**Renal and Ureteric Stones**

**Abstract**

This clinical review will focus on renal and ureteric stones and will discuss how stones form, the incidence, risks, and complications associated with calculi. Additionally, it will reflect on the management and treatment options available, and highlight the importance of nurses and those working in advanced clinical practice roles in utilising their knowledge and rational clinical decision making, to ensure timely recognition, prompt investigation, management and ongoing health promotion.

**Incidence and risks of renal calculi**

The incidence of kidney stone disease is rising, with a lifetime risk of 10–15% (Khan et al. 2016). In 2019 - 2020 there was approximately 90,000 hospital admissions in the United Kingdom (UK) with kidney stone disease (National Health Service [NHS]) Digital 2020) equating to substantial economic burden in excess of £324 million pounds (Geraghty et al. 2020). Kidney stone disease encompasses stones, commonly referred to as calculi, located within the urinary tract which includes the kidneys, ureters, bladder and the urethra (Kaisary, Ballaro and Pigott 2016). Urolithiasis refers to stones originating anywhere in the urinary tract, nephrolithiasis is stone presence in the kidneys and ureterolithiasis stones located in the ureters (Khan et al. 2016).

Risk of stone formation is multifaceted including intrinsic factors such as ethnicity and gender, with a 3:1 ratio of men to women (National Institute for Health and Care Excellence (NICE) 2019) and genetical dispositions paired with extrinsic factors such as climate, lifestyle, dietary and water intake (Alelign and Petros 2018). Aune et al’s. (2018) meta-analysis concluded there is a 21% increase in risk of stones per 5 units increase in BMI. Poore et al. (2020) reiterate the association between obesity and stone formation suggesting the constituents involved in stone formation such as calcium, oxalate, and urate levels were much higher in obese subjects; furthermore, there is bidirectional associations with stone formation and co-morbidities commonly attached to obesity such as hypertension and diabetes.

**Stone formation**

Stones form in the presence of increased urinary supersaturation which occurs when the urine solvent contains more solutes than it can hold in solution (Khan et al. 2016). Supersaturation results in an imbalance of stone-forming constituents, subsequently forming crystalline particles a preface to stone formation. Other formation factors include crystal nucleation, aggregation of ion particles, cell surface molecules which favour or inhibit crystal adhesion, stagnancy of substrate (urine) (Kaisary, Ballaro and Pigott 2016, Reynard, Brewster and Biers 2013).

There are several types of stone, grouped according to their biochemical composition. Calcium-based stones account for 60-80% and include calcium oxalate and calcium phosphate stones, usually a mixture of both (British Association of Urological Surgeons (BAUS) 2021). Formation predominately stems from elevated calcium in the urine known as hypercalciuria, of which there are three types (Kumar and Clark 2017). Absorptive which refers to increased intestinal absorption of dietary calcium, renal where there is impaired renal reabsorption equating to increased urinary levels and resorptive referring to an excessive skeletal resorption of calcium (Kaisary, Ballaro and Pigott 2016).

Struvite stones, often the composition of staghorn calculi, account for 10-15% and are made of calcium, magnesium and ammonium phosphate (BAUS 2021). Struvite stone formation occurs in the presence of infection, associated with bacteria that produce the enzyme urease, urease hydrolyses urinary urea producing ammonia (Flannigan et al. 2014, Alelign and Petros 2018). As ammonia production increases urine pH elevates, the alkalisation of urine paired with increased ammonium ion availability promotes crystallisation (Kumar and Clark 2017).

Uric acid stones account for 10% in the UK, the primary causative factors are low urinary pH, low urine volume and increased uric acid production. Uric acid is the end breakdown product of purine metabolism, some causes of hyperuricosuria include increased cellular breakdown, protein catabolism and inherited metabolic disorders (Sakhaee 2014, Kaisary, Ballaro and Pigott 2016). Other types of stone are rare and include formation from underlying inherited enzyme deficiencies, genetic defects for example cystinuria and some medications result in increased risk of crystal growth (BAUS 2021).

