

The structure of the kidney: causes of kidney disease



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The structure of the kidney - The kidney is surrounded by the renal capsule and split into 3 sections, the medulla, the cortex and then the renal pelvis. Each kidney is supplied with oxygenated blood, by the renal artery and removes deoxygenated blood via the renal vein. Once the kidneys carry out their filtration mechanism, they empty their waste product, down the ureter.

The nephron is the functional unit of the kidney and over a million of these are found within each kidney allowing it to carry out its function. Notice how it spans across the different kidney sections.

(i) The juxtaglomerular apparatus is the main filtration of blood occurs in nephrons and this is where the glomerulus and Bowman's capsule interact.

(ii) The mesangial cells are found closely associated with the filtration part of the juxtaglomerular apparatus and their position links with their role in causing inflammation in glomeruli.

(iii) The Podocytes are also found near glomerular capillaries and these may fuse together and influence the filtration of the glomerulus, causing Hodgkins disease. This disease is a type of swelling due to the diversion of accumulating products, which are not filtered and so deposited to other parts of the body.

Glomerulonephritis (GN) is a type of kidney disease; where by filtration of the blood is disrupted. It is mainly associated with the glomeruli in the kidneys, becoming inflamed (NHS Choices 2009) and there can be different types of the disease which may be proliferative or non-proliferative.

The main cause of the disease is not precisely known but, there are many possible explanations. The most common explanation for proliferative GN is due to an immune system response, where inflammatory cells like platelets or macrophages become trapped in the glomeruli (Couser 1999). Here they circulate and accumulate, initiating a mechanism that leads to inflammation of the glomeruli (Couser 1999). This is the mechanism for the most common form of proliferative GN, known as Immunoglobulin A (IgA) nephropathy (D'Amico 1987). This is when IgA proteins, which fight infections, build up within the glomeruli and therefore inflammation (Geeky Medics 2010). Another immune system response involves antibodies interacting with antigens, formed by the glomerular basement membrane, which can also trigger inflammation (Watson and Royle 1987).

Another possible explanation for proliferative GN is infection-related, following invasion by bacteria of the Streptococci strain (Ryan and Ray 2004), which targets the skin or pharyngeal tissue (Watson and Royle 1987). This results in post-infectious GN which can also be associated with other infections like bacterial endocarditis or HIV (Mayo Clinic 2009).

In addition, it is also suggested that vasculitic disorders, like Wegener's Granulomatosis can result in crescentic GN (Geeky Medics 2010) (Figure 4).

Crescentic GM - In Wegener's Granulomatosis, blood vessels become inflamed, having an effect on the filtration rate of the glomerulus and leads to the formation of crescent shaped scars.

Non-proliferative GN can be idiopathic, such as membranous GN, or may just simply be genetically linked like focal segmental GN (Geeky Medics 2010).
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When looking at GN (mainly proliferative) we need to also consider the mesengial cells (Figure 3, ii). GN can be recognised by an increase in the number of mesengial cells and their intracellular contents (Churg 2006). They rapidly multiply, increasing the thickness of this layer and press against the glomerular capillaries (Churg 2006) (Figure 5).

Histology of proliferative GN - As the mesengial cells multiply, they increase in number and compress against the glomerular capillary and contribute towards the glomerulus increasing in circumference. Taken from (Churg 2006).

In some cases, the mesengial cells may even invade the glomerular capillaries and sit in between the filtration part of the nephron, made up of endothelial cells and the basement membrane (Figure 6) (Churg 2006). Hence, the basement membrane appears split, disrupting renal filtration and therefore resulting in a certain type of GN, known as membranoproliferative GN (Hope et al. 1993).

A Normal Glomerular Capillary - Proliferation of the mesengial cells leads to invasion between the epithelial cells and the basement membrane, disrupting glomerular filtration and leading to GN. Taken from www.uncnephropathology.org/jennette/ch1.htm

The glomerular capillaries are also where proteins from the immune system may be trapped between the basement membrane and the epithelial cells, which accumulate and form 'humps' in the glomerular capillary walls (Churg 2006), resulting in membranous GN (Hope et al. 1993).

Specifically in crescentic GN, which is infection related, there is an increase in epithelial cells which compress the glomerulus and causes scars, described as 'crescent shaped' (Malvinder 2008) (Figure 4).

However there can be milder forms of GN, with the most common being minimal change GN, caused by the fusion of podocytes (Hope et al. 1993) (Figure 3, iii).

When looking at post-infectious GN, we find that it is normally the group A beta-haemolytic streptococcus bacteria which causes infection (Watson and Royle 1987) and brings about acute post-streptococcal GN (APSGN) (Duvuru 2010). The activity of this bacterium is thought to be associated with the accumulation of streptococcal antigens, binding to the immune antibodies, which are then deposited on the glomerulus basement membrane (Field et al. 2010) (Figure 7).

APSGN - (Arrows show where the antigen-antibody complexes have been deposited.) As the antigen is bound to the antibodies, it prevents the antibodies from inflicting a defence mechanism and leads to modification of the glomerular basement membrane (Field et al. 2010).

