

CASE 2

Short case number: 3.14.2

Category: Renal and Urinary Systems

Discipline: Medicine_nephrology

Setting: Urban: Emergency department

Topic: Renal Calculi

Case

41 year Peter Horvath presents with severe left sided loin pain, it has been coming and going for the last 2 hours and has now become more constant and severe. He has vomited twice and feels very faint and unwell.

Vital Signs: Afebrile; HR: 100 bpm; BP 140/80; RR 20/min

Questions

1. What are the key features of history that assist in the differentiation of pain due to renal calculi, compared with other causes of abdominal pain?
2. What are the underlying mechanisms / pathophysiology of renal colic pain?
3. What are urinary calculi and how do they form?
4. What are the predisposing factors for renal and ureteric calculi?
5. What are the key features of examination that support a diagnosis of renal calculi?
6. Outline your immediate management of Peter.
7. Outline your on-going management plan for Peter, including recommendations for prevention of the formation of further urinary calculi.
8. Based on the location of the stone, briefly outline the different operative and non-operative means of removing calculi.

Suggested reading:

- Colledge NR, Walker BR, Ralston SH, Penman ID, editors. Davidson's Principles and Practice of Medicine. 22nd edition. Edinburgh: Churchill Livingstone; 2014. Chapter 17.

ANSWERS

1. What are the key features of history that assist in the differentiation of pain due to renal calculi, compared with other causes of abdominal pain?

The patient is suddenly aware of pain in the loin, which radiates anteroinferiorly to the groin and often into the testis or labium, in the sensory distribution of the first lumbar nerve. The pain steadily increases in intensity to reach a peak in a few minutes.

The patient is restless, and generally tries unsuccessfully to obtain relief by changing position or pacing the room. Frequency, dysuria and haematuria may occur. The pain is usually constant during attacks, although slight fluctuations in severity may occur. Subsequent to an attack of renal colic there may be intermittent or constant dull ache in the loin or back.

History of previous renal colic (family history of renal calculi)

2. What are the underlying mechanisms / pathophysiology of renal colic pain?

Distension of the renal pelvis seems to be responsible for the development of renal colic. The rise in pelvic pressure due to a ureteric calculus can result from various mechanisms such as increased diuresis, inflammatory oedema around the stone and increased frequency of ureteric contractions. Prostaglandins can play an important role in these mechanisms, therefore inhibition of prostaglandin synthesis by drugs such as non-steroidal anti-inflammatory drugs could contribute to the lowering of pelvic pressure and distension, and thus to the relief of renal colic.

3. What are urinary calculi and how do they form?

Renal calculi consist of aggregates of crystals containing small amounts of proteins and glycoprotein that can lodge anywhere along the course of the urinary tract. Human urine is often saturated to the limit with uric acid, phosphates and calcium oxalate. Normally due to the secretion of various protective compounds – proteins, glycosaminoglycans, pyrophosphate and citrate – and natural mechanisms that control the pH of urine, these substances remain suspended in solution. If the protective compounds are overwhelmed or immunity becomes depressed, the substances may crystallize and the crystals may begin to clump together, eventually forming calculi. There are four basic kinds of renal calculi which may be jagged or smooth:

- Calcium (most commonly as oxalate but also as phosphate)
- Uric acid
- Struvite (composed of magnesium ammonium phosphate, these are often associated with infection e.g. staghorn calculi)
- Cystine (rare, tend to occur at a younger age)

Different types vary in frequency around the world, probably as a consequence of dietary and environmental factors, but genetic factors may also contribute. About 90% of all calculi contain calcium

as the chief constituent. In Europe, 80% of calculi are calcium oxalate. In developing countries, bladder calculi are common, particularly in children. In developed countries, the incidence of childhood bladder calculi is low, renal calculi in adults are more common.

4. What are the predisposing factors for renal and ureteric calculi?

Environmental and dietary

- Low urine volumes, high ambient temperatures, low fluid intake
- Diet: high protein intake, high sodium, low calcium
- High sodium excretion
- High oxalate excretion
- High urate excretion
- Low citrate excretion

Acquired causes

- Hypercalcaemia of any cause e.g. hyperparathyroidism, malignancy etc.
- Ileal disease or resection (leads to increased oxalate absorption and urinary excretion)
- Renal tubular acidosis type I

Congenital and inherited causes

- Familial hypercalciuria
- Medullary sponge kidney
- Cystinuria
- Renal tubular acidosis type I
(distal) 70% will develop calculi
- Primary hyperoxaluria

5. What are the key features of examination that support a diagnosis of renal calculi?

The classic patient with renal colic is writhing in pain, pacing about, and unable to lie still, in contrast to a patient with peritoneal irritation, who remains motionless to minimize discomfort. There may be pallor, sweating and often vomiting. Fever is not part of the presentation of uncomplicated nephrolithiasis. The most common finding in ureterolithiasis is loin tenderness due to the dilatation and spasm of the ureter from transient obstruction as the calculus passes from the kidney to the bladder. Abdominal examination is usually unremarkable. Bowel sounds may be decreased, a reflection of mild ileus, which is not uncommon in patients with severe, acute pain. Testes may be painful but should not be very tender and should appear normal.

- Urinalysis
- Haematuria present in 80 – 90% of cases
 - Pyuria in a patient with ureterolithiasis should prompt a careful search for signs of infected hydronephrosis.
 - Urine pH >7 suggests urea-splitting organisms and struvite calculi. pH <5 suggests uric acid calculi.