**Symptoms**

A substantial proportion of urolithiasis can be asymptomatic; stone movement within the ureters often is the predisposing factor to acute symptoms (BAUS 2021). Severe colicky loin to groin pain known as renal colic is the classical presentation of urolithiasis (NICE 2020, BAUS 2021). Renal colic is caused by a combination physiological factors including ureteral muscle spasms, increased proximal peristalsis, stone-induced localised inflammatory changes, renal oedema and generalised irritation (Reynard, Brewster and Biers 2013). The mainstay analgesic recommendation is non-steroidal anti-inflammatories (NSAIDs) (NICE 2019, BAUS 2021). Afshar et al. (2015) Cochrane review concluded NSAIDs were significantly more effective in reducing pain by 50% within the first hour than alternative non-opioid medications and placebo. Pathan, Mitra and Cameron (2017) support NSAID’s effectiveness concluding NSAID’s reduced the requirement of rescue medication and lowered rates of side-effects compared with opioids.

Haematuria, the presence of blood in the urine, which can be established by performing urine analysis is also a positive predictor for urolithiasis (Turk et al. 2021, NICE 2020). Urine analysis is a quick, easy, cost-efficient screening tool utilised in the work up of many clinical presentations including suspected renal colic, with relatively high sensitivity, approximately 84% (Minotti et al. 2020). However, absence of haematuria does not exclude renal colic as a differential diagnosis as an estimated 10–20% of patients with urolithiasis can present without microscopic haematuria (Mefford et al. 2017). Attention should also be paid to the presence or absence of leukocytes, nitrates and to the urinary pH. Pyuria, the presence of white blood cells in urine, is a fairly common response to irritation caused by a stone, however may be indicative of a more serious infective urolithiasis complication (Dorfman et al. 2016).

**Investigations**

Alongside urine analysis initial investigations of suspected urolithiasis should include full blood count (FBC), C-reactive protein (CRP), Serum creatinine and electrolytes and calcium. A clotting screen as a baseline if percutaneous intervention is likely and blood cultures if the patient is pyrexial or displaying signs of infection are also recommended (Tsiotras et al. 2018, Wright, Rukin, and Somani 2014). Timely thorough assessment is vital to acknowledge and respond to any systematic stone complications. Complications of urolithiasis increase risk of morbidity and mortality ten-fold (Kum et al. 2016). Advanced Clinical Practitioners (ACP’s) are optimally placed, by practising in accordance with the four pillars of advanced practice (Health Education England (HEE) 2017). ACPs high level of critical thinking and rational clinical-decision making can improve timely recognition and management. Furthermore, evidence has provided overwhelmingly positive conclusions that ACPs provide equivalent quality of care to medical colleagues, enhance patient satisfaction, improve departmental efficiency and cost-efficiency and provide a service that supplements and compliments care delivery (Martinez-Gonzalez et al. 2014, Li et al. 2013, Royal College of Nursing 2018).

**Complications**

The main complications of renal and ureteric stones are obstruction of urinary flow equating to hydronephrosis and infection which occur in an estimated 8.5% of acute presentations (Turk et al. 2021). Ureteral obstruction in the form of a calculi prevent homeostatic urinary flow, in turn increasing intratubular pressures equating to intense renal vasoconstriction and a rapid fall in renal blood flow alongside a decline in the glomerular filtration rate; if prolonged fibrosis, cellular toxicity and nephron damage ensue (Reynard, Brewster and Biers 2013, Keddis and Rule 2013). Obstructing urolithiasis is one of the main causes of post-renal acute kidney injury (AKI) characterised by a decline in renal excretory function resulting in failure to maintain fluid, electrolyte, and acid-base homeostasis (NICE 2018).

