Managing urologic disease in the horseshoe kidney

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Targets for today

- General overview of horseshoe kidneys in adults.

- Critical anatomic features.

- The special case of the horseshoe kidney in:
  - Ureteral obstruction
  - Nephrolithiasis

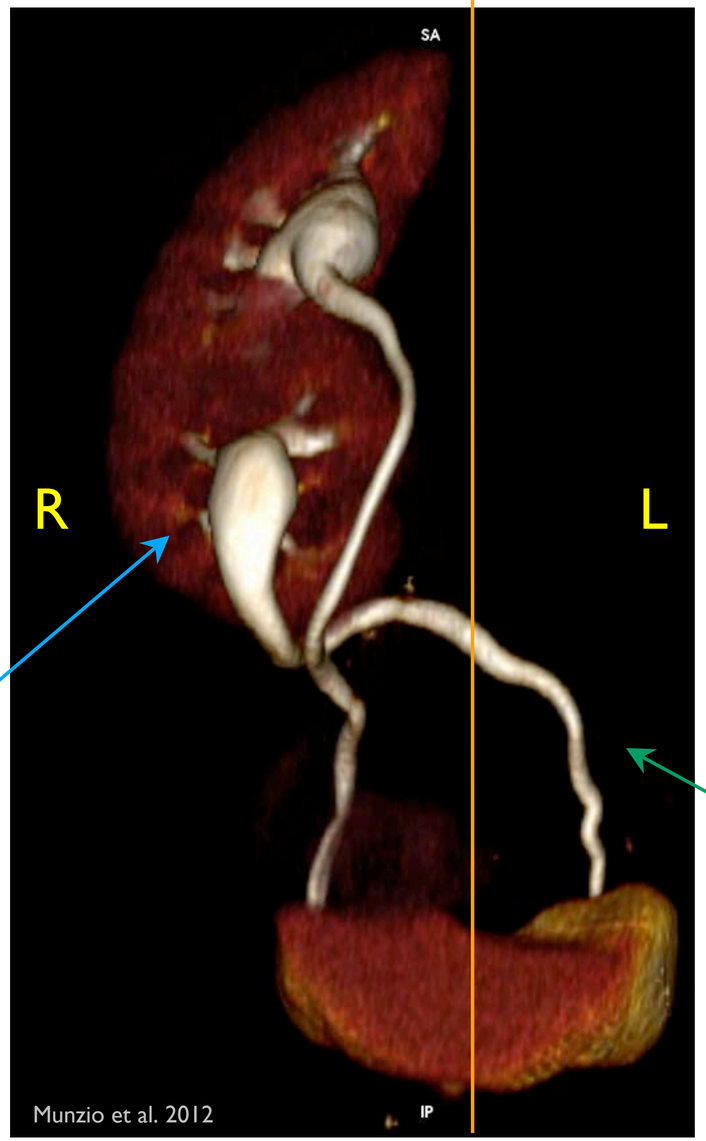
  → Infection

  - Surgical management (heminephrectomy, isthmus division, partial nephrectomy, donor nephrectomy)

Horseshoe kidney demographics

- The most common of all renal fusion anomalies.
- Occurs in 0.25% of the population (1 in 400).
- Abnormality occurs between the 4th and 6th week of gestation.
- Higher frequency in children with vertebral and neural tube defects.
- Kidneys are not ectopic.