6. Outline your immediate management of Peter.

- Obtain intravenous access to facilitate delivery of analgesic and antiemetic medications.
- Analgesia should be provided promptly. IV morphine. Indomethacin suppository (the pain of renal colic is mediated by prostaglandin E2)
- Antiemetics should be administered as necessary.
- Intravenous hydration if the patient is considered clinically dehydrated.
- Bloods collected for - full blood count (elevated WBC suggests infected hydronephrosis, electrolytes (hypokalaemia and decreased serum HCO_3^- level suggests underlying distal [type 1] renal tubular acidosis), creatinine (serum level is the major predictor of contrast-induced nephrotoxicity), uric acid, phosphorus, calcium (if elevated check PTH)
- Occasionally, a patient may require urinary catheterization to relieve retention due to extreme pain or an obstructing bladder neck calculus.
- Strain the urine for calculus collection.
- If, after analgesics, the patient is pain-free he could be discharged from the ED and undergo imaging in 2-3 weeks depending on symptoms.
- If the pain persists after analgesia then imaging becomes necessary. KUB (kidney, ureters, bladder) has low (40-50%) sensitivity and specificity for ureterolithiasis. Most calculi will appear larger on KUB radiograph than on CT. CT KUB is the imaging technique of choice for suspected calculi in the urinary tract.

7. Outline your on-going management plan for Peter, including recommendations for prevention of the formation of further urinary calculi.

Consider the use of MET – active medical expulsive therapy – in any patient with a reasonable probability of calculus passage. It is probably most useful in calculi 3 – 10mm in size as those $\leq 3\text{mm}$ have an 85% chance of passing spontaneously. Overall, MET is associated with a 65% greater likelihood of calculus passage. The calcium blocker nifedipine relaxes ureteral smooth muscle and enhances calculus passage. Alpha-1 selective blockers, such as tamsulosin also relax musculature of the ureter and lower urinary tract. MET with calcium channel blockers and alpha-blockers also appear to improve the results of extracorporeal shock-wave lithotripsy (ESWL) inasmuch as the fragments resulting from the treatment appear to clear the system more efficiently.

CT KUB should be arranged if not already performed and further management determined pending result e.g. if there is still evidence of obstruction (hydroureter and/or hydronephrosis) then a referral to a Urologist is necessary.

A 24 hour urine analysis for urea, creatinine clearance, sodium, calcium, oxalate; magnesium and citrate (both important chemical inhibitors of calculus formation esp. citrate), pH (some stones are pH dependent e.g. uric acid and struvite). The analysis should be performed if :-

- initial presentation with multiple calculi
- initial presentation before the age of 30
- family history of calculi
- solitary kidney
- bilateral calculi
- more than one calculus in the past year

Recommend measures to prevent calcium calculus formation

- diet
 - fluid - at least 2 litres output per day (intake 3-4 litres)
 - check with 24 hour urine collections
 - intake distributed throughout the day (esp. before bed)
 - sodium - restrict intake
 - protein - moderate intake, not high
 - calcium – plenty in diet (because calcium forms an insoluble salt with dietary oxalate, lowering oxalate absorption and excretion)
 - avoid supplements away from meals (increase calcium Excretion without reducing oxalate excretion)
 - oxalate - avoid foods that are rich in oxalates (e.g. rhubarb, spinach, beets, peanuts, chocolate, sweet potatoes)
- (a number of studies have recommended the daily ingestion of lemon juice – citric acid – to slow the production of calcium calculi however this is not a generalized recommendation)
- drugs
 - thiazide diuretics - reduce calcium excretion, valuable in recurrent calculi-formers and patients with hypercalciuria
 - allopurinol - if urate excretion high
 - avoid - Vitamin D supplements as they increase calcium absorption and excretion

8. Based on the location of the stone, briefly outline the different operative and non-operative means of removing calculi.

Calculus in the renal pelvis or kidney

- extracorporeal shock-wave lithotripsy (ESWL) in which shock waves generated outside the body are focussed to the calculus, breaking it into smaller pieces which can pass easily down the ureter. This requires free drainage of the distal urinary tract. The technique is limited somewhat by the size and location of the calculus. Larger than 1.5cms or one located in the lower section of the kidney is treated less successfully.
- percutaneous nephrolithotomy allows fragmentation and removal of large calculi from the kidney and ureter and is often used for the many ESWL failures. A needle, and then a wire, over which is passed a hollow sheath with a 1cm lumen, are inserted directly in the kidney through the skin of the flank. Because of the increased morbidity, percutaneous procedures are generally reserved for large and/or complex renal calculi and failures from other modalities.
- open surgery (very rarely)

Calculus in the upper ureter

- ESWL
- ureteroscopic destruction – laser or mechanical. A small endoscope, which may be rigid, semirigid or flexible, is passed into the bladder and up to the ureter to directly visualize the calculus. Often, a ureteral stent must be placed following this procedure in order to prevent obstruction from ureteric spasm and oedema. A ureteral stent is often uncomfortable and may be avoided in selected patients.
- laparoscopic removal (rarely)
- open surgery (very rarely)

Calculus in the lower ureter

- ESWL
- ureteroscopic destruction
- Dormier basket extraction

Calculus in the bladder

- cystoscopic destruction – calculus punch
- open removal (suprapubic cystostomy) - easy removal of several calculi at the one time, removal of calculi that are adherent to bladder mucosa, and the ability to remove large stones (bigger than a hen's egg) that are too hard or dense to fragment expeditiously via transurethral or percutaneous techniques.