

# RENAL VASCULAR DISEASES

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# Objectives

1) Identify different pathological processes which can affect the renal vasculature.

- I. Atherosclerosis, Fibromuscular dysplasia
- II. Renal artery stenosis
- III. Embolism, Thrombosis,
- IV. Nephrosclerosis (benign/malignant)
- V. Thrombotic microangiopathies
- VI. Vasculitis

2) Outline the morphology and pathophysiological process underlying each of these.

3) Explain the clinical significance of above.

# Introduction

- Glomerular filtration is dependent on an adequate blood supply to the capillaries of the tuft.
- Vascular lesions, in addition to tissue damage, alter the fluid volume and electrolyte balance.
- The kidneys receive 25% of the cardiac output, a larger proportion than any other organ.
- Thus vascular lesions significantly affect these organs.

# Renal vascular diseases

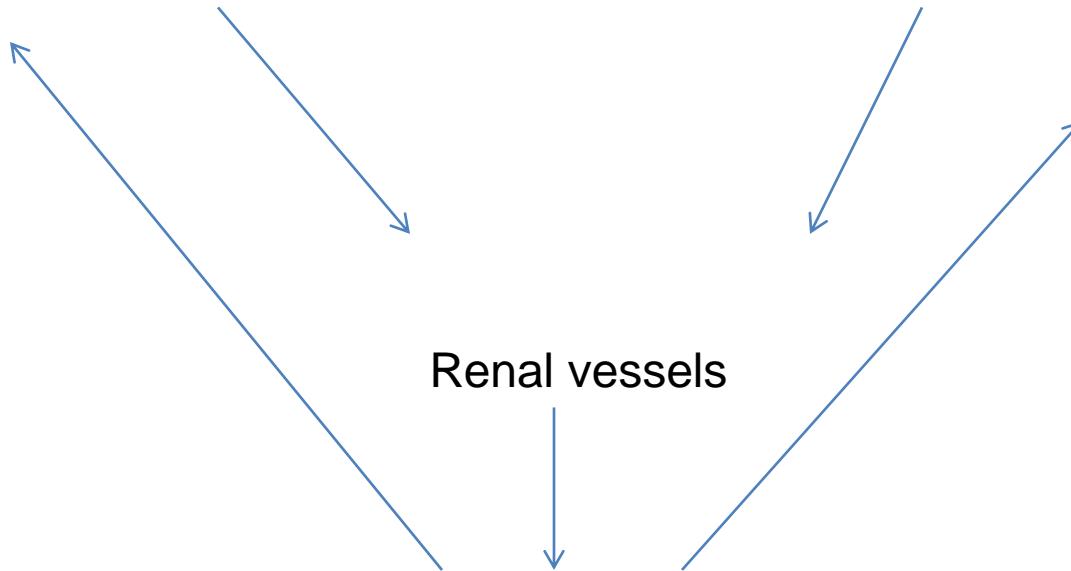
- **Diseases confined to the the kidney.**
  - Primary vascular disease  
Eg: Renal artery stenosis
  - Secondarily involve the vessels  
Eg: Chronic glomerular nephritis causing renal vessel thickening
- **Systemic diseases affecting the kidney**  
Eg: Systemic hypertension cause nephrosclerosis

Kidney diseases

Systemic diseases

Renal vessels

consequences



Diseases affecting  
the kidney

Systemic diseases

**Diseases of  
Renal vessels**

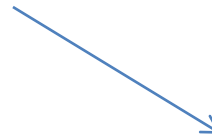
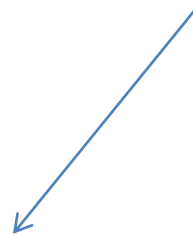
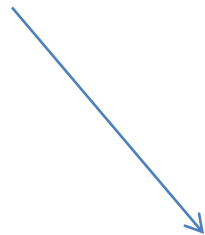
Small vessels

Medium sized

Large vessels

narrowing of vessel

Reduced blood flow



Reduced renal blood flow



Renal Ischemia



↑ Renin



↑ Angiotensin



↑ Aldosterone

(Inhibits)



Blood Pressure



Peripheral Resistance



Sodium Retention

Autoregulation



Cardiac Output



Cardiac Output



# Pathologies affecting the renal vessels

- I. Renal artery stenosis
- II. Atherosclerosis, Fibromuscular dysplasia
- III. Embolism, Thrombosis,
- IV. Arteriosclerosis, Nephrosclerosis (benign/malignant)
- V. Thrombotic microangiopathies
- VI. Vasculitis



# Renal artery stenosis

- Cause hypertension and may progress to Renal failure
- Unilateral renal artery stenosis is an uncommon cause of hypertension
- A potentially **reversible form of hypertension**
- Renin -angiotensin system initiates hypertension

Reduced renal blood flow



Renal Ischemia



↑ Renin



↑ Angiotensin



↑ Aldosterone

(Inhibits)



Blood Pressure



Peripheral Resistance



Sodium Retention

Autoregulation



Cardiac Output



Cardiac Output



# Renal artery stenosis: Causes

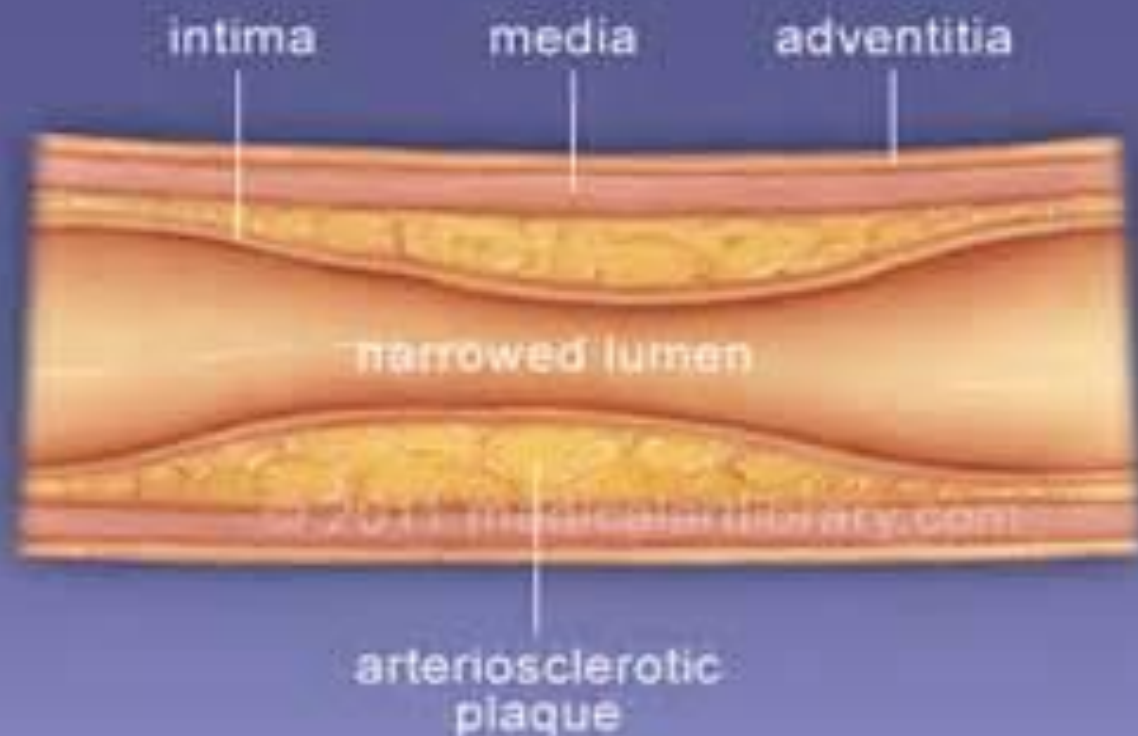
Mainly due to

- Occlusion by an atheromatous plaque(70%)
- Fibromuscular dysplasia.

