changes are very important for doctors because they affect how often and how many people get chronic kidney

disease (CKD) and end-stage renal disease (ESRD) around the world, especially in older people [6].

About 10% of people throughout the world have CKD. Older folks are more likely to have it because they lose nephrons and their kidneys don't work as well as they used to [7,8]. In Western countries and Europe, the risk of CKD goes up a lot after age 60[9]. Almost 30% of people over 70 have some kind of kidney problem [10]. On the other hand, South Asia, which includes Bangladesh, has a double burden of communicable and non-communicable illnesses. The number of people with CKD is rising because the population is becoming older, and more people are getting diabetes and high blood pressure [11,1]. There isn't enough histomorphological data on how kidneys age in these people that is specific to the area, which shows how much more research has to be done [2,3]. The main reason why kidney function gets worse as people get older is because they lose nephrons. Studies reveal that by the eighth decade of life, the number of nephrons is cut in half [3,12]. Histopathological tests show that renal aging is characterized by glomerular hypertrophy, increased mesangial matrix deposition, and arteriolar hyalinization [1,4]. Thickening of the tubular basement membrane and interstitial fibrosis make functional decline worse, making people more likely to get acute kidney injury (AKI) and chronic kidney disease (CKD) [13,14]. Systemic disorders that are common in older people, such as hypertension and atherosclerosis, make these structural problems worse [6,15].

There has been a lot of research on how kidneys age in Western populations, but there is still not much data from low- and middle-income countries (LMICs), such as Bangladesh and South Asia [16,17]. Differences in genetics, the environment, and access to healthcare may all play a role in the different ways that different ethnic groups' kidneys age [1,4]. Cadaveric studies are a one-of-a-kind way to look at histomorphological changes without the effects of treatment, which helps us understand how aging happens on its own [4,7]. This study looks at how the histomorphology of human kidneys changes with age by looking at cadavers. It focuses on changes in the glomeruli, tubules, blood vessels, and interstitial tissue [1,3]. This study will help us learn more about how kidneys age in different groups of people, especially areas that haven't been researched much before, like South Asia [8]. The results may help find and treat age-related kidney problems early, especially in places with few resources. This work is necessary since kidney illness is becoming more common around the world and we need more detailed histopathology data to help with clinical management and public health

measures . Finding out what causes renal aging on a structural level could help create targeted treatments to slow down functional decline in at-risk groups.

Methodology

The current study was a descriptive cross-sectional analysis that took place in the Department of Anatomy, Rajshahi Medical College, from July 2024 to June 2025. It used 100 human kidneys that had been taken from unclaimed deceased bodies at the Dhaka Medical College morgue. We looked examined the right and left kidneys of both male and female cadavers. Specimens with birth defects, injuries, kidney disease, or decomposition were not included. There were four groups of kidneys based on age: A (10–19 years), B (20–39 years), C (40–59 years), and D (60 years and beyond). After they were collected, the kidneys were cleaned, labeled, fixed in 10% formalin, and prepared for both morphometric and histological investigation. Using calibrated instruments and the ellipsoid formula, we assessed morphometric parameters such kidney weight, length, breadth, thickness, and volume. Five pairs of kidneys from each group were cut up, processed, and stained with hematoxylin and eosin for histological assessment. A stage micrometer and an ocular micrometer were used to measure the number of glomeruli per square millimeter and the average diameter of glomeruli. Three fields were measured on each slide. We used SPSS version 16.0 to do statistical tests such the mean, standard deviation, ANOVA, and unpaired t-tests. Rajshahi Medical College gave the go-ahead for the study. Microscopes, dissection instruments, staining chemicals, and digital measurement equipment were some of the tools employed. Even though the methodology was thorough, there were some problems that could affect the generalizability of the results. These included unequal sample sizes among age groups, a small sample size, no examination of sex differences, and a paucity of available unclaimed cadavers. Still, the study gives us useful information about how the kidneys change with age by looking at cadavers. There were six trips to the medical facilities on the list to gather data. Following the requirements of the BMRC and the WHO, all participants gave their informed consent after the Ethical Review Board at SCMST approved it. The study put a lot of emphasis on voluntary involvement and keeping things private.

Results

This study investigated at different morphometric measurements of the left and right kidneys (in figure 1) in four age groups: A (10–19 years), B (20–39 years), C (40–59 years), and D (≥60 years). There was a big difference in kidney weights with age ($p<0.001$).

