

Gross and Histopathological Renal Findings in Medico-Legal Autopsies: A Cross-Sectional Study in Maharashtra

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ABSTRACT

Background: Medico-legal autopsies offer a unique opportunity to detect renal pathologies that may be incidental or contributory to sudden and unnatural deaths. This study aimed to correlate gross and histopathological renal alterations with causes of death in autopsy cases. **Methods:** A cross-sectional study was conducted on 150 medico-legal autopsies in Maharashtra between December 1995 and November 1997. Gross renal examination assessed size, weight, capsular features, cortical thickness, and surface morphology. Formalin-fixed, paraffin-embedded tissue sections were stained with hematoxylin and eosin, along with special stains where necessary. Renal compartments—glomeruli, tubules, interstitium, and vasculature—were systematically examined and correlated with macroscopic findings, age, and cause of death. **Results:** Gross renal abnormalities were noted in 66 cases (44%), with renal cysts (22%) and bilateral contracted kidneys (10.66%) being the most common. Histopathological lesions were identified in 94 cases (63%). Acute tubular necrosis (ATN) was most frequent (37.23%), particularly in younger individuals with thermal injuries. Chronic tubulo-interstitial nephritis (29.78%) was associated mainly with accidental deaths. Nephrosclerosis (19.14%) occurred predominantly in older individuals. Notably, 28 macroscopically normal kidneys exhibited significant microscopic lesions. Distinct findings such as medullary ATN and hemorrhagic necrosis were characteristic of snakebite fatalities. **Conclusion:** Histopathology revealed significant renal pathology undetectable on gross examination in medico-legal autopsies. The associations of ATN with burns and TIN with accidents suggest potential causal links warranting further study. Comprehensive renal assessment

is crucial for elucidating the role of kidney pathology in mortality during forensic evaluations.

KEYWORDS: Kidney lesions, Acute tubular necrosis, Tubulo-interstitial nephritis, Nephrosclerosis, Cysts, Maharashtra, India, Cause of death, Incidental findings, Forensic pathology, Postmortem examination

INTRODUCTION

The kidneys play a critical role in maintaining homeostasis, including fluid and electrolyte balance, waste excretion, and blood pressure regulation. However, their intricate structure and high metabolic demand render them susceptible to a wide range of pathological insults, many of which may remain undetected until autopsy. Medico-legal autopsies, performed to determine the cause of sudden, unnatural, or suspicious deaths, provide a unique opportunity to study renal pathology in individuals who may not have had prior clinical evaluation. These autopsies often reveal incidental renal findings that can offer insights into the prevalence of subclinical kidney disease and its association with various causes of death, such as trauma, poisoning, or asphyxia. [1, 2]

Renal pathology encompasses a spectrum of conditions, including glomerulonephritis, acute tubular necrosis (ATN), tubulo-interstitial nephritis (TIN), and nephrosclerosis, each with distinct gross and histopathological features. [1, 2] ATN, for instance, is a common finding in cases of shock or toxin exposure, characterized by tubular epithelial damage and necrosis, often with sparing of the glomeruli. [3] Similarly, TIN, marked by interstitial inflammation and tubular injury, has been associated with infections, drugs, and autoimmune

processes.^[4, 5] Nephrosclerosis, a hallmark of chronic hypertension, manifests as vascular hyalinization and interstitial fibrosis, reflecting long-standing hemodynamic stress.^[6] These conditions may not only contribute to death but also serve as incidental findings that highlight underlying comorbidities.

Recent studies have emphasized the value of autopsy-based research in uncovering occult renal pathology.^[1, 7, 8] A study by Perrone et al. reported that up to 30% of autopsies revealed previously undiagnosed renal abnormalities, underscoring the importance of systematic histopathological examination.^[2] Furthermore, advances in forensic pathology have highlighted the correlation between specific causes of death and renal changes. For example, snakebite envenomation, a significant cause of mortality in tropical regions, has been linked to acute kidney injury (AKI), with histopathological evidence of hemorrhagic necrosis and ATN.^[9, 10] Similarly, burns and trauma, prevalent in younger populations, are associated with hypovolemic shock and subsequent renal tubular damage.^[11, 12]