# Renal atherosclerosis

- Common among **old**
- **Males** > Females
- Affects **proximal 1/3** of the renal artery.
- Not always associated with HT
- B/L disease is a common cause of chronic ischaemia with renal insufficiency.
- Severe ATH leads to intraparenchymal emboli formation.

## Renal Artery Cross Section



## Renal artery stenosis



# Fibromuscular dysplasia

- A noninflammatory, nonatherosclerotic condition
- Commoner in **young** individuals
- **Females**>males
- Affects large muscular arteries and medium sized ones.
- Renal artery involvement is most common.
- Involves **distal 2/3 of main renal artery**, occasionally extending into its branches
- All three layers of the vessel can be involved.

Focal irregular thickening of the vessel wall by  
medial and intimal hyperplasia  
and fibrosis

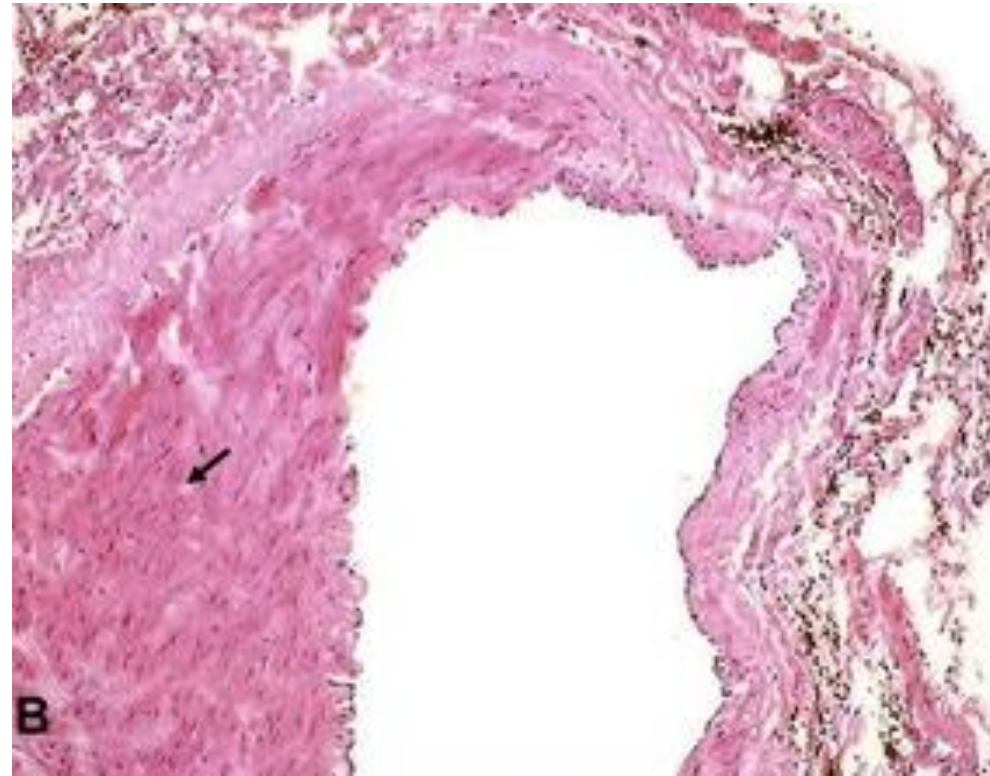
Intima, media and adventitia can be affected.  
Classified according to the layer of the vessel involved.  
Commonest is medial FMD.





### Macroscopy:

alternating thickened and thinned arterial walls give rise to the characteristic **"sausage-string"** or **"string of beads"** appearance



### Microscopy:

fibromuscular thickening of the media alternating with areas of thinning and loss of the internal elastic lamina

# Nephrosclerosis

Renal pathologies associated with sclerosis of renal arterioles and small arteries.

Walls of affected vessels are thickened and lumina narrowed.

Result focal parenchymal ischaemia.

- glomerulosclerosis
- Interstitial fibrosis
- Tubular atrophy
- Arteriosclerosis, arteriolosclerosis

Nephrosclerosis is commonly associated with hypertension.

HTN Can be a cause and a consequence of nephrosclerosis!

# Benign nephrosclerosis

(Hyaline arteriosclerosis/Arterionephrosclerosis/Nephrosclerosis)

Thickening and sclerosis of the arterial walls and renal changes associated with the **benign hypertension**.

Involve the **small arterioles**.

Similar changes can also be seen in **diabetic** microangiopathy and normotensive **elderly** patients.

But the changes are more **diffuse and severe in hypertension**.

Hyaline thickening of  
small arteries, arterioles  
Narrowed vessel lumina



Obstruction to the blood  
flow



Ischemia of kidney  
(all structures)



Ischaemic atrophy of all the  
structures



Diffuse tubular atrophy,  
sclerosed glomerular tufts,  
interstitial fibrosis

# Macroscopy

- Symmetrically atrophic kidneys
- Cortex is thin –due to the loss of nephrons
- Fine granularity of renal surface (because intact nephrons undergo hyperplasia)
- Depressions (secondary to fibrosis by ischemia)

**“Granular contracted kidney”**



# Microscopy

Thickening **and hyalinization** of vessel walls- Narrowed lumens of **arterioles and small arteries**.

(Hyaline arteriosclerosis)

**Arcuate arteries and the interlobular arteries** show medial smooth muscle hypertrophy, reduplication of internal elastic lamina, fibrous intimal thickening-Narrowed lumina

(Fibroelastic hyperplasia)

Due to vascular narrowing, there is patchy **ischemic atrophy**, which consists of

1) Foci of tubular atrophy and interstitial fibrosis

2) Glomerular alterations.