There are many signs and symptoms associated with GN, which can vary between the different forms of GN, but there are common symptoms that are found in all types. As the glomeruli are obstructed, filtration is reduced and allows for blood to leak into the tubules and therefore this blood passes out into the urine (Watson and Royle 1987). The urine may also be described as 'cloudy' and this is due to proteinuria. This is when excess serum proteins are passed out, in the urine (Nordqvist 2009) due to the impaired filtration
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mechanism (Field et al. 2010) . This excess serum may also be linked with symptoms of nausea and vomiting, which are also associated with GN (Unanue 2011). The urine may also be described as, haematuria, where red blood cells are lost, triggering anaemia in GN sufferers (Watson and Royle 1987). Another common symptom is swelling, as there is a diversion of accumulating products, which are not filter, to other parts of the body (Hicks 2009). Symptoms related to respiratory problems such, a sore throat or skin rash would be more significant in post-infectious GN due to streptococci bacteria infecting the pharyngeal tissue and the skin (Feldon et al. 2010). Another common symptom is hypertension, caused by salt and water preservation and therefore activation of the renin-angiotensin system (Field et al. 2010) (Figure 8).

The Renin-angiotensin (aldosterone) system (RAS) - As there is an accumulation of water and salt, the circulating volume also increases and activates RAS. RAS then vasoconstricts blood vessels, causing an increase in blood pressure, which is a symptom of GN.

Diagnosis of GN, tends to be via Urinalysis, in order to find the presence of blood and proteins in the urine (Haggerty 2002). Also a blood test can be taken and if there is an accumulation of waste products, such as creatinine or urea-nitrogen then this can indicate GN (Haggerty 2002). The blood can also be checked for anti-streptolysin titre, due to reactions by streptococci bacteria and another indication of GN (Brunner and Suddarth 1990).

Otherwise a much simpler swab of the throat could be used to detect the streptococcal infection, which is used widespread (Hicks 2009). A final

diagnostic evaluation is by carrying out a renal biopsy in order to view the <https://assignbuster.com/the-structure-of-the-kidney-causes-of-kidney-disease/>

inflamed glomeruli and accumulation of cells surrounding the glomerular capillaries (Brunner and Suddarth 1990). These tend to be the most common diagnostic procedures but investigations can be made by means of other methods, like in radiology, where a renal ultrasound is used (Hope et al. 1993).

Treatments on GN sufferers can range and depends on the type of GN that they suffer from, but the main aim of treatment is to promote kidney function and reduce symptoms of GN (Hicks 2009). By simply getting plenty of rest, until the urine becomes clear and levels of nitrogenous waste products regularize, can encourage the regain of renal function and a reduction of the other symptoms associated with GN (Hope et al. 1993).

Another treatment used is by regulating the diet and fluids of the GN sufferer, for example, by placing restrictions on dietary proteins and compensating for fluid losses by drinking plenty of fluids (Hope et al. 1993). It has been predicted that drugs which block the Angiotensin II receptors or ACE inhibitors may be a form of treatment, for reducing the effects of GN, but this is still being investigated (McMillan 2010). As there are different forms of the disease, different drugs may be used to treat each form, for example in GN caused by immune response, corticosteroids or immunosuppressant may be used, but this is not a definite treatment for GN (McMillan 2010). Treatment of vasculitic disorders like Wegener's granulomatosis, can be a form of treatment, which found that plasma exchange can be used to minimise the effects of immune antibodies which lead to the development of GN (Casian 2011).

Current novel methods being researched, investigate pathological mechanisms of GN, to possibly produce a drug to reverse this mechanism. One interesting study identified that the voltage-gated potassium channel, Kv1.3 was found in the glomeruli and tubules of rats, with GN (Hyodo et al. 2010). They suggest that Kv1.3 targets and restrain memory T cells, which act like an immune response by recognising foreign bodies (Hyodo et al. 2010). After using a Kv1.3 blocker drug, they found that the rats produced less proteinuria and their glomeruli had less scarring (Hyodo et al. 2010). The study concluded that this Kv1.3 could be the cause of GN and could be a useful finding to potentiate a cure for GN in humans, which is still being investigated (Hyodo et al. 2010).

Another study suggested that kidney disease may be linked with bone morphogenetic proteins (BMPs), which are growth factors that are important in the regulation on kidney function (Suh et al. 2011). As they interact with binding sites found in the epithelial cells, this study investigated whether polymorphism of the gene for BMP, may play a role in GN (Suh et al. 2011). The study concluded that mutations in this gene may cause children to become susceptible to IgA nephropathy, which is currently being investigated and could mean a possible treatment mechanism (Suh et al. 2011).

One other study investigated the presence of myeloperoxidase-associated anti-neutrophil cytoplasmic antibody (MPO-ANCA) and anti-glomerular basement antibodies (anti-GBM Ab) as a possible cause of the crescent shaped scars in rapid progressive GN (RPGM), but this is also still being investigated (Nakabayashi et al. 2011).

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To conclude GM, is a diverse renal disease, which can be acute or chronic in terms of its causes and consequences. The disease is still being thoroughly investigated today as no definite treatment has been found.

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