In India, where medico-legal autopsies are frequently conducted due to high rates of unnatural deaths, renal assessment remains underexplored. A study by Neha et al. found that incidental renal findings were present in a majority of autopsy cases in a tertiary care center, suggesting a need for detailed morphological studies.^[8] Such investigations can bridge the gap between clinical and forensic medicine, enhancing our understanding of renal pathology's role in mortality. This study aims to correlate gross and microscopic renal changes in medico-legal autopsies and to explore incidental morphological findings associated with various causes of death, including accidents, burns, poisoning, and snakebites etc.^[8]

METHODS

Study Design and Setting

This study was conducted in the Department of Pathology at Government Medical College, Nagpur, in collaboration with the Forensic and Toxicology Department. The research period extended from December 1995 to November 1997. The study focused on the renal assessment, both gross and microscopic, in medico-legal autopsies performed at the institution.

Study Population

The study included 150 postmortem cases, comprising 93 males and 57 females, ranging in age from 1 to 85 years. The cases selected represented individuals who had suffered sudden or acute deaths. Accidental deaths were excluded due to the lack of clinical data. No selectivity criteria or consecutive case series were applied.

Ethical Considerations

Consent for the removal and examination of kidneys was obtained from the next of kin or surviving relatives in the presence of forensic experts, in accordance with ethical and legal guidelines.

Autopsy Procedure

Autopsies followed a standardized protocol based on established techniques by Otto Saphir (1958) and Ludwig (1979).

1. **Inspection of the Body:** External body examination was performed to identify signs of renal pathology, such as facial edema indicating potential renal failure.
2. **Incision:** A Y-shaped incision was made, extending bilaterally from the anterior margins of the axillae to the xiphoid process of the sternum. A longitudinal incision from the sternal notch to the symphysis pubis was also performed.
3. **Abdominal Cavity Examination:** After inspecting the peritoneal cavity, kidneys were exposed for detailed examination.

Kidney Removal and Gross Examination

The Virchow technique, involving organ removal one by one, was employed. After excising the upper abdominal aorta, the surrounding adipose and connective tissue of the kidneys were carefully removed. Congenital anomalies (e.g., horse-shoe kidney) and abnormalities in the renal vasculature were noted. Kidneys were dissected to reveal the cortex, medulla, pelvis, and ureters, which were opened longitudinally for inspection.

Gross renal features were recorded within six hours of removal. Parameters assessed included kidney size, weight, capsule consistency, cortical thickness, vascular integrity, and surface appearance (granularity, scars, cysts, and petechiae). The cortico-medullary ratio was evaluated, and renal vessels were examined for stenosis, thrombosis, or arteriosclerotic lesions.

Gross Morphological Examination Grading

Gross pathological findings were assessed following the criteria outlined by Rezek and Millard (1963).^[13] Kidney atrophy was defined as one kidney weighing less than 100 g and the other weighing approximately 120 g.^[14] Consistency changes, such as softening in acute inflammation or nephrosis and firmness in fibrosis or chronic venous congestion, were also examined as per Rezek and Millard (1963).^[13]

Capsular adherence was categorized as either easily stripped off in cases of edema (e.g., nephrosis or glomerulonephritis) or difficult to strip in cases of fibrosis or chronic inflammation. Cortical scars were classified by size and

shape, with small scars (<0.5 cm) and large scars (0.5–5 cm) assessed for associated conditions such as pyelonephritis or arteriosclerosis. Granularity was categorized as fine (<1 mm) or coarse (1–3 mm), reflecting conditions like arteriosclerosis and chronic pyelonephritis. Hemorrhagic findings, including petechiae and larger hemorrhages, were evaluated for their association with conditions such as glomerulonephritis, hypertension, trauma, or coagulation disorders.

Histopathological Examination: [1, 14–16]

Kidney specimens were fixed in 10% formalin immediately after removal. Representative sections from the renal cortex, medulla, and pelvis were embedded in paraffin, sectioned at 3–4 μm thickness, and stained with hematoxylin and eosin (H&E) for routine histopathological evaluation. Special stains, including Periodic Acid-Schiff (PAS) and Masson's trichrome, were used to highlight basement membrane changes, interstitial fibrosis, and other specific pathological features when necessary.