AKI is associated with significant mortality as high as 20-30% (NICE 2018) paired with extensive and potentially deliberating long-term consequences for the patient, care providers and the economy (Caskey and Dreyer 2018). Early recognition and treatment are paramount in preventing deaths and reducing complications (NICE 2018). Local guidelines suggest management strategies are guided by consideration of four domains. Perfusion considers volume status, strict fluid balance and the appropriate administration of intravenous fluids and conjuncts such as vasodepressors. Underlying cause and the management of cause, Monitoring and medication optimisation of nephrotoxic drugs, finally prevent and treat complications (University Hospitals of Derby and Burton 2019). Considering medicine optimisation in specific relation to the topic, NSAIDS have been discussed as the gold standard analgesia for renal colic but NSAIDs are also nephrotoxic. The Medicines and Healthcare products Regulatory Authority (MHRA) released a safety alert recommending NSAID’s should be avoided in patients at risk of renal impairment, a known risk with urolithiasis (MHRA 2014). Hence prescribing NSAID’s in the acute phase of renal colic should be with a high degree of caution and careful balance of risk and benefit until a patient’s renal function is obtained.

Prolonged obstruction consequently can result in an inability to filter metabolic waste products causing retention of nitrogenous wastes which act as a reservoir for bacterial culture, urinary statis enables bacteria to adhere to the urothelium mediating the production of pro-inflammatory cytokines that induce cellular and humoral cascades (Wagenlehne et al. 2013). This complex amplified pro-inflammatory and anti-inflammatory response induces widespread dysregulation of innate homeostatic systems and ultimately multi organ failure (Kumar and Clark 2017). Management of sepsis and or anuria in an obstructed kidney is a urological emergency. Initial care should mirror that of any acutely unwell patient, a comprehensive airway, breathing, circulation, disability, exposure assessment, appropriate fluid resuscitation, timely antibiotic administration and source control (Reynard, Brewster and Biers 2013). Given the potential devastating impacts of sepsis, the Surviving Sepsis Campaign was introduced providing international recommendations including the sepsis-6 bundle which is utilised locally (UK Sepsis Trust 2019). This care bundle has six components, three baseline measurements and three treatment interventions, which when instigated within the first hour of suspected sepsis has been demonstrated to reduce relative-risk of mortality by up to 46% (NHS England 2014).

Urgent decompression is required in the means of placement of an indwelling ureteral stent or percutaneous placement of nephrostomy tube (PCN) (Tsiotras et al. 2018, Turk et al. 2021). Borofsky et al. (2013) reinforces urgent decompression which directly increases chance of survival. In their trial mortality rate was 8.82% compared to 19.2% in the absence of decompression. PCN and stenting display indistinguishable superiority, the choice of mode of drainage is predominantly guided by logistical factors to prevent any delays, patient stability, surgeon preference and patient choice (Reynard, Brewster and Biers 2013, Tsiotras et al. 2018). However, mode of decompression can potentially impact of long-term quality of life, Shoshany et al. (2019) suggests PCN significantly favourable for symptom relief and overall quality of life compared to stenting where higher proportions of patients suffer persisting symptoms and reduced quality of life.

**Imaging**

Imaging to provide accurate diagnosis is essential (NICE 2019) being recommended to occur within 14 hours of presentation (Tsiotras et al. 2018). ACPs often are the static workforce member in an ever-changing medical workforce, this awareness to local hospital policy, treatment pathways and processes can enhance efficiency of patient journeys (Li et al. 2013) enabling targets such as the above to be achieved.

In the acute phase computed tomography (CT) of the kidneys, ureter and bladder (KUB) is the gold standard imaging modality given high sensitivity and specificity of 95-97% (Tsiotras et al. 2018, NICE 2019). However, there is radiation risk with CTKUB, hence in specific cohorts for example pregnant females and known stone formers who have had multiple CTKUB’s an ultra-sound (US) KUB is the recommended alternative (NICE 2019). Smith-Bindman et al. (2014) supports utilising USKUB reiterating it is a non-invasive, cost-effective technique, achieving accurate diagnosis in most cases without the need for radiation.

**Treatment options**

Treatment decisions for are based on several general aspects such as stone composition, stone size, anatomical location and patient symptoms (NICE 2019, Turk et al. 2021). In the clinically stable patient, with stones less than 5 millimetres (mm) in size watchful waiting is recommended (NICE 2019) as stones of 4 mm or less have a 95% chance of spontaneous passage within 40 days (Turk et al 2021).