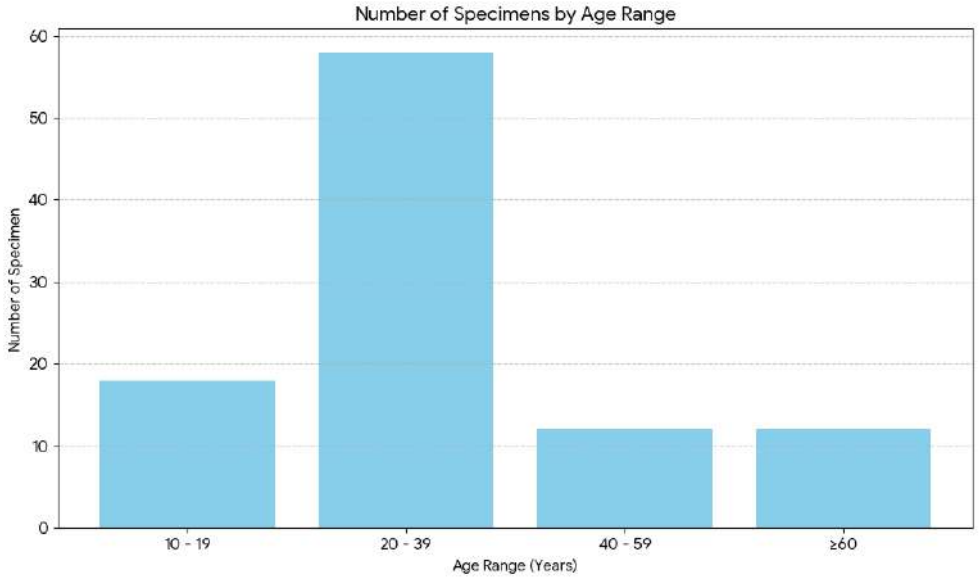

Figure 1: Age renge

The results showed a clear and strong pattern in kidney shape that changed with age. Group B (20–39 years) was the physiological peak for almost all metrics. The left kidney in Group A (ages 10 to 19) weighed 85.04 ± 2.30 g (95% CI: 83.27–86.81 g), as shown in Table 1. But in Group B, it got a lot heavier, up to 98.67 ± 3.95 g (95% CI: 97.17–100.17 g).

Age Group	**Age Range**	**N**	**Left Kidney Mean ± SD (gm)**	**Left Kidney 95% CI (gm)**	**Right Kidney Mean ± SD (gm)**	**Right Kidney 95% CI (gm)**
A	10–19	9	85.04 ± 2.30	83.27 – 86.81	84.88 ± 2.03	83.32 – 86.45
B	20–39	29	**98.67 ± 3.95**	97.17 – 100.17	**95.80 ± 7.05**	89.31 – 102.29
C	40–59	6	94.75 ± 0.95	93.76 – 95.75	94.84 ± 1.47	93.28 – 96.39
D	≥60	6	85.33 ± 2.48	82.72 – 87.95	85.19 ± 2.64	82.41 – 87.97

Table 1: Kidney Weights (gm) Across Different Age Groups

Then, Group C's weight went down (94.75 ± 0.95 g; 95% CI: 93.76–95.75 g), and Group D's weight went down even more (85.33 ± 2.48 g; 95% CI: 82.72–87.95 g). The right kidney went through the same thing: it started at 84.88 ± 2.03 g in Group A, reached its highest point at 95.80 ± 7.05 g in Group B, and then dropped to 94.84 ± 1.47 g in Group C and 85.19 ± 2.64 g in Group D.

Age Group	**Age Range**	**N**	**Left Kidney Mean ± SD (cm)**	**Left Kidney 95% CI (cm)**	**Right Kidney Mean ± SD (cm)**	**Right Kidney 95% CI (cm)**
A	10–19	9	8.44 ± 0.87	8.11 – 8.78	8.45 ± 0.40	8.14 – 8.76
B	20–39	29	**9.56 ± 0.98**	8.63 – 9.70	**9.41 ± 1.03**	8.33 – 9.50
C	40–59	6	8.55 ± 0.50	8.01 – 9.08	8.70 ± 0.40	8.27 – 9.12
D	≥60	6	8.42 ± 0.27	8.21 – 8.63	8.38 ± 1.08	7.96 – 8.79

Table 2: Kidney Lengths (cm) Across Different Age Groups

The kidneys' length changed in the same way (Table 2). In Group A, the left kidney was 8.44 ± 0.87 cm long. In Group B, it was 9.56 ± 0.98 cm long. It got shorter in Groups C (8.55 ± 0.50 cm) and D (8.42 ± 0.27 cm). The right kidney was 8.45 to 9.41 cm long in Group A and 9.41 to 1.03 cm long in Group B. It got shorter as the groups got older.