Histopathological examination was performed to evaluate multiple renal compartments. In the glomeruli, cellular changes such as hypercellularity and glomerulosclerosis were assessed, along with basement membrane alterations including thickening or wrinkling, and the presence of necrosis, adhesions, or capillary tuft abnormalities was noted. For the tubules, the examination focused on identifying atrophy, necrosis, or regenerative changes, as well as the presence of intratubular casts and epithelial desquamation. The interstitium was evaluated for evidence of edema, fibrosis, or infiltration by inflammatory cells, such as lymphocytes and plasma cells. Vascular lesions were also examined, with attention to arteriolar hyalinization and intimal thickening in hypertensive nephropathy, as well as fibrinoid necrosis and concentric "onion-skin" arteriolitis in cases of malignant hypertension.

Histological Examination Grading

Histological evaluation was conducted using the grading system introduced by Pirani et al. (1975), which examines four principal compartments of the kidney—glomeruli, tubules, interstitium, and vessels—with each feature scored on a scale from 0 (normal) to 4+ (severe). Chronic glomerulonephritis was analyzed following the methodologies of Cotran et al. (1996) and Rezek and Millard (1963), emphasizing glomerular sclerosis, cortical thinning, and interstitial fibrosis. Diabetic glomerulosclerosis was identified by the presence of nodular (Kimmelstiel-Wilson lesion) and diffuse glomerular alterations as described by Cohen et al. (1996) and Porter (1978). Hypertensive nephropathy was classified into benign and malignant forms per Cotran et al. (1996) and Striker et al. (1992), with evaluation of vascular hyalinization and fibrinoid necrosis. These assessments are in line with current recommendations provided by the KDIGO 2012 Clinical Practice Guidelines for the Evaluation and Management of Chronic Kidney Disease. [15, 16]

Evaluation of Acute and Chronic Renal Injuries

Acute tubular necrosis (ATN) was assessed using criteria established by Rezek and Millard (1963) and Porter (1978), focusing on tubular epithelial necrosis, the presence of hyaline casts, and evidence of regeneration. Tubulointerstitial nephritis (TIN) was evaluated based on the descriptions provided by Rezek and Millard (1963), Cohen et al. (1996), and Heptinstall (1983), with considerations including interstitial edema, inflammatory infiltrates, and tubular atrophy or damage. Contemporary guidelines from KDIGO also endorse these histopathological criteria for a comprehensive evaluation of both acute and chronic renal pathologies. [15, 16]

Diagnostic Focus

Histological features were correlated with gross findings to diagnose conditions such as glomerulonephritis, diabetic nephropathy, acute tubular necrosis, and tubulointerstitial nephritis.

Statistical Analysis

Descriptive statistics were used to summarize the morphological findings, including gross and histopathological parameters. Categorical data were expressed as percentages. The association between renal lesions and causes of death was qualitatively analyzed.

RESULTS

Demographic and Cause-of-Death Distribution

The study included 150 cases of medico-legal autopsies. The majority of cases (33; 22%) were in the 20–30 years age group, followed by 30–40 years (30; 20%) (Table 1). 93 cases (62%) were males.

The leading cause of death was accidents, recorded in 68 cases (45.33%), with a notable predominance in males (59 cases) compared to females (9 cases). Burns were the second most common cause, accounting for 37 cases (24.66%), primarily involving females (32 cases) compared to males (5 cases). Deaths due to unknown causes accounted for 19 cases (12.66%), with a nearly equal gender distribution. Accidents and burns accounted for the majority of deaths, particularly in younger adults, with males being more frequently involved in accidents and females in burns-related cases.

Gross Morphological Findings of Kidneys

Gross examination identified abnormalities in 66 cases (44%) and normal findings in 84 cases (56%). Table 2 presents the general findings, while Table 3 focuses on detailed surface findings.

Age Group (years)	No. (%)	Cause of Death	Male	Female	Total (%)
1–10	5 (3.33)	Accidents	59	9	68 (45.33)
10–20	13 (8.66)	Burns	5	32	37 (24.66)
20–30	33 (22.00)	Unknown	11	8	19 (12.66)
30–40	30 (20.00)	Asphyxia	5	5	10 (6.66)
40–50	27 (18.00)	Snake Bite	3	0	3 (2.00)
50–60	21 (14.00)	Pulmonary Tuberculosis	2	1	3 (2.00)
60–70	10 (6.66)	Others*	6	1	7 (4.66)
>70	11 (7.33)				
Total	150 (100)	Total	93	57	150 (100)

*Others: myocardial infarction, intestinal perforation, alcoholic encephalopathy, liver cirrhosis with GI bleed, and uremic encephalopathy.