collapse of the GBM,

deposition of collagen within Bowman space,

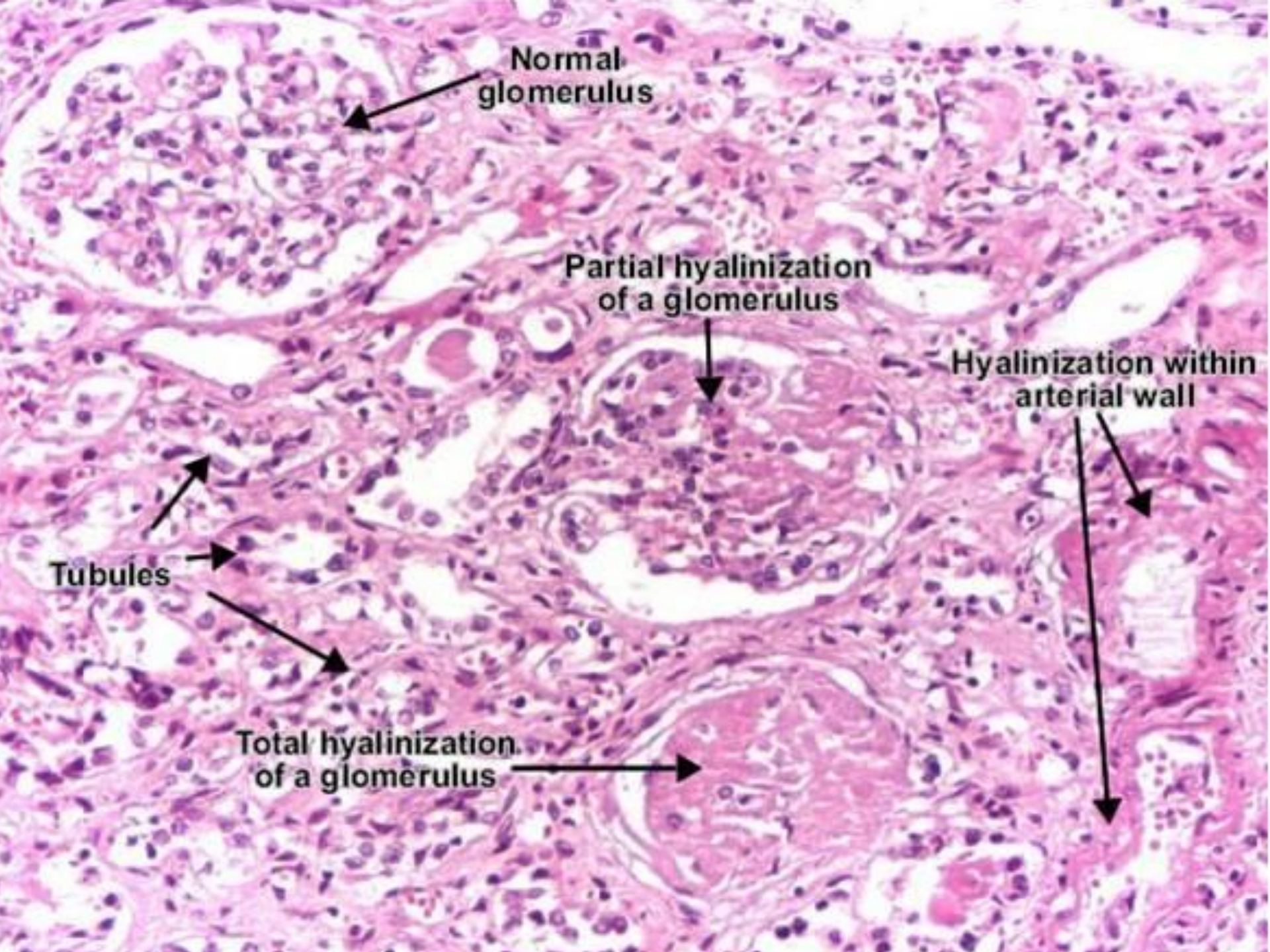
periglomerular fibrosis,

total sclerosis of glomeruli

Subcapsular scars with sclerotic glomeruli and tubular dropout alternating with areas of preserved parenchyma.

(Finely granular surface)





Normal  
glomerulus

Partial hyalinization  
of a glomerulus

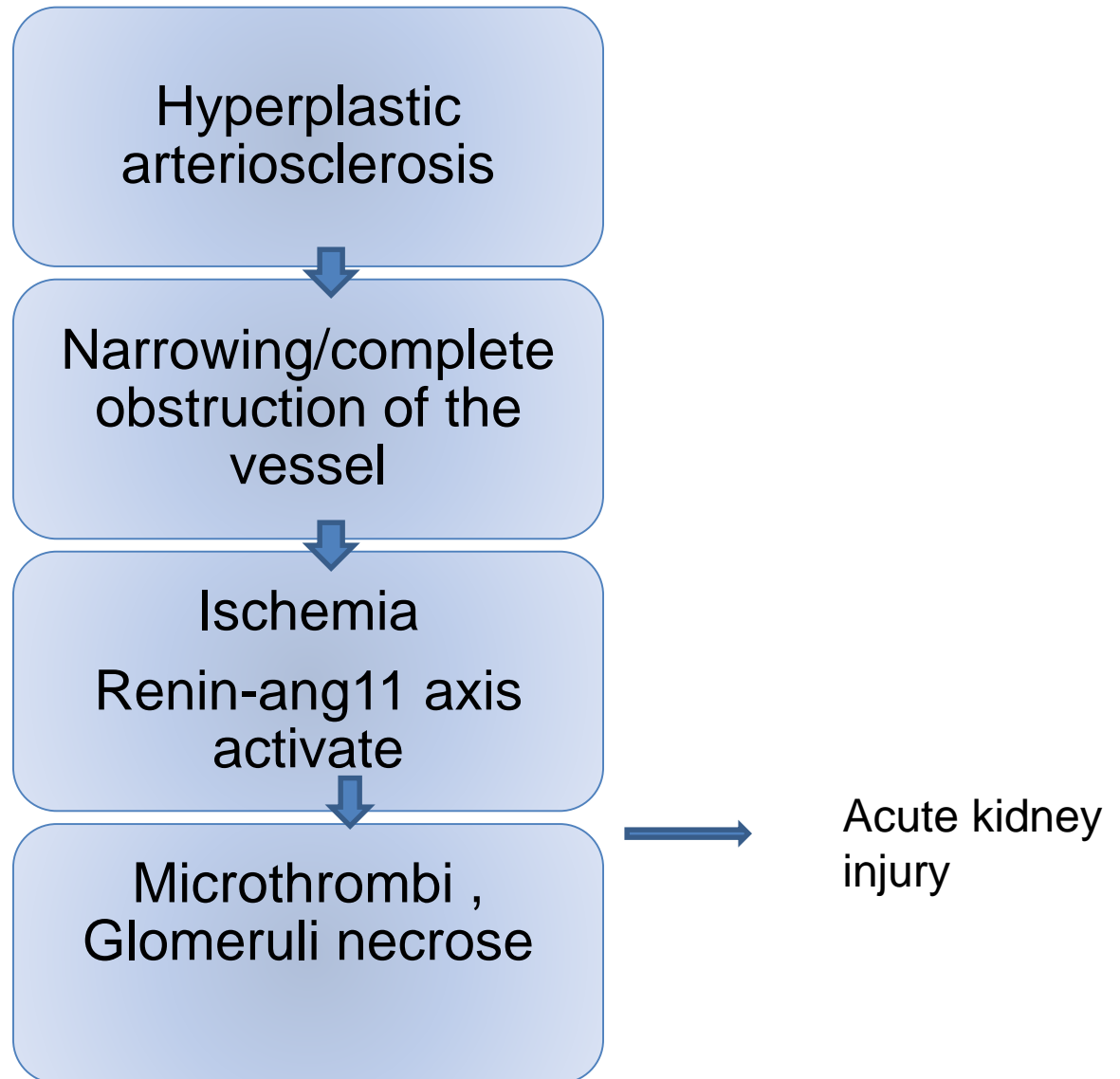
Hyalinization within  
arterial wall

Tubules

Total hyalinization  
of a glomerulus

# Malignant nephrosclerosis

- Seen in malignant hypertension
- Usually associated with pre-existing hypertension, glomerulonephritis or reflux nephropathy
- Higher frequency in young men.





# Macroscopy

Kidneys are normal or small in size depending on the duration of hypertension.