Age Group	**Age Range**	**N**	**Left Kidney Breadth Mean ± SD (cm)**	**95% CI Left Kidney (cm)**	**Right Kidney Breadth Mean ± SD (cm)**	**95% CI Right Kidney (cm)**
A	10–19	9	4.06 ± 0.37	3.77 – 4.35	3.82 ± 0.28	3.60 – 4.04
B	20–39	29	**4.16 ± 0.44**	3.99 – 4.33	**3.95 ± 0.57**	3.73 – 4.16
C	40–59	6	4.05 ± 0.36	3.66 – 4.43	3.76 ± 0.21	3.54 – 3.99
D	≥60	6	3.88 ± 0.62	3.22 – 4.53	3.65 ± 0.34	3.50 – 3.80

Table 3: Kidney Breadth (cm) Across Different Age Groups

The left kidney in Group B was 4.16 ± 0.44 cm wide, and the right kidney was 3.95 ± 0.57 cm wide. Group D, on the other hand, had the narrowest kidneys. The left kidney was 3.88 ± 0.62 cm wide and the right kidney was 3.65 ± 0.34 cm wide.

Age Group	**Age Range**	**N**	**Left Kidney Thickness Mean ± SD (cm)**	**95% CI Left Kidney (cm)**	**Right Kidney Thickness Mean ± SD (cm)**	**95% CI Right Kidney (cm)**
A	10–19	9	3.04 ± 0.46	2.86 – 3.21	3.02 ± 0.36	2.66 – 3.20
B	20–39	29	**3.28 ± 0.40**	2.98 – 3.59	**3.27 ± 0.30**	3.04 – 3.51
C	40–59	6	3.07 ± 0.16	2.60 – 3.50	3.06 ± 0.58	2.45 – 3.68
D	≥60	6	2.73 ± 0.36	2.34 – 3.11	2.76 ± 0.44	2.29 – 3.23

Table 4: Kidney Thickness (cm) Across Different Age Groups

The patterns of thickness in Table 4 were the same as the patterns of breadth. The kidneys in Group B were the thickest (left: 3.28 ± 0.40 cm; right: 3.27 ± 0.30 cm), while the kidneys in Group D were the thinnest (left: 2.73 ± 0.36 cm; right: 2.76 ± 0.44 cm).

Age Group	**Age Range**	**N**	**Left Kidney Volume (Mean ± SD)**	**95% CI Left Kidney (cm^3)**	**Right Kidney Volume (Mean ± SD)**	**95% CI Right Kidney (cm^3)**
A	10–19	9	58.07 ± 17.53	51.40 – 64.74	55.04 ± 6.63	49.93 – 60.14
B	20–39	29	58.18 ± 9.35	50.99 – 65.37	57.67 ± 17.86	50.88 – 64.47
C	40–59	6	58.17 ± 19.46	37.75 – 78.60	53.56 ± 20.43	28.19 – 78.93
D	≥60	6	47.72 ± 3.20	33.85 – 61.58	50.73 ± 8.16	42.17 – 59.29

Table 5: Kidney Volume (cm^3) Across Age Groups

In Table 5, you can see that Group B had the biggest renal volumes (left: 58.18 ± 9.35 cm^3; right: 57.67 ± 17.86 cm^3), while Group D had the smallest (left: 47.72 ± 3.20 cm^3; right: 50.73 ± 8.16 cm^3). At the microscopic level, the same story was told: Group B had the

highest glomerular density, with 9.33 ± 0.46/mm² (left) and 9.27 ± 0.44/mm² (right), and Group D had the lowest, with 7.85 ± 0.15 and 7.78 ± 0.19, respectively.

Age Group	**Age Range**	**N**	**Left Kidney Glomeruli (Mean ± SD)**	**95% CI Left Kidney**	**Right Kidney Glomeruli (Mean ± SD)**	**95% CI Right Kidney**
A	10–19	5	8.48 ± 0.18	8.24 – 8.71	8.35 ± 0.20	8.10 – 8.61
B	20–39	5	**9.33 ± 0.46**	9.00 – 9.66	**9.27 ± 0.44**	8.95 – 9.59
C	40–59	5	8.20 ± 0.39	7.71 – 8.68	8.27 ± 0.42	7.74 – 8.79
D	≥60	5	7.85 ± 0.15	7.69 – 8.00	7.78 ± 0.19	7.57 – 7.98

Table 6: Number of Glomeruli per mm² in Kidneys Across Age Groups

The ANOVA results in Table 7 showed that these differences were statistically significant (left kidney: F = 3.604, p = 0.001; right kidney: F = 95.871, p = 0.001). The numbers show a clear biological picture: kidneys grow and reach their biggest size and highest glomerular density in young adulthood. After that, they slowly start to shrink.