Table 1: Demographic Data and Causes of Death in 150 cases of medico-legal autopsies

Table 2 highlights those 66 cases (44%) showed gross abnormalities, with cysts being the most common finding (33 cases; 22%), predominantly retention cysts in older individuals. Bilateral contracted kidneys were noted in 16 cases (10.66%), and congenital anomalies such as horseshoe kidney and ectopic kidney were observed in 9 cases (6%). Rare findings included obstructive uropathy (2 cases; 1.33%), hemorrhagic kidneys (2 cases; 1.33%), and a single case of renal adenoma (0.66%).

Surface and Size Variations of Kidneys

Capsular adherence was normal in 33.33%, increased in 22.66% (indicative of fibrosis), and decreased in 44% (suggesting edema). Scars were observed in 45 cases (30%), with small scars being the most common. Cortical granularity was seen in 38 cases (25.33%), predominantly fine granularity in older individuals. Size abnormalities included bilateral contracted kidneys (16 cases; 10.66%), unilateral atrophy (1 case), and large kidneys (2 cases).

Gross Finding	No. of Cases	%
Normal	84	56.00
Abnormal	66	44.00
- Cysts	33	22.00
- Bilateral Contracted Kidneys	16	10.66
- Congenital Anomalies	9	6.00
- Obstructive Uropathy	2	1.33
- Hemorrhagic Kidneys	2	1.33
- Large Kidneys	2	1.33
- Renal Adenoma	1	0.66
Total Abnormal	66	44.00

Table 2: Gross Morphological Findings of Kidneys 150 cases of medico-legal autopsies

Histological Examination in 150 Cases

Histological findings were assessed in all 150 cases. Of these, 94 cases (63%) showed abnormalities, while 26 cases (17.33%) were normal indicating no underlying renal pathology. Other 22 cases (14.66%) exhibited post-mortem changes, characterized by congestion of glomeruli and vessels, denudation of tubular lining, and bacterial colonies and 8 cases (5.33%) were autolyzed, precluding detailed histological assessment (Table 3).

Table 3 outlines the histological abnormalities identified in 94 cases with abnormal findings. The most frequent lesion was acute tubular necrosis (ATN), observed in 35 cases (37.23%), including ATN without interstitial nephritis (IN), ATN with hemorrhagic IN, and ATN with chronic IN. Notably, 17 cases of ATN appeared grossly normal, highlighting the importance of histological examination. Tubulo-interstitial nephritis (TIN) was the second most common lesion, found in 28 cases (29.78%), predominantly in chronic forms. This lesion correlated with gross abnormalities in 22 cases, while 6 cases showed no gross changes. Nephrosclerosis was identified in 18 cases (19.14%), primarily in the form of benign nephrosclerosis, with two cases showing malignant features. It was grossly abnormal in 14 cases and appeared normal in 4 cases.

Other findings included cystic changes (9 cases; 9.57%) (Figure 1), vacuolar tubular nephropathy (2 cases; 2.12%), and rare lesions such as diabetic glomerulosclerosis (1 case) and renal adenoma (1 case), both associated with gross abnormalities. The correlation between histological lesions and gross findings revealed that 28 cases appeared grossly normal but exhibited significant histological abnormalities, underscoring the diagnostic value of histopathology in detecting subclinical renal pathologies.

Histological Lesions	Cases No. (%)	Correlation with Gross Findings
Acute Tubular Necrosis (ATN)	35 (37.23)	17 cases grossly normal; 18 grossly abnormal
- ATN without IN	22	
- ATN with Hemorrhagic IN	8	
- ATN with Chronic IN	5	
Tubulo-Interstitial Nephritis	28 (29.78)	6 cases grossly normal; 22 grossly abnormal
- Acute TIN	3	
- Chronic TIN	24	
- Hemorrhagic IN	1	
Nephrosclerosis	18 (19.14)	4 cases grossly normal; 14 grossly abnormal
- Benign Nephrosclerosis (BNS)	15	
- BNS with Malignant Features	2	
- BNS with IN	1	
Cystic Changes	9 (9.57)	All grossly abnormal
Vacuolar Tubular Nephropathy	2 (2.12)	1 grossly normal; 1 grossly abnormal
Diabetic Glomerulosclerosis	1 (1.06)	Grossly abnormal
Renal Adenoma	1 (1.06)	Grossly abnormal
Total	94 (100)	