Cortical surface- coarsely irregular, small pinpoint petechial hemorrhages.

(from rupture of the arterioles or glomerular capillaries)

**“Flea bitten appearance”**



# Microscopy

## ➤ **Intimal cell proliferation**

Concentric arrangement of the intimal smooth muscles and concentrically laid down collagen

Hyperplastic arteriosclerosis



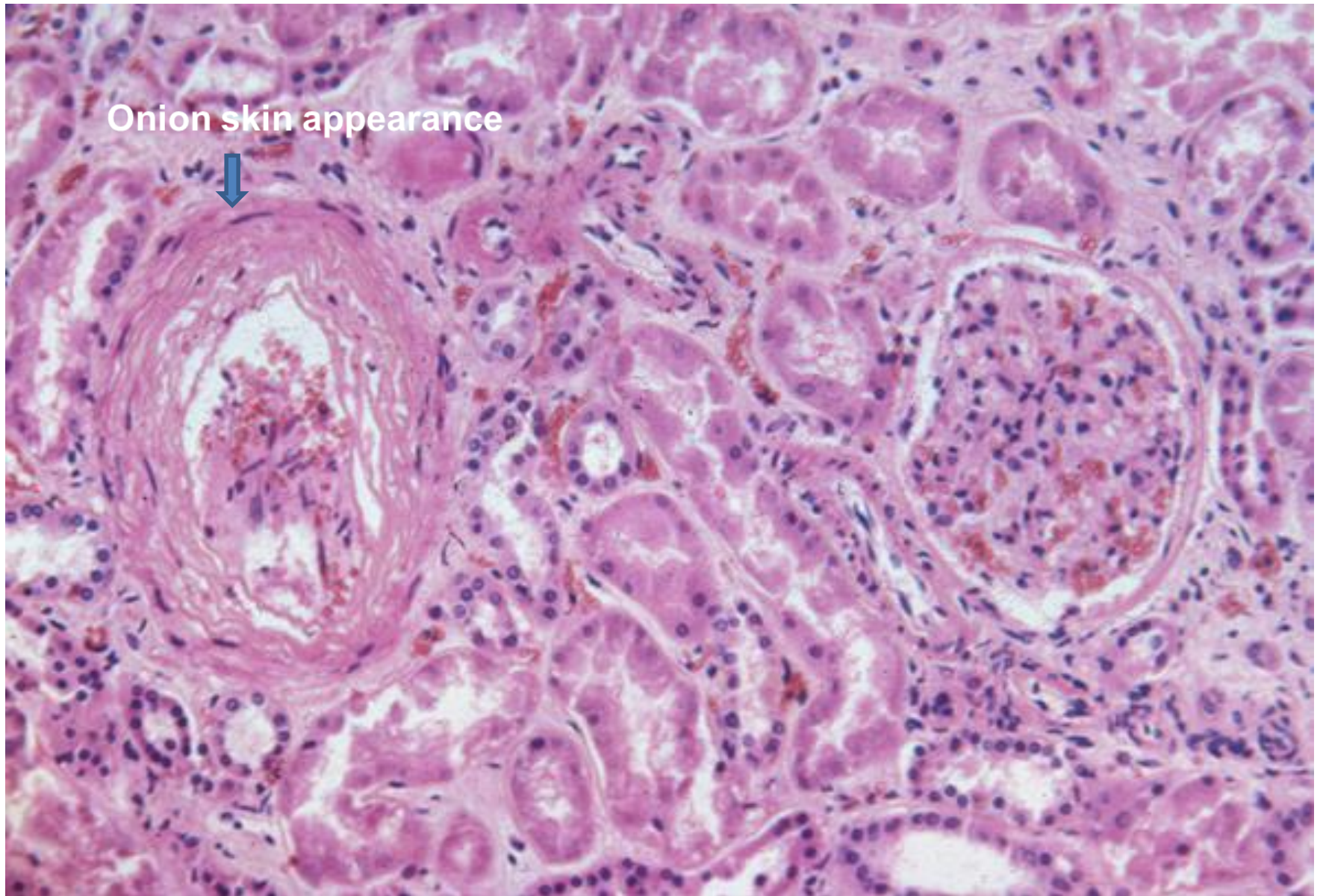
“onion skin appearance”

## ➤ **Fibrinoid necrosis**

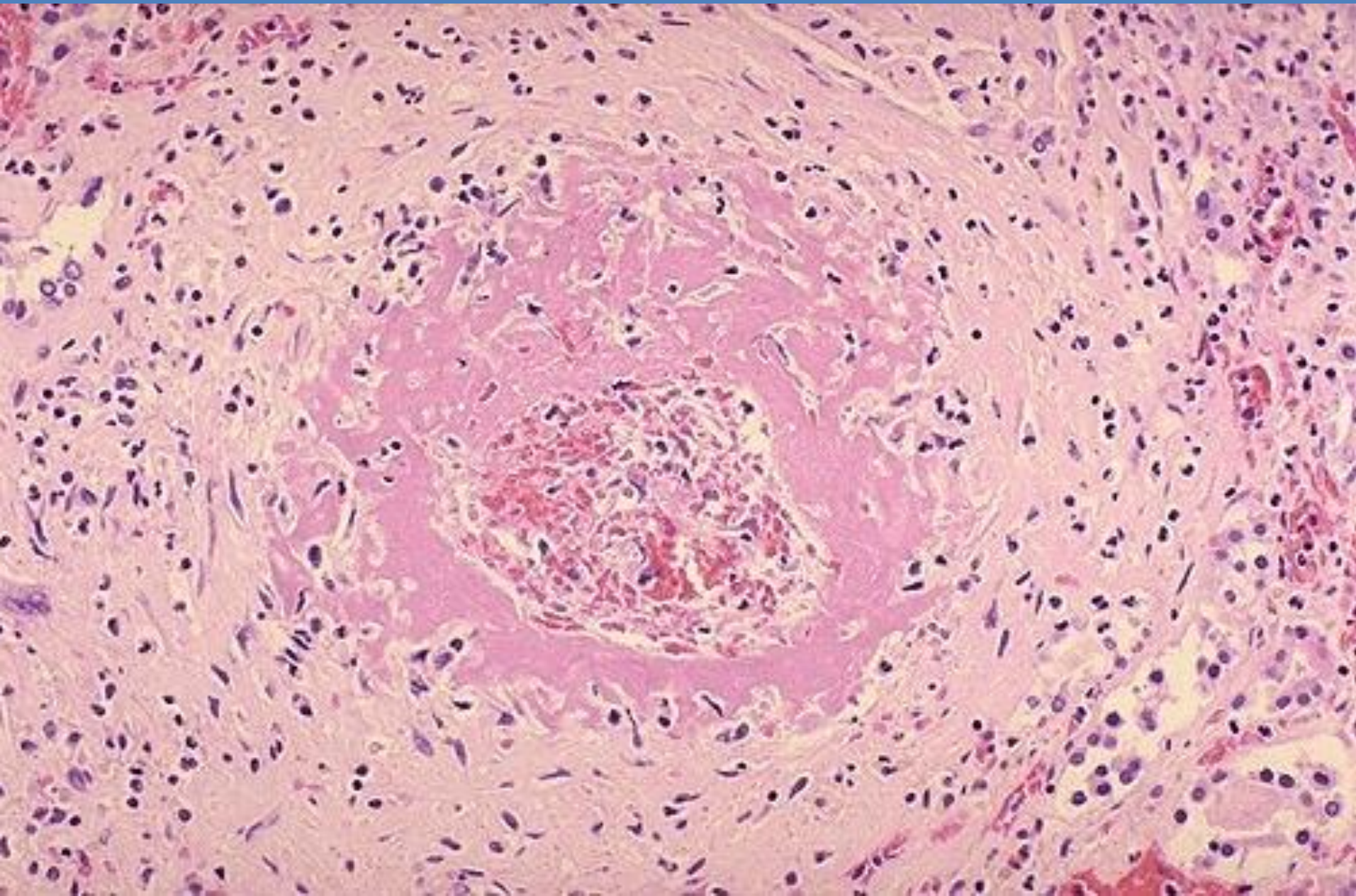
vessels have a homogenous, granular eosinophilic appearance, masking the underlying detail.

