PCNL in Special Circumstances: Horse-shoe Kidney Calyceal Diverticulum Anterior Calyceal Stone Retro-renal Colon

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Difficulties with access in percutaneous renal surgery

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Abstract: Percutaneous renal surgery provides a minimally invasive approach to the kidney for stone extraction in a number of different clinical scenarios. Certain clinical cases present inherent challenges to percutaneous access to the kidney. Herein, we present scenarios in which obtaining and/or maintaining percutaneous access is difficult along with techniques to overcome the challenges commonly encountered. Also, complications associated with these challenging percutaneous renal surgeries are discussed.

Keywords: angiomyolipoma, calyceal diverticulum, horseshoe kidney, nephrolithotomy, obesity, PCNL
PCNL in Special Circumstances:

HORSE-SHOE KIDNEY
Horse-shoe kidney is the most common type ofrenal fusion anomaly.

It occurs in 1 per 400 live births with a ratio of 2:1 in M:F.

Horse-shoe kidney consists of two distinct functioning kidneys on each side of the midline, connected at the lower poles by an isthmus of functioning renal parenchyma or fibrous tissue.
Horse-shoe kidneys resulted from the incomplete cranial migration and rotation of the kidney [Jones et al. 1991]. Therefore, horse-shoe kidneys may be found at any location along the path of normal renal ascent from the pelvis to the mid abdomen. The kidneys may be lower than normal because the isthmus is tethered by the inferior mesenteric artery during renal ascent.
The collecting system has a characteristic appearance on intravenous urography because of an incomplete inward rotation of the renal pelvis, which faces anterior because of the lower pole's connection with the isthmus.

The ureter may have a high insertion point into the renal pelvis and may cross anteriorly over the isthmus as it descends to the bladder - PUJ obstruction 35%.

Rarely does the collecting system cross the isthmus to the contralateral kidney.

Due to all these, aberrancy of the ureteropelvic junction and the course of the proximal ureter which is more superior & anterior, a relative ureteral obstruction can occur which will give rise to urinary stasis and stone formation in up to 70% of patients [Lampel et al. 1996].
Accessory renal arteries may be present, entering at the renal hilum as with accessory arteries in normally situated kidneys.

Accessory polar arteries may also arise from the aorta, common iliac, or internal iliac arteries.

Due to the malrotation, malascended with numerous accessory arteries of the horse-shoe kidney, proper planning should be considered for a PCNL access.

Malrotation places the lower pole calyces angled medially.

Therefore, a more medial and deeper upper pole puncture should be made to avoid injury of major renal vessels in most cases [Janetschek and Kunzel, 1988]
**PRE OP PLANNING**

- **Preoperative CT imaging** will be helpful for planning access to avoid percutaneous puncture through a retrorenal colon or other adjacent organs.

- This will also allow planning of either performing multiple tracts or usage of **flexible nephroscopy** to access and adequately clear the stone burden effectively [Raj et al. 2003; Al-Otaibi et al. 1999].

- One might also consider usage of a **longer** Amplatz sheath because a horse-shoe kidney is usually more deeply located.
PCNL in Special Circumstances:

CALYCEAL DIVERTICULUM
Calyceal diverticula are outpouchings of the pelvicalyceal system that are lined with non secreting transitional cells, often communicating with the renal collecting system via a narrowed infundibulum.

Calyceal diverticula is present in less than 0.5% of patients.

Smaller diverticula are associated with a low incidence of complications but larger diverticula with a narrow communication to the main collecting system will predispose to calculus formation as a result of stasis of urine within the diverticulum [Hulbert et al. 1986].

Stone formation within calyceal diverticula is reportedly found in 10–50% of cases [Jones et al. 1991].
Percutaneous access into calyceal diverticula containing stones is challenging due to multiple factors. However, a percutaneous approach to stone extractions has been demonstrated to be more successful than ureteroscopic and ESWL [Canales and Monga 2003, Jones et al 1991].

PCNL also allows the surgeon to manage the diverticulum with fulguration or incision of the diverticular neck [Nakada SY et al. 1999, Cohen TD et al. 1997].

Diverticular neck is often very narrow.

The calyceal diverticulum presents as a limited cystic cavity, therefore maintaining access after initial puncture into the diverticulum can be difficult.
It is challenging and at times not feasible to advance a guidewire beyond the diverticulum into the pelvicalyceal system to provide additional stability for tract dilation due to the narrow infundibulum.