Crossed fused ectopic kidney



Kidney is ectopic

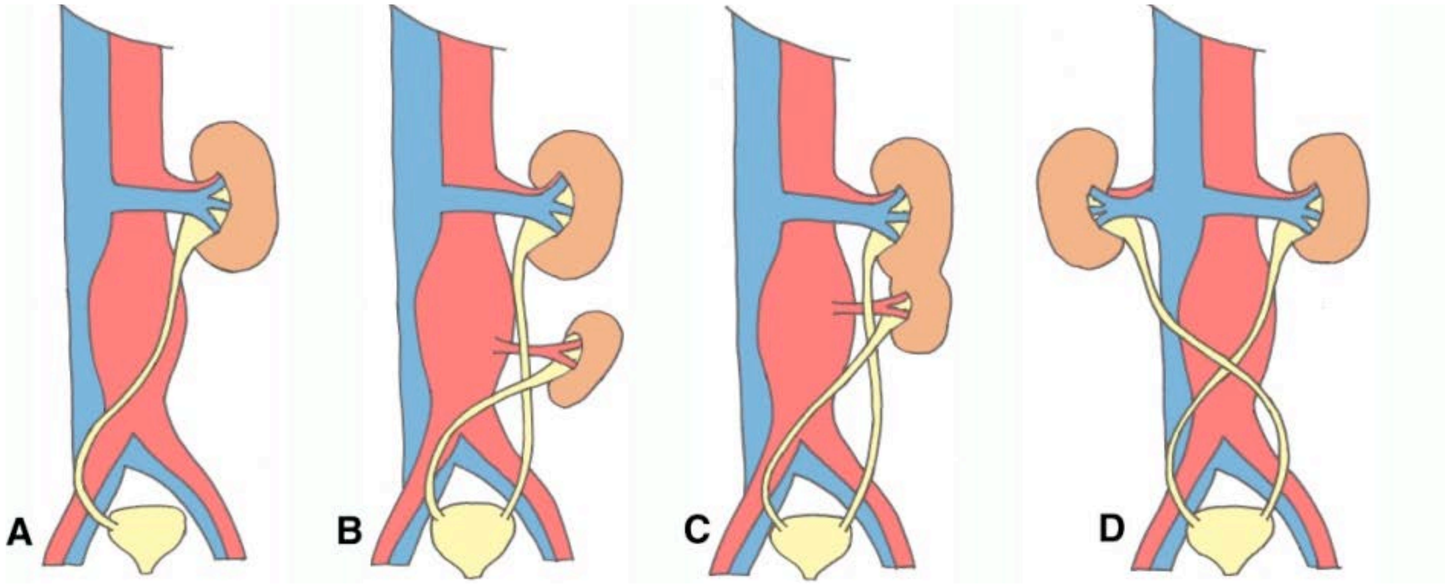
Midline

90% of crossed ectopic kidneys are fused with the contralateral kidney

Ureter is usually orthotopic

Ectopic kidneys