Intravascular thrombosis

Onion skin appearance





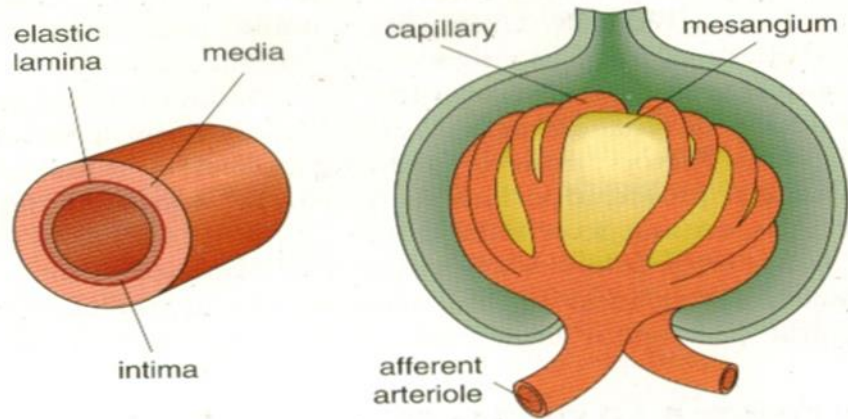


**Fibrinoid necrosis of small renal arteries**

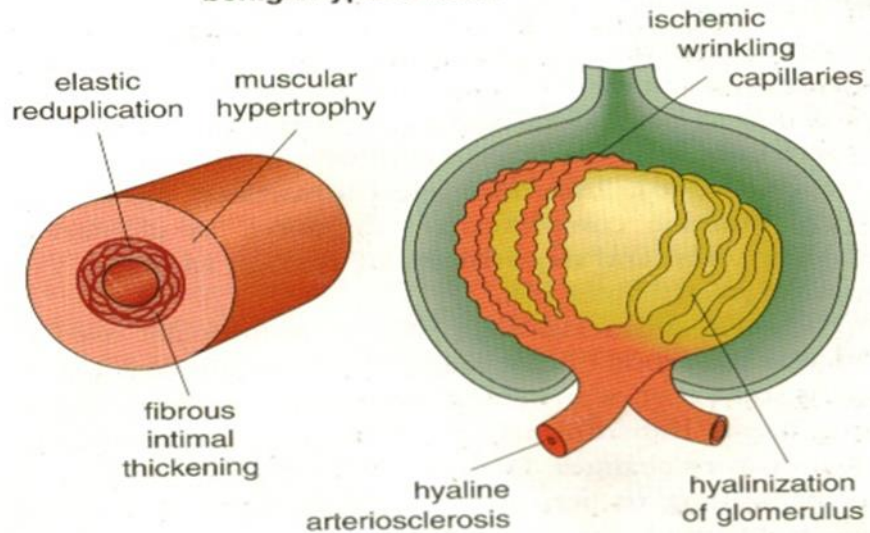


# Pathogenesis of hypertension

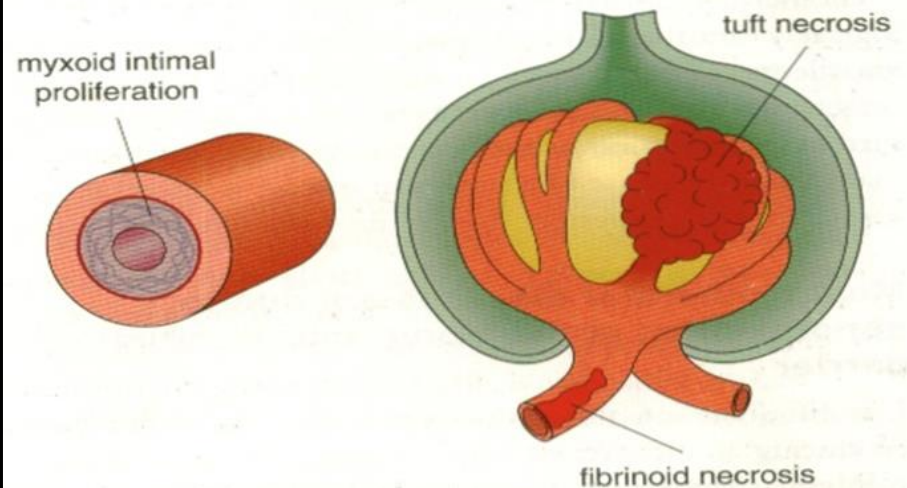
normal



benign hypertension



malignant hypertension



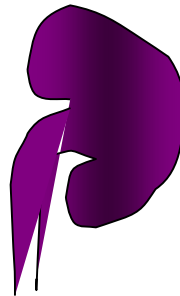


## Benign hypertension

Mild-moderate  
increase in BP, over a  
longer period of time

## Accelerated hypertension

Rapid, severe  
increase in BP,



Renal damage is slight  
with minimal functional  
impairment

Severe renal damage

Haematuria, proteinuria and  
renal failure

## Benign nephrosclerosis

## malignant nephrosclerosis

# Read

What are the causes for

- 1. granular contracted kidney
- 2. Flea bitten kidney



# Thrombotic microangiopathies

Lesions seen in various clinical syndromes characterized

morphologically by widespread **thrombosis** in the microcirculation

and

Clinically by haemolytic anemia, thrombocytopenia, +/- renal failure (tissue ischaemia).

# Thrombotic microangiopathies cont...

A spectrum of clinical syndromes that include

- Thrombotic thrombocytopenic purpura(TTP)  
and
  - Haemolytic uraemic syndrome (HUS)
- 
- Some drugs, malignant hypertension, scleroderma also can cause thrombotic microangiopathies.