The size of the stone or stones within the diverticulum further adds challenge to passing adequate wire length into the cavity in preparation for dilation.
PCNL IN CALYCEAL DIVERTICULUM STONE

- To best define the location and caliber of the diverticular neck, preoperative CT scan with contrast-enhancement, with axial imaging and delayed pyelogram phase should be performed [Matlaga BR et al 2006]

- Intraoperative retrograde pyelogram can be performed to correlate diverticular location and plan the best approach

- Direct puncture into the calyceal diverticulum and dilation for nephroscope access provides better chance for stone extraction

- Direct puncture also allows superior visualization and maneuverability for definitive management of the diverticulum, both important in preventing stone recurrence [Shalhav et al 1998]
Once access is obtained into the calyceal diverticulum and the stone burden is evacuated, attention is directed toward management of the calyceal diverticulum to help prevent recurrence of stone, infections, and pain.

The ostium can be identified intraoperatively with retrograde instillation of methylene blue through a ureteral catheter.

Once identified the neck can be dilated or incised to provide a patent outflow tract and help prevent stasis within the cavity.

Fulguration of the urothelial lining is one option either alone or in conjunction with dilation of the diverticular neck to reduce chances of stone recurrence [Shalhav et al 1998].
Percutaneous management of stones within calyceal diverticula including fulguration of the diverticular lining and dilation of the infundibulum following stone extraction.
PCNL in Special Circumstances:

ANTERIOR CALYCEAL DIVERTICULUM
The **acute angle** required for direct puncture prevents complete visualization and instrumentation within the cavity.

One option for management includes **direct puncture** through a posteriorly located calyx with stone removal and fulguration, but without management of the diverticular neck.

However, a direct puncture of the stones traverses a large amount of renal tissue.

In addition, a difficult turn is often created as the guidewire are placed in the renal pelvis.
Alternatively, **indirect puncture** often proves to be more favorable for anterior calyces.

This involves puncture onto the **posterior calyx** which provides as straight as possible a pathway to the anterior calyx containing stones.

Upper pole anterior calyceal stones can often be approached through a lower pole posterior calyx.

Lower pole anterior calyceal stones are probably best approached via a posterior, midpole calyx.
PCNL in Special Circumstances:

RETRO-RENAL COLON
An anatomical variant to note is the retrorenal colon which is reported to occur in 1 - 1.9% of supine patients and in up to 10 – 16% of prone patients [Hopper, Sherman et al. 1987; Tuttle, Yeh et al. 2005]

This retroperitoneal bowel loop is usually gas-distended and is found mostly around the lower renal poles

Preoperative CT scan is imaging test of choice [Sharma G et al 2015]
POSSIBLE COMPLICATIONS OF PCNL
PULMONARY COMPLICATIONS

- Pleural injuries constitute 0.1-0.3% [Dyer, Regan et al. 2002; Ramchandani, Cardella et al. 2003]

- Pneumothorax, hydrothorax, and hemothorax are all potential complications of supracostal access, for calculi sitting at the upper poles, in which the pleural fold is compromised and there is introduction of air, irrigation fluid, or blood into the pleural space.

- The risk increases in interventions performed above the 12th rib - 4-12% [Carey, Siddiq et al. 2006]
PULMONARY COMPLICATIONS

- Reports of upper pole access and multiple dilated percutaneous tracts for access increases the risk of pulmonary complications \[Munver et al. 2001; Lam et al. 1992\]

- Prompt recognition and treatment (pigtail drainage, chest tube) helps reduce the formation of pleural fibrosis and subsequently decreases the risk for a fixed or entrapped lung \[Ogan et al. 2003; Ogan and Pearle, 2002\]
Injury to adjacent organs (small bowel, colon, spleen, liver, etc) is rarely encountered.

Rates of adjacent organ injury are commonly reported as less than 0.5%.

Nevertheless, bowel and solid organ injury is always a possible complication with percutaneous renal surgery, which is minimized by operative planning using preoperative CT imaging, anatomic landmarks, and real-time ultrasonographic and/or biplanar fluoroscopic guidance.
However, in cases of abnormally situated kidneys such as horseshoe, there is an added risk of bowel injury as well as solid visceral organ injury due to the path required for the percutaneous tract to access the kidney.

There has been an association reported between horseshoe kidneys and retrorenal colon increasing the risk of a colonic perforation [Skoog et al. 1985].
Colonic perforation during percutaneous nephrolithotomy: An 18-year experience [Mohammed AslZare et al, 2014]

Out of the 5260 PCNL procedures, colonic perforation occurred in 11 patients (0.2%)

The first step in the treatment of colon perforation should be based on conservative management

This includes separating the nephrocolic communication, including double J stent insertion for adequate urinary drainage and retraction of the nephrostomy tube from the pelvicalicial system into the colon as a percutaneous colostomy tube – control fistula
COLONIC INJURY

- Administration of **broad spectrum antibiotics** covering gram negative and anaerobic bacteria and **parenteral nutrition** should also be started.