Jimenez and Morant, 2011

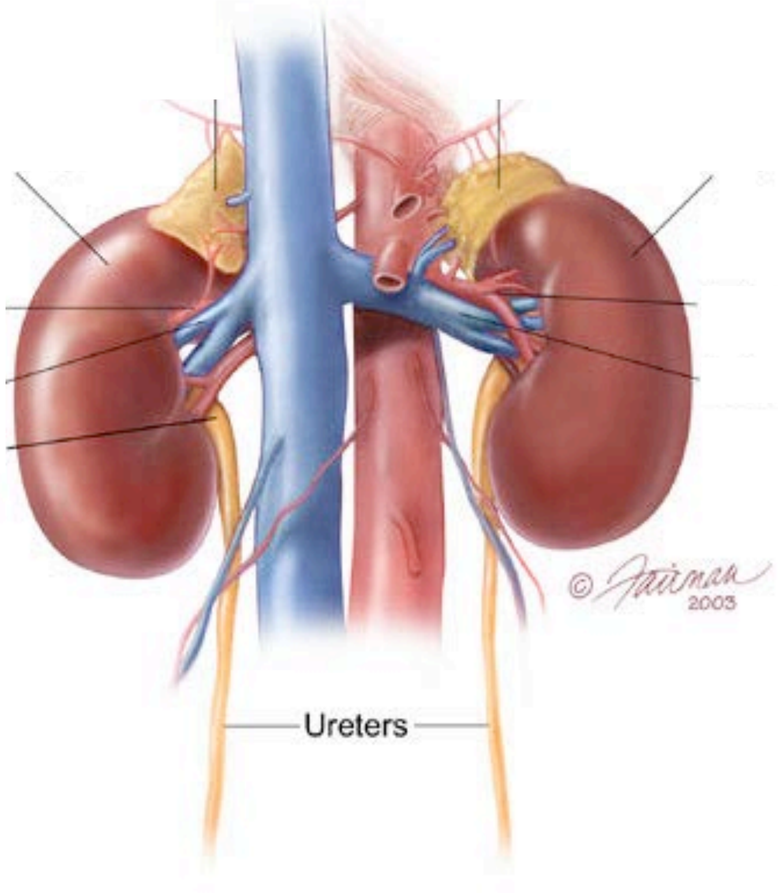


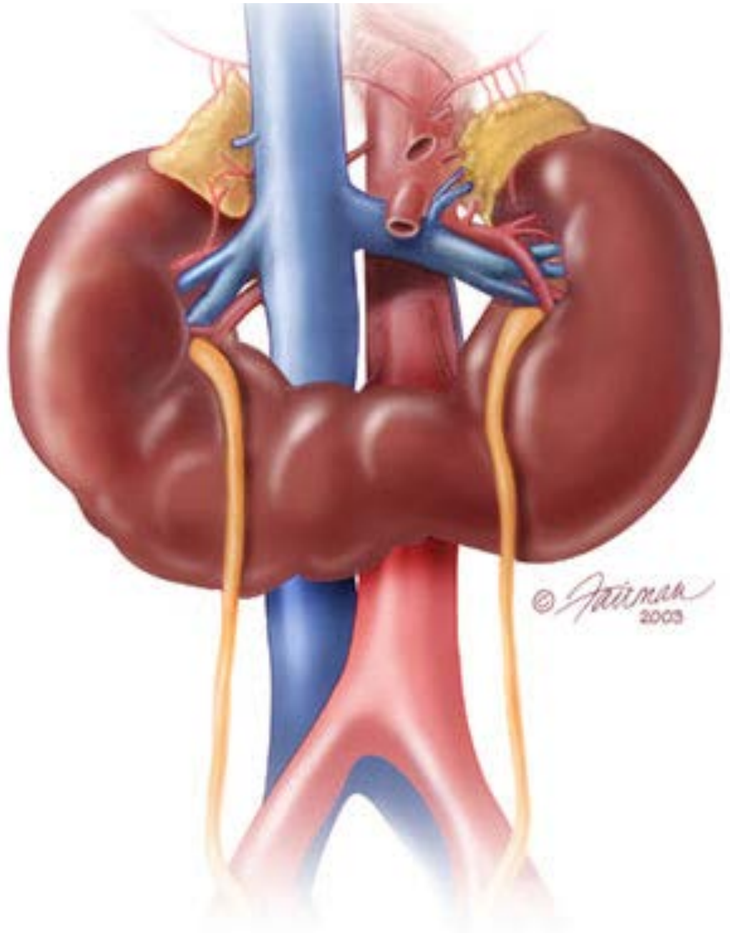
Solitary crossed ectopic kidney

Crossed ectopic kidney

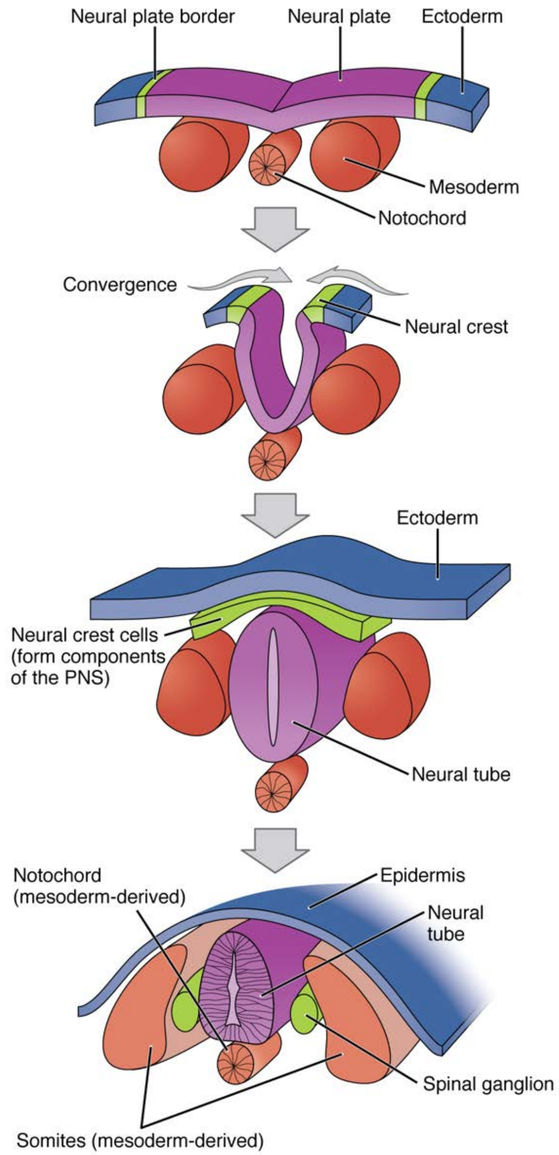
Crossed fused ectopic kidney