Medical expulsive therapy (MET) in the form of alpha-blockers such as Tamsulosin remains controversial and widely debated. NICE (2019) guidelines recommend consideration of alpha-blockers in stones less than 10mm. Whereas in direct contrast the BAUS suggest patients should not be routinely commenced on MET (Tsiotras et al. 2018). Pickard et al. (2015) advocates not administering alpha-blockers, finding the percentage of subjects not requiring further intervention was mirrored in the treatment and placebo group, 80% and 81%, overall concluding alpha-blockers are not effective at decreasing the need for further treatment, likelihood of spontaneous passage or analgesia requirement. Considering this is a large, blinded, multi-centre randomised control trial which are considered gold standard in the realms of health care implying the conclusions drawn are highly reliable and generalisable (Denscombe 2014) but on the contrary the use of alpha-blockers is supported in a large Cochrane review, which is at the top of the quantitative research hierarchy (Bowling 2014). In contrast Campschroer et al. (2018) results are supportive of alpha-blockers finding reduced episodes of pain, significantly higher stone-free rates and stone expulsion reduced by 2.91 days in the alpha-blocker group. However, they did also conclude that patients using alpha‐blockers were more likely to experience adverse effects. There is clear controversy within the evidence on the use of alpha-blockers, it is vital to acknowledge that recommendations are only based on the evidence available, whilst it can be informative evidence-based medicine does not replace a clinician's expertise or individualised holistic judgment (Fernandez et al. 2015).

Definitive surgical management is gold standard for symptomatic stones greater than 5mm (NICE 2019, Tsiotras et al. 2018). Extracorporeal shock wave lithotripsy (ESWL), Ureteroscopy and Percutaneous nephrolithotomy (PCNL) are the mainstay treatment modalities for renal stones. Treatment choice is multifactorial including clinician factors, patient factors such as body habitus and medical co-morbidities alongside stone factors including size and anatomical location (Khan et al. 2016).

ESWL involves the non-invasive delivery of high-energy acoustic waves that fragment a kidney stone into smaller particles that will pass spontaneously (Kaisary, Ballaro and Pigott 2016). ESWL is non-invasive, has a low risk of complications, and does not require anaesthesia equating to reduced hospital stay and cost effectiveness (McClinton et al. 2020). However, efficacy of stone clearance in larger stones and lower-pole stones appears relatively low and may require repeated treatments to match the effectiveness of its counterparts and residual fragment increase risk of stone re-formation (Khan et al. 2016). Broadly speaking ESWL is a favourable option in stones less than 10mm located in the upper pole, middle pole and renal pelvis (Tsiotras et al. 2018, Turk et al. 2021, NICE 2019).

Ureteroscopy involves the passage of a small telescope through the urethra and bladder, up the ureter to the location of the stone allowing delivery of instruments, such as laser fibres and baskets (BAUS 2017b). Ureteroscopy requires anaesthesia to minimise pain and the visceral response to ureteral and renal dilation (Khan et al. 2016). As technologies have progressed with availability of high-definition rigid and flexible ureteroscopies ureteroscopy is suitable for nearly all size stones and in any anatomical location given the majority of areas in the urinary tract can be readily accessed (Khan et al. 2016, Turk et al. 2021). Benefits include it is minimally invasive with high accuracy of stone assessment and low complication rates of approximately 3.5% which are mostly minor (Wright, Rukin, and Somani 2014). Furthermore, it has minimal contra-indications and it suitable for specific high-risk cohorts such as those anticoagulated and pregnant (Turk et al. 2021). Aboumarzouk et al. (2012) Cochrane review concluded ureteroscopy favourable in terms of stone-free rates and rate of need for re-treatment directly compared with ESWL; although further finding higher complication rates and longer hospital stays.

PCNL is considered the treatment of choice for large and staghorn calculi, it involves the direct passage of an endoscope percutaneously through skin, muscle and perirenal fat, and into the kidney making it the most invasive of the three procedures (Khan et al. 2016, Turk et al. 2021). PCNL has high rates of stone clearance, attaining stone free rates of up to 95% and can be successful treating even the most challenging staghorn calculi (Ganpule et al. 2016). PCNL is however associated with higher risk of complication, including infection, bleeding and damage to surrounding structures, with rates reported of approximately 10% (Turk et al. 2021).