Table 3: Distribution of Histological Lesions in 94 Abnormal Cases

Table 4 highlights the correlation between histological lesions, age groups, and causes of death in the 94 abnormal cases. Acute tubular necrosis (ATN) was the most common lesion, observed in 22 cases, predominantly in younger individuals (20–40 years). Burns were the leading cause (18 cases), reflecting hypovolemic and inflammatory damage, while other cases were attributed to accidents and unknown causes. ATN with interstitial nephritis (IN) was seen in 13 cases, mostly in adults over 40 years, primarily due to burns.

Tubulo-interstitial nephritis (TIN) was identified in 28 cases, commonly in adults aged 20–60 years, and was often an incidental finding in individuals who died from accidents (17 cases). Nephrosclerosis, observed in 18 cases, was

Histological Lesions	No. of Cases	Age Group	Primary Causes of Death
Acute Tubular Necrosis (ATN)	22	Younger (20–40 yrs)	Burns (18 cases), Accident (2 cases), Unknown (2 cases)
ATN with Interstitial Nephritis	13	Adult (40+ yrs)	Burns (12 cases), Snake Bite (1 case)
Tubulo-Interstitial Nephritis	28	Adult (20–60 yrs)	Accidents (17 cases), Burns (1 case), Others (4 cases)
Nephrosclerosis	18	Older (40–80 yrs)	Accidents (9 cases), Unknown (5 cases), Others (4 cases)
Cystic Changes	9	Adult (40+ yrs)	Burns (4 cases), Accidents (2 cases), Others (3 cases)
Diabetic Glomerulosclerosis	1	49 years	Accident
Renal Adenoma	1	55 years	Accident

Table 4: Correlation of Histological Findings with Age and Cause of Death in 94 abnormal cases of medico-legal autopsies

associated with older age (40–80 years) and was linked to accidents and unknown causes, reflecting chronic vascular damage.

Cystic changes were noted in 9 cases, mainly in individuals over 40 years, with causes including burns, accidents, and miscellaneous factors. Rare findings included diabetic glomerulosclerosis in a 49-year-old male who died in an accident and renal adenoma in a 55-year-old male, both identified as incidental findings.

DISCUSSION

This cross-sectional study conducted in Maharashtra between 1995 and 1997 revealed a high prevalence of renal abnormalities, with 44% of cases exhibiting gross changes and 63% showing histological lesions. These findings underscore the importance of systematic renal

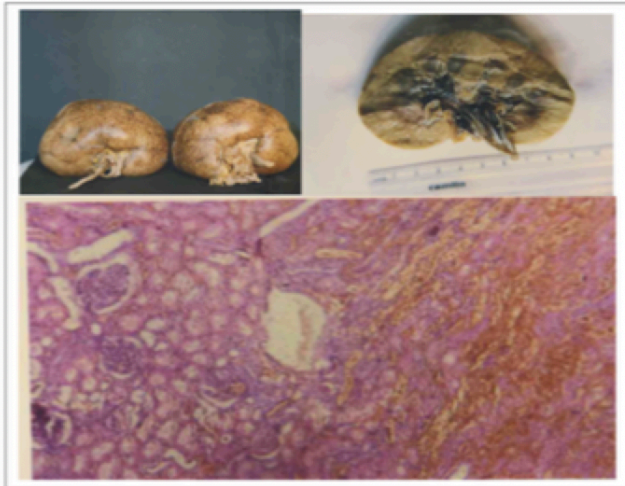


Figure 1: In patient died due to snake bite. A) Flea-bitten like appearance (on external surface of kidney) B) Extensive haemorrhagic necrosis in papillae, calyces, pelvis, and ureter. C) Cortex spared and medulla showing acute tubular necrosis

assessment during autopsies, as a significant proportion of these abnormalities were subclinical and might have remained undetected otherwise.

Our study found that cysts were the most common gross finding (22%), predominantly retention cysts in older individuals. This is consistent with the understanding that simple renal cysts are frequently age-related and often asymptomatic.^[14] Bilateral contracted kidneys, indicative of chronic kidney disease, were observed in 10.66% of cases, highlighting the burden of end-stage renal disease in the deceased population, even in the absence of prior clinical diagnosis. Congenital anomalies were noted in 6% of cases, emphasizing the role of autopsy in identifying such conditions, which may occasionally contribute to or complicate the cause of death.