Bilateral crossed ectopic kidneys



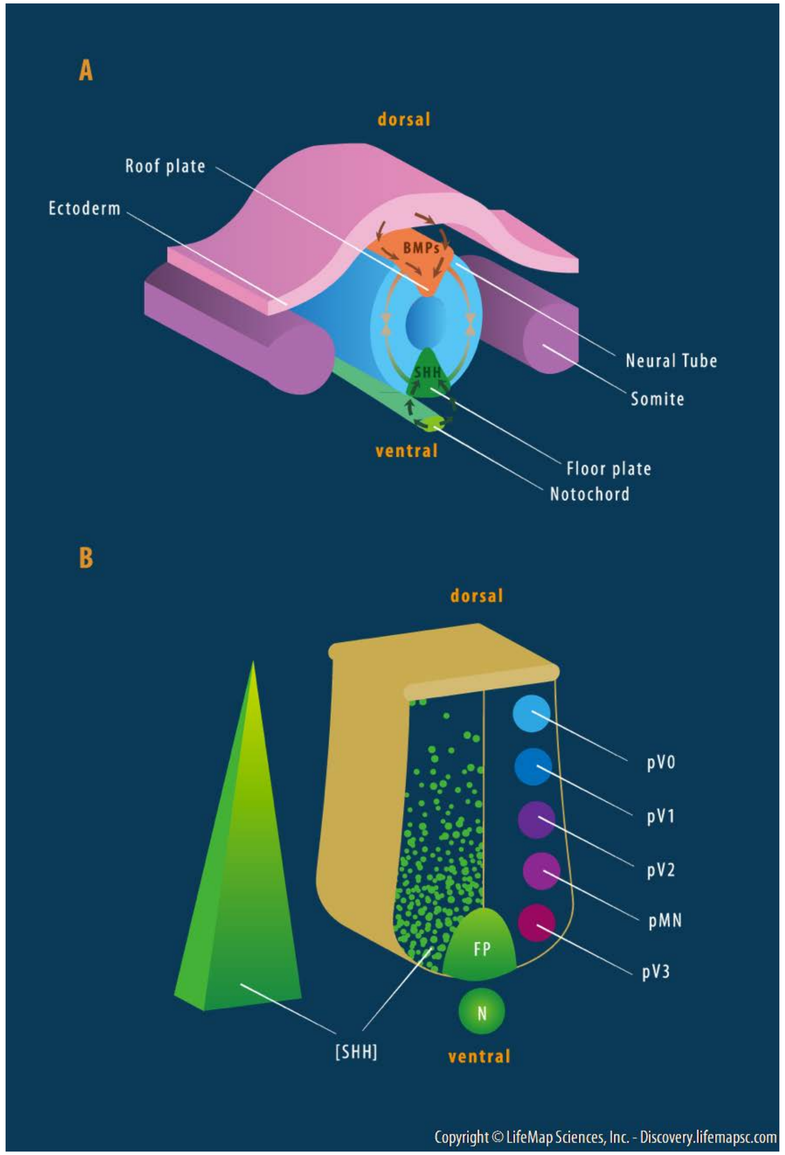


98% of horseshoe kidneys are fused at the lower pole



Notocord and floor plate of the neural tube play an important role in kidney development.