**Preventative strategies**

Following the initial management long term preventative strategies are paramount given a recurrence rate of 50% within 10 years (Kumar and Clark 2017). Providing health promotion is part of all health professional’s duty of care, working collaboratively to improve the health of our population (HEE 2017, Nursing and Midwifery Council 2020). Health promotion is essential to reduce health inequalities and sustain the NHS for future generations (NHS England 2016). ACPs can utilise their dual-approach gained from their diverse and experienced clinical backgrounds to make every contact count.

All stone formers, independent of their individual risk, should be given fluid intake, diet and lifestyle advice (NICE 2019, Turk et al. 2021). Relationship between low fluid intake and increased stone formation has been repeatedly demonstrated, hence drinking adequate amounts of fluid can independently reduce the likelihood of stone recurrence by 30-40% (BAUS 2017a). NICE (2019) recommend adults to drink 2.5 to 3 litres of water per day. A common-sense approach to diet should be taken, that is, a mixed, balanced diet with contributions from all food groups, without any excesses alongside a cautioned usage of salt (BAUS 2017a, Turk et al. 2021). NICE (2019) suggest adults have a daily salt intake of no more than 6g, Sorensen et al. (2012) found that a higher dietary sodium intake increased the risk of nephrolithiasis by 11% to 61%. More specific dietary advice can be tailored dependant on the chemical composition of the stone (Turk et al. 2021).

Individual risk including potential underlying genetical dispositions and causative medical conditions such be investigated and treated where able (Kaisary, Ballaro and Pigott 2016). Targeted medical therapy can be an effective preventative method following biochemical analysis of stone, the drug should halt stone formation with minimal side effects to achieve good compliance (Turk et al. 2021). Most ACPs are non-medical prescribers, enabling holistic autonomous care. NMPs are accountable to ensure prior to any prescribing decision is reached they have assessed the patient, considered the options and reached a shared-decision to maintain safe, effective, patient-centred prescribing (Royal Pharmaceutical Society (RPS) 2016).

Medication suitability is dependent on underlying metabolic abnormalities and stone composition (Turk e al. 2021). Considering the most prevalent calcium-based stones Thiazide diuretics or Potassium citrate can be considered (NICE 2019). Thiazides stimulate calcium reabsorption in the distal renal tubule and decrease extracellular fluid volume increasing proximal renal tubular calcium reabsorption (Turk et al. 2021). Potassium citrate binds with urinary calcium, thereby reducing the supersaturation of urine and binds calcium oxalate crystals further preventing crystal growth (Krieger et al. 2015). Phillips et al. (2015) Meta-analysis concluded potassium citrate significantly reduce stone size and prevented new stone formation by up to 75%.

**Conclusion**

The incidence of urolithiasis is on the increase, subsequently is frequently encountered in the acute urological setting. The text book symptoms are renal colic and haematuria in the acute presentation; a detailed synthesis of history of presenting complaint and clinical examination should occur to rule out potential differential diagnosis. ACPs are in the ideal position to utilise their knowledge and rational clinical-decision making to ensure timely recognition, prompt investigation and initial management. Once a diagnosis is confirmed treatment decisions for are based on several aspects such as stone composition, stone size, anatomical location and patient symptoms, utilising conservative, medical and surgical management strategies.

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Appendix 1

Competency Mapping

Health Education England

Multi-professional framework for advanced clinical practice in England

|  |
| --- |
| Competencies |
| Clinical Practice | 1.4, 1.6, 1.7, 1.8, 1.11 |
| Leadership and Management | 2.7, 2.11 |
| Education | 3.2, 3.7 |
| Research | 4.3 |

Derbyshire School of Advanced Clinical Practice: Core Competency Framework

|  |
| --- |
| Competencies |
| Generic  | GC1, GC2, GC3, GC5, GC6, GC7, GC11, GC16, GC21 |
| Core Clinical  | CC1, CC2, CC4i, CC4ii, CC4xviii |