- However, occasionally surgery is indicated in intraperitoneal perforation, peritonitis, sepsis and persistent nephrocutaneous fistula.

- Some researchers have also shown optimal primary results of fibrin glue application in some cases to correct persistent nephrocutaneous fistulas.
PCNL in Special Circumstances:

CONCLUSIONS
Particular clinical scenarios present challenges for percutaneous renal access.

For each anatomic limitation, there are specific imaging modalities, modified surgical techniques, and novel instrumentation to facilitate overcoming the challenges.

Recognition of these challenging scenarios, understanding surgical limitations, and employing methodical approaches to overcome difficulties encountered will help minimize potential complications which may arise more commonly in these complex clinical cases.
I’m sorry, kids. But last night your father... "passed."

A difficult day for the Kidney Stone family.

THANK YOU
ANATOMICAL CONSIDERATIONS

- PCNL is usually performed using ultrasound or fluoroscopic guidance
- PCNL should not be performed without adequate review of all relevant imaging performed prior to the procedure
- Although in many cases, CT may have been performed to arrive at the diagnosis prior to the procedure and correlation with these images may prove to be beneficial
- The primary diagnosis should be reviewed thoroughly, and this should include the cause and level of obstruction, degree of pelvicalyceal dilatation, as well as the most accessible renal calyx for catheter placement
ANATOMICAL CONSIDERATIONS

• If urinary calculi are present within the renal pelvis, their exact nature and location must be elucidated.

• The success rate for percutaneous nephrostomy has been reported to be lower in patients with a non-dilated collecting system, complex calculus disease and staghorn calculus. [Ramchandani, Cardella et al. 2003]

• The kidney itself must also be assessed for the presence of anatomical variants or congenital anomalies such as horseshoe kidney.
Equally important to note is the vascular anatomy of the target kidney.

Its precise delineation, as well as the presence of abnormal vascular malformations or aneurysmal dilatation should be noted.

Injury to the first order segmental renal arteries may occur in the region of the renal pelvis, particularly if the puncture is made too medially.

To prevent vascular injury and bleeding complications, the safest approach has been described by approaching the cusp of the papilla as far peripherally as possible, and by entering the kidney via the Brodel’s line (Dyer, Regan et al. 2002).

Brodel’s line is a zone of relative avascularity and watershed territory, which is located just posterior to the lateral convex margin.
ANATOMICAL CONSIDERATIONS

- Care should be taken to avoid a through-and-through two-wall puncture of the renal pelvis as this runs the risk of injury to the anterior segmental renal artery.

- The position of the affected kidney relative to the surrounding abdominal viscera should be thoroughly assessed as this has a bearing in determining the safest and most effective approach for renal puncture.

- Under normal circumstances, the posterolateral margins of the kidneys are immediately adjacent to the posterolateral aspects of the abdominal wall with no organs to interpose in between.

- Hence, a posterior approach is advantageous in avoiding the surrounding organs (Hruby 1990).
ANATOMICAL CONSIDERATIONS

- Although the spleen, liver, pancreas and the adrenal glands are in close proximity to the kidneys, they are usually not shown to interpose between the posterior aspect of the kidney and the adjacent abdominal wall.

- Hruby described no injury to these organs in their retrospective review of 3100 patients who underwent percutaneous nephrostomy. However trans-splenic puncture has been reported in a series of patients who underwent percutaneous nephrostomy for nephrolithotomy (Carey, Siddiq et al. 2006).
Then a guidewire can be passed into and coiled within the cavity

The diverticular neck is then balloon-dilated or endoinfundibulotomy is performed with an electrosurgical probe or laser

The nephroscope is then advanced into the diverticulum and stones are fragmented and removed [Bellman GC et al. 1993]
A study was performed to evaluate and compare the outcomes of percutaneous nephrolithotomy (PNL) for the treatment of posterior and anterior caliceal stones [Abdulkadir Tepeler et al. 2012]

A retrospective analysis of 86 patients with isolated caliceal stones who underwent PCNL

The patients were classified into two groups according to the localization of the stone on axial plane CT scan, anterior (41) or posterior (45)

Although the postoperative hemoglobin drop did not significantly differ between groups, hemorrhaging was more severe in patients with anterior caliceal stones than in those with posterior caliceal stones
Colonic perforation is a rare complication of PCNL, for which early diagnosis and conservative management can minimize patient morbidity and mortality.

Conservative management can lead to excellent healing of the colonic perforation.