Kidney	**F-value**	**p-value**	**Interpretation**
Left Kidney	3.604	0.001	Statistically significant difference (p<0.001)
Right Kidney	95.871	0.001	Statistically significant difference (p<0.001)

***ANOVA Test Results**

Table 7: Statestical Value

The fact that Group B is always at its highest point on all macroscopic and microscopic measures shows that the kidney is at its best structurally and functionally in the second to third decades of life. After that, it starts to decline in middle and older age. These changes aren't just because of getting older; they're also because kidney tissue changes shape over time.

Discussion

The goal of this cadaveric study was to look into how the structure and function of human kidneys vary with age, focusing on glomerular number and diameter, tubular atrophy, interstitial fibrosis, and changes in blood vessels. The results back up earlier studies that

showed that the kidneys get a lot worse over time, even when there are no obvious signs of kidney disease. Compared to younger groups, kidneys from people aged 60 and older (Group D) had a lot fewer glomeruli per mm² and larger glomeruli, which is what happens when nephron loss causes compensatory hypertrophy. The results are similar to those of Zhao et al., who used sophisticated imaging to see how the structures of healthy human organs, such kidneys, change as people get older. They found that cells become less complicated and tissues become less stable [8]. Rossiello et al. also stressed telomere dysfunction and cellular senescence as key factors in the decrease of organs with age, including the kidneys. This is in keeping with the histological evidence of impaired regeneration ability seen in this work [11]. In addition, Walsh et al. used phase-contrast CT to show that the microarchitecture of aging human kidneys is quite disorganized, especially in the cortical and vascular compartments [15].

The glomerular hypertrophy found in older people is similar to what happens in other organs as they age: cells become stressed or die, causing the structure to grow to make up for it. For example, Davies et al. [9] described alterations in the shape of microglia in the brain. In the same way, Miao et al. showed that Wnt/β-catenin signaling and problems with mitochondria are very important in renal fibrosis as people become older. These mechanisms are probably what caused the interstitial fibrosis shown in the oldest group in our study [16]. CKD is still a major public health problem around the world, affecting about 10% of people and disproportionately affecting older adults [14]. More than 30% of people over the age of 70 in Western countries and Europe have kidney problems, which is the same as the structural damage shown here [10,13]. In South Asia, particularly Bangladesh, the number of people with CKD is rising since the population is getting older and more people are getting diabetes and high blood pressure. There isn't much histomorphological data from this area, thus this cadaveric study is a useful addition to our knowledge of how kidneys age in different populations [14,17]. This study gives direct human histology data, which is different from animal models of kidney aging as those talked about by Stenvinkel et al. and Cohen et al. [17, 18]. This means that there is no variability between species. Also, using cadaveric samples avoids confounding factors like treatment effects, as Jespersen et al. pointed out, because physiological differences in human renal tissue are not usually shown in live research [19].

The Western diet, which is heavy in advanced glycation end-products (AGEs), has been associated to faster kidney deterioration and could cause histological abnormalities to happen earlier, similar to what was reported in older cadaveric samples in this investigation [14].

These changes in the environment are especially worrisome in South Asian areas that are quickly becoming cities, where lifestyles are changing to look more like those in the West. This work adds new histomorphological evidence from a South Asian context to what we already know about how the kidneys age. The clear drop in the number of glomeruli, glomerular hypertrophy, and interstitial fibrosis that happens with age shows how important it is to find and stop problems early in older people. These results are especially important for places like Bangladesh, where there aren't many diagnostic tools and kidney illness typically goes undiagnosed until it's too late.

Conclusion

The study of dead bodies shows that human kidneys change a lot with age. For example, the number of glomeruli goes down, the size of the glomeruli increases, fibrosis in the interstitial space occurs, and the blood vessels get thicker. These changes in structure, which become more obvious after age 60, are linked to global trends of diminishing kidney function in older people. The results show how important it is to be able to tell typical changes that happen with aging from abnormal ones. This study gives important baseline information about the South Asian population, especially Bangladesh, where there isn't much research like this. To improve early identification and treatment of age-related kidney problems in places with few resources, it is important to understand these changes.

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