## TTP

- Fever
- Thrombocytopenia
- Microangiopathic haemolytic anaemia (MAHA)
- **Transient neurological deficits**
- Renal failure

## HUS

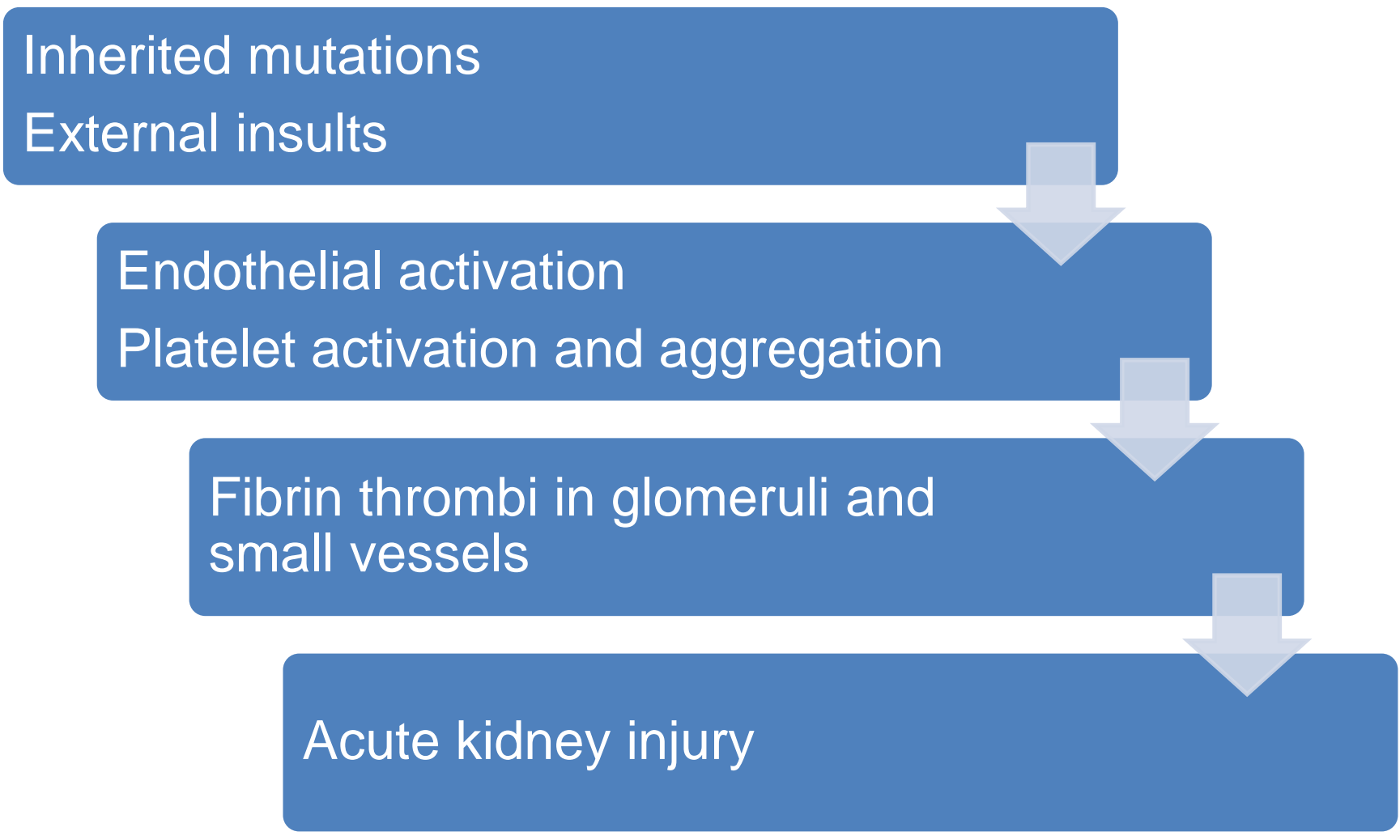
- MAHA
- Thrombocytopenia
- Absence of neurological deficits
- **Prominence of ARF**

TTS/HUS syndrome  
Difficult to demarcate



# What causes renal injury?

Inherited mutations  
External insults



```
graph TD; A["Inherited mutations<br/>External insults"] --> B["Endothelial activation<br/>Platelet activation and aggregation"]; B --> C["Fibrin thrombi in glomeruli and<br/>small vessels"]; C --> D["Acute kidney injury"];
```

The diagram is a vertical flowchart with four blue rectangular boxes. The first box at the top contains the text 'Inherited mutations' and 'External insults'. A light blue arrow points down from the right side of this box to the second box. The second box contains 'Endothelial activation' and 'Platelet activation and aggregation'. Another light blue arrow points down from the right side of the second box to the third box. The third box contains 'Fibrin thrombi in glomeruli and' and 'small vessels'. A third light blue arrow points down from the right side of the third box to the fourth box. The fourth box at the bottom contains 'Acute kidney injury'.

Endothelial activation  
Platelet activation and aggregation

Fibrin thrombi in glomeruli and  
small vessels

Acute kidney injury

# vasculitis

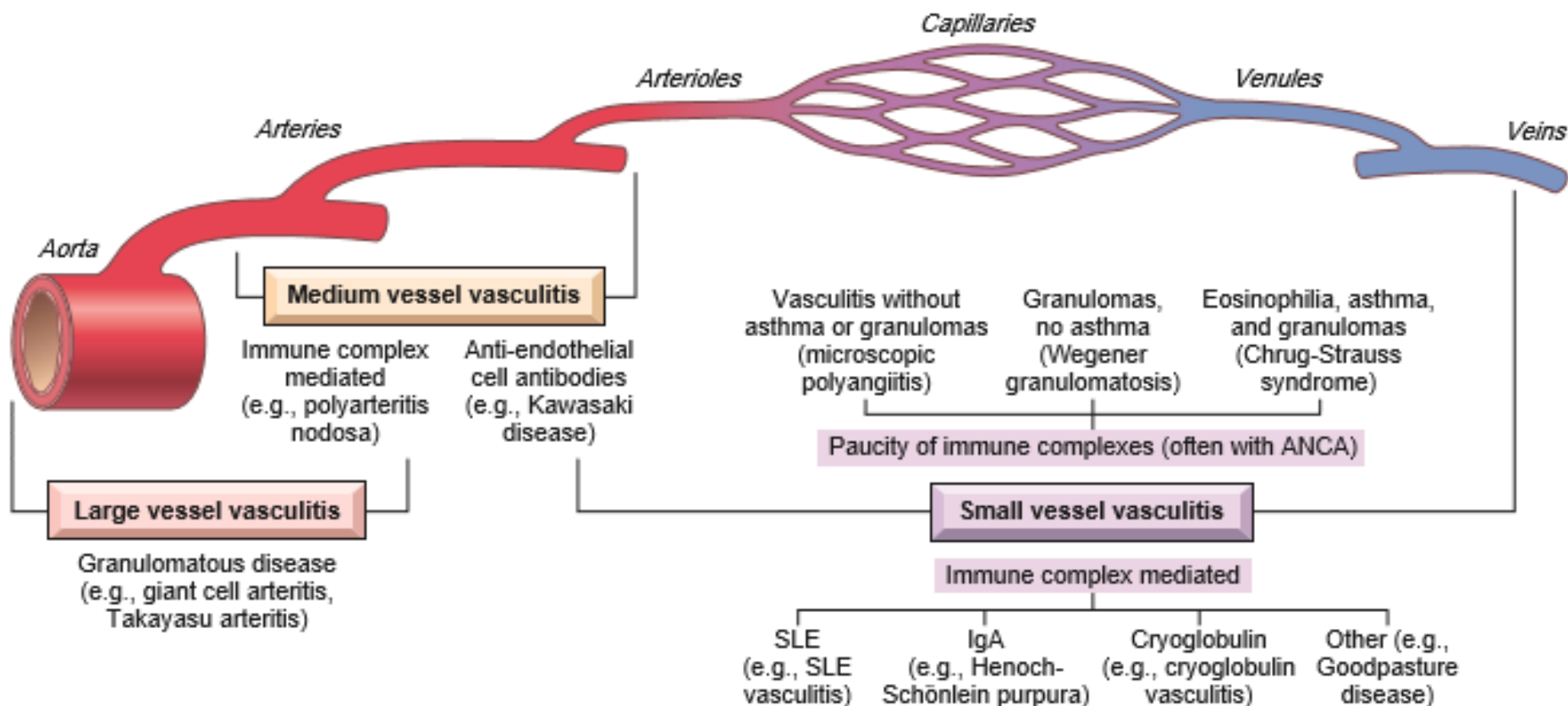
**‘Inflammation of the walls of vessels’**

Vessel of any type virtually in any organ can be affected.