Histologically, acute tubular necrosis (ATN) was the most frequent lesion (37.23%), often observed in younger individuals who died due to burns. This finding aligns with existing literature that identifies burns as a significant cause of AKI, primarily due to hypovolemia, sepsis, and the release of nephrotoxic substances.^[11, 12] The presence of ATN in 18 cases with grossly normal kidneys further emphasizes the necessity of histological examination in detecting acute renal injuries. A more recent study by Khare et al. (2021) also reported ATN as a common finding in autopsy kidneys, although their study population and geographical location differences.^[1]

Tubulo-interstitial nephritis (TIN) was the second most common histological lesion (29.78%), predominantly chronic TIN, and was frequently associated with accidental deaths in adults aged 20-60 years. This suggests that chronic TIN might be an underrecognized comorbidity in individuals succumbing to trauma. While our study did not delve into

the specific etiologies of TIN, it is known to be caused by various factors including infections, medications, and autoimmune diseases.^[4, 5]

Nephrosclerosis was found in 19.14% of cases, primarily in older individuals and linked to accidents and unknown causes. This reflects the association between aging, hypertension, and chronic vascular changes in the kidneys.^[6] Perone et al.^[2] (2018) also highlighted the frequent occurrence of previously undiagnosed medical renal diseases, including nephrosclerosis, in adult autopsies, reinforcing the value of autopsy in uncovering occult renal pathology.

Interestingly, our study observed specific renal findings in cases of snakebite, including a "flea-bitten like appearance," extensive hemorrhagic necrosis in the renal pelvis and ureters, and ATN predominantly affecting the medulla with relative sparing of the cortex. These observations are consistent with the known nephrotoxic effects of snake venom, which can lead to acute kidney injury characterized by tubular damage and hemorrhage.^[9, 10] A recent scoping review by Meena et al. (2024) on kidney histopathology in snakebite-induced AKI in India corroborates these findings, emphasizing the prevalence of ATN and hemorrhagic changes.^[9]

The correlation between gross and histological findings in our study revealed that a significant number of cases (n=28) with grossly normal kidneys exhibited substantial histological abnormalities. This highlights a key limitation of relying solely on gross examination during autopsy and underscores the crucial role of histopathology in a comprehensive renal assessment. Similarly, Sahoo et al. (2023) emphasized the importance of histopathological examination in revealing a broader spectrum of renal lesions in autopsies than what is apparent on gross examination alone.^[7]

The distribution of renal lesions across different age groups and causes of death in our study provides valuable insights into the potential etiological factors. The high incidence of ATN in younger individuals dying from burns suggests a direct link between the acute insult and renal damage. The prevalence of TIN in accident victims warrants further investigation into potential underlying factors contributing to this lesion in this population. The association of nephrosclerosis with older age is expected, given its link to chronic hypertension and vascular aging.

Our study, while providing valuable data, has some limitations. The study period (1995-1997) means that the demographic and etiological factors for unnatural deaths might have changed over time. Additionally, the lack of detailed clinical history in medico-legal cases limits our ability to correlate the autopsy findings with pre-existing conditions or clinical trajectories. Future studies incorporating more recent data and, where possible, linking autopsy findings with available clinical information would further enhance our understanding of renal pathology in medico-legal contexts.

CONCLUSION

This cross-sectional study of renal findings in medico-legal autopsies in Maharashtra revealed a high prevalence of both gross and histological renal abnormalities, many of which were subclinical. Acute tubular necrosis, often associated with burns in younger individuals, and tubulointerstitial nephritis, frequently seen in accident victims, were the most common histological lesions. Nephrosclerosis was prevalent in older individuals. Notably, a significant number of cases with grossly normal kidneys showed substantial histological pathology, emphasizing the importance of microscopic examination in comprehensive renal assessment during autopsies. The specific renal findings observed in snakebite cases corroborate existing literature on snake venom-induced nephrotoxicity. This study highlights the value of medico-legal autopsies in uncovering the spectrum of renal diseases in the population and underscores the need for detailed gross and histopathological evaluation of the kidneys in forensic investigations. Further research with more recent data and integration of clinical information is warranted to provide a more contemporary understanding of renal pathology in medico-legal settings.

DISCLOSURE

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