Disruption of these structures during development results in renal fusion anomalies.



Sonic Hedgehog (Shh) protein forms a gradient in the neural tube and has particularly high expression in notocord and floor plate

Developmental Biology 340 (2010) 518–527

Contents lists available at ScienceDirect

Developmental Biology

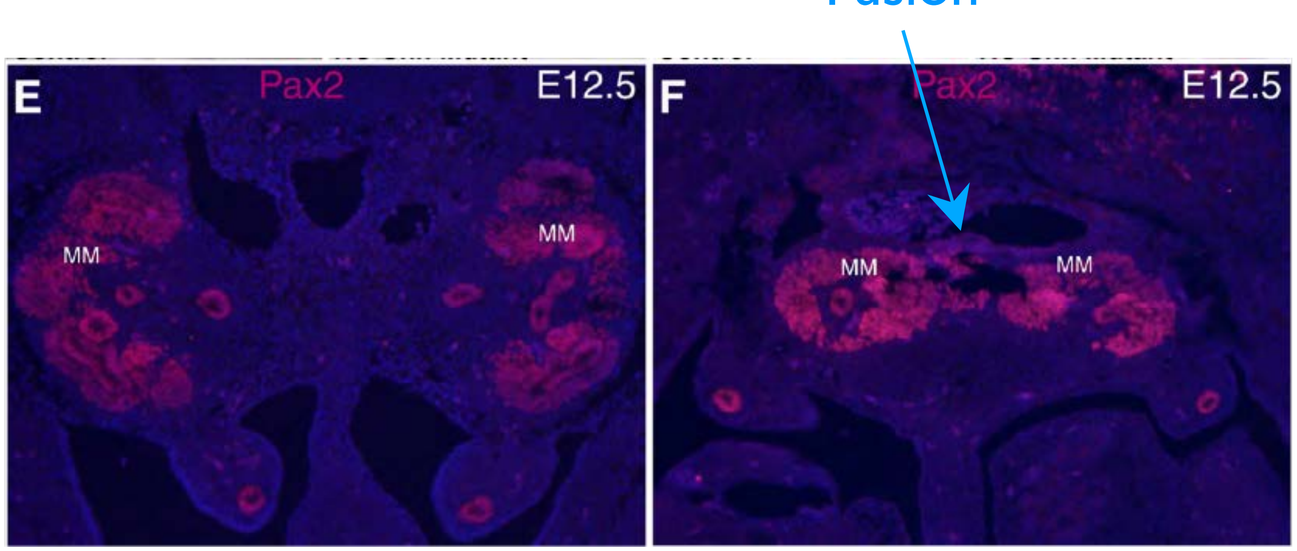
journal homepage: www.elsevier.com/developmentalbiology

Midline signaling regulates kidney positioning but not nephrogenesis through Shh

Piyush Tripathi [a], Qiusha Guo [a], Yinqiu Wang [a], Matthew Coussens [a], Helen Liapis [b], Sanjay Jain [a,b], Michael R. Kuehn [c], Mario R. Capecchi [d], Feng Chen [a,e,*]

[a] Internal Medicine, Renal Division, Washington University School of Medicine, St. Louis, MO, USA
[b] Department of Pathology and Immunology, Washington University School of Medicine, St. Louis, MO, USA
[c] Laboratory of Protein Dynamics and Signaling, NCI, NIH, Frederick, MD, USA
[d] Human Genetics, University of Utah, HHMI, Salt Lake City, UT, USA
[e] Department of Cell Biology and Physiology, Washington University School of Medicine, St. Louis, MO, USA

Selective inactivation of Shh (sonic hedgehog) in notocord and floor plate resulted in renal fusion but not agenesis.