## Mechanisms

- 1) Direct invasion of the vascular walls by infectious pathogens
- 2) Immune mediated mechanisms





What are the types of vasculitis which commonly affect the kidney?

- Renal involvement is seen in many vasculitides as the kidney is a highly perfused organ.
- Depending on the type of vasculitis arteries, arterioles or glomerular capillaries get involved

# Large vessel vasculitis

- Renal involvement is rare.
- Lesions in main renal artery and/or in intraparenchymal arteries.
- Takayasu arteritis can affect renal arteries.

# Medium sized vessel vasculitis

## -Poly arteritis nodosa

- A systemic vasculitis characterized by necrotizing inflammatory lesions that affect **medium-sized and small muscular arteries**,
- often with superimposed thrombosis.
- Preferentially at vessel **bifurcations**.
- Usually involve **part** of the vessel circumference.
- Involve **renal and visceral** vessels but **spare pulmonary circulation**.

# Microscopy

## Acute lesions

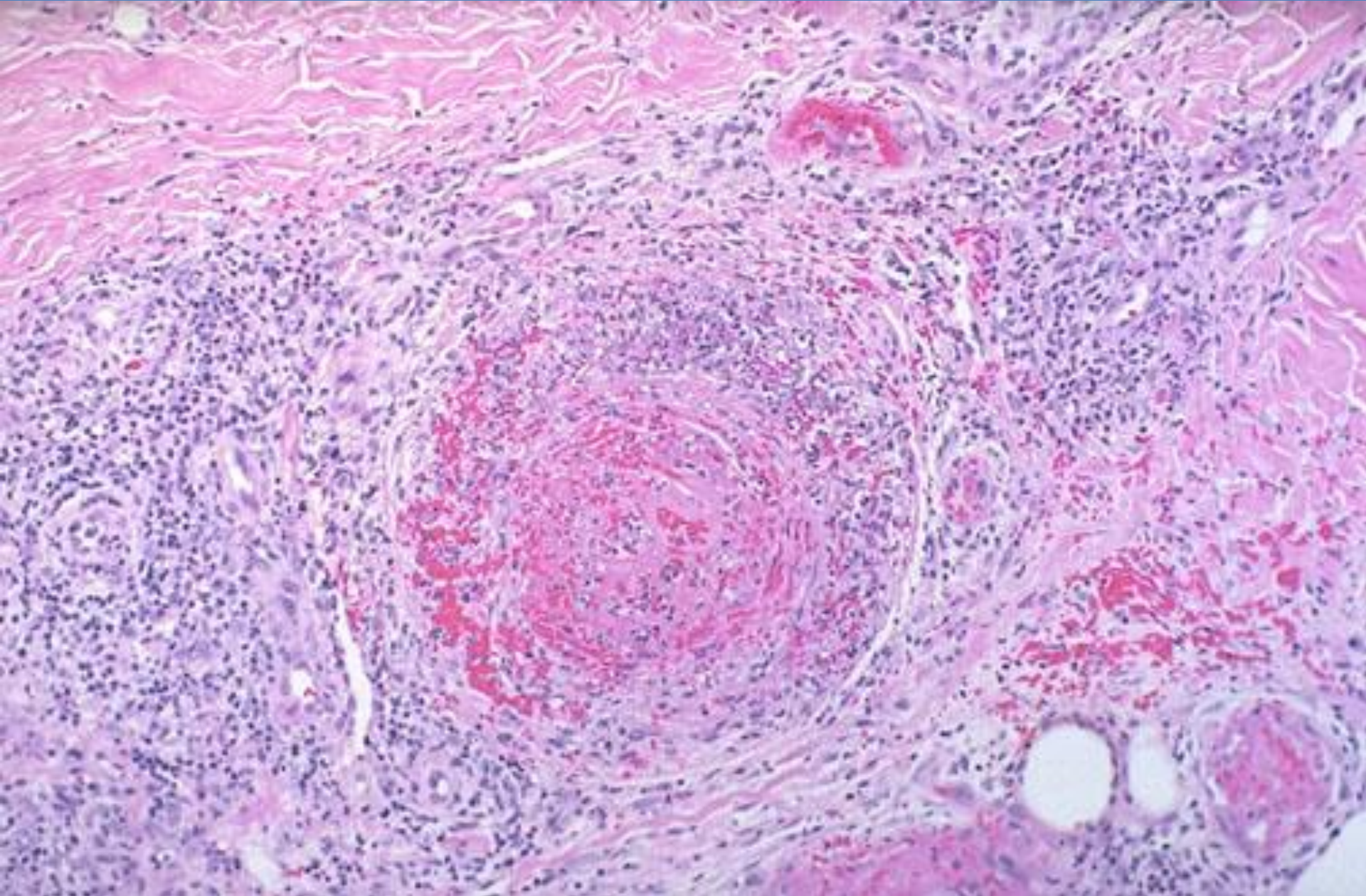
- Transmural mixed inflammatory infiltrate.
- Fibrinoid necrosis
- Luminal thrombosis

## Older lesions

Fibrous thickening of the vessel wall  
Extend into the adventitia.

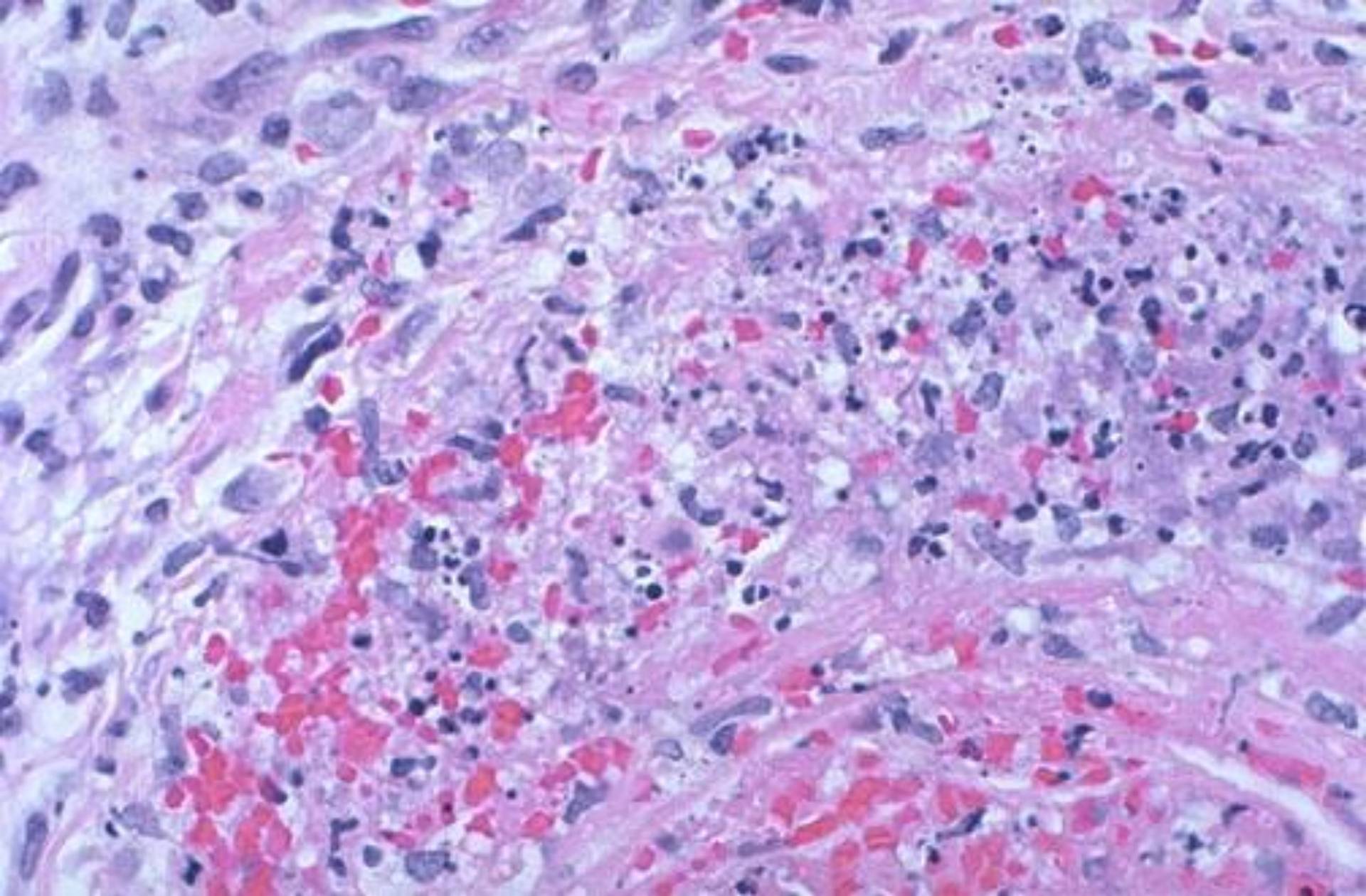
Lesions of all stages will coexist in different vessels or in the same vessel.





This muscular artery shows a severe vasculitis with acute and chronic inflammatory cell infiltrates, along with fibrinoid necrosis of the vascular wall





- Result

micro aneurysm formation,  
aneurysmal rupture with hemorrhage,  
thrombosis,  
consequently, organ ischemia or infarction.



# Clinical presentation

- Affect multiple systems
- Presentation can be variable.
- Classic presentation usually involve rapidly progressing hypertension due to renal artery involvement.
- Renal failure is a major cause of death among these patients.

# Small vessel vasculitis

## i) Wegener granulomatosis

- A necrotizing vasculitis.
- Characterized by
  - **Acute necrotizing granulomas** of the upper res.tract.
  - Necrotizing or granulomatous **vasculitis** affecting small and medium sized vessels
  - **Glomerulonephritis**

## Microscopy-

- Necrotizing granulomatous vasculitis.
- Renal lesions :
  - focal segmental necrotizing glomerular nephritis to advanced lesions with diffuse necrosis and crescentic Glomerulonephritis.

# Clinical presentation

- B/L pneumonitis with nodules and cavitations
- Chronic sinusitis
- Ulcerations of nasopharynx
- Haematuria, proteinuria
- Rash, arthralgia

Majority responds to treatment, but at high risk of recurrence and ultimately result renal failure.

## ii) Microscopic polyangitis

- A **necrotizing vasculitis** that generally affects the capillaries, as well as the small arterioles and venules.
- **All lesions** in any given patient are at a **similar** age.
- lungs, brain, kidney, skin, GIT, muscle etc can be involved.
- **Glomerulonephritis** seen in 90%.

# Microscopy

- Segmental **fibrinoid necrosis** of the media with focal transmural necrotizing lesions.
- Some areas (post capillary venules) only infiltrating **neutrophils** are present.
- **No granulomas.**
- Macroscopic **infarcts are uncommon.**

# Clinical presentation

- Depend on the vascular bed involved

GIT	abdominal pain, bleeding
lung	haemoptysis ...
kidney .....	
muscle	.....
.....	.....

## iii)Churg-strauss syndrome

- Necrotizing **small vessel vasculitis**
- Extravascular **necrotizing granulomas**
- Vascular and perivascular **eosinophilic infiltrate**

**P/C:** cutaneous involvement, GI bleeding, renal disease, cardiomyopathy (due to cytotoxicity produced by eosinophils)

### **Histology:**

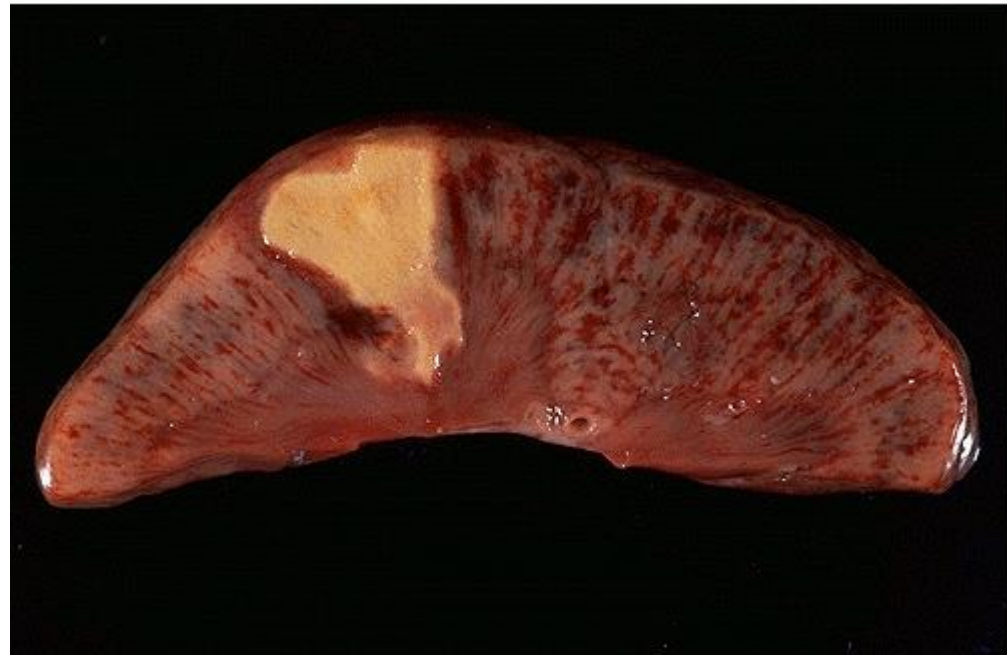
- A focal segmental glomerulosclerosis
- Abundance of **eosinophils** in the inflammatory perivenular exudate



# Renal infarction

- A common consequence of many renal vascular diseases
- Kidney has an end arterial supply
- Risk of infarction increase due to
  - Emboli
  - Advanced ATH
  - Acute vasculitis

Revise -  
Macroscopy, Microscopy



# Summary

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