Shh+/Shh+ control

Shh-/Shh-

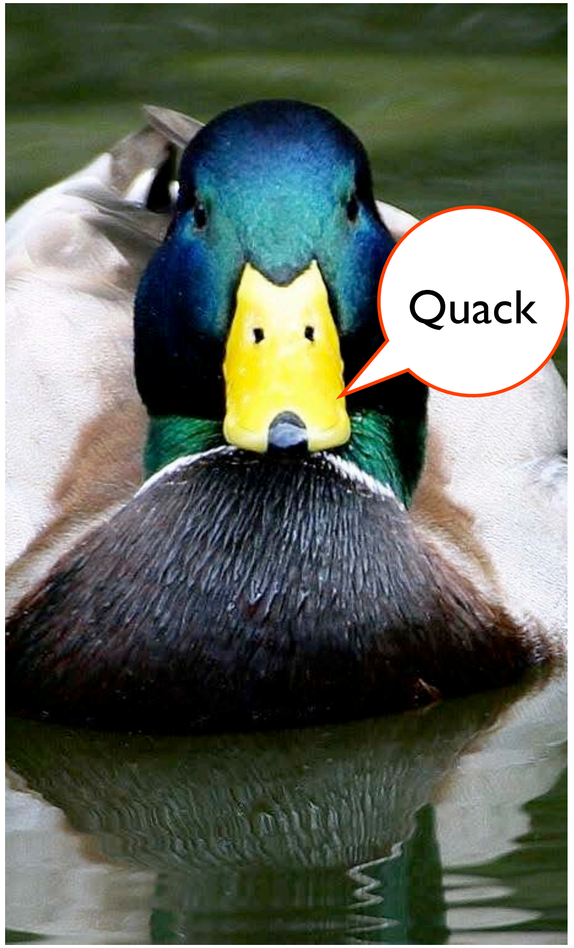
Not today...

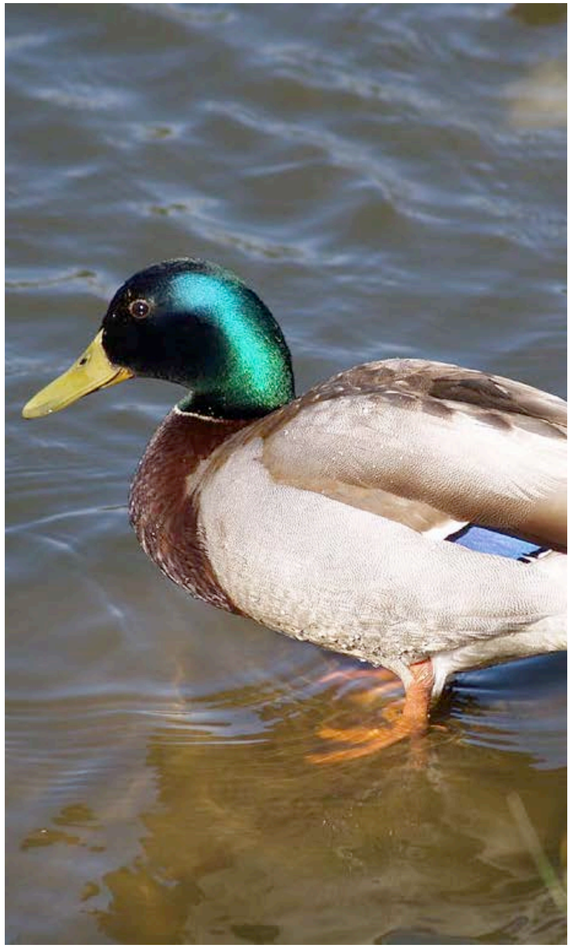
Horseshoe kidney

- > 50% of patients with horseshoe kidneys are asymptomatic.
- Even during an era (the 1950s) prior to routine abdominal ultrasound and CT imaging, 58% of patients with horseshoe kidneys observed for > 10 years remained asymptomatic.

Glenn, 1959. Glenn JF: Analysis of 51 patients with horseshoe kidney. *N Engl J Med* 1959; 261:684.

- Even when anatomic features appear dramatic, they may not be functionally relevant (e.g. hydronephrosis with normal drainage on mag3 renal scan).





Watch out for anatomic/functional correlation

684 THE NEW ENGLAND JOURNAL OF MEDICINE Oct. 1, 1959

ANALYSIS OF 51 PATIENTS WITH HORSESHOE KIDNEY*

JAMES F. GLENN, M.D.†

DURHAM, NORTH CAROLINA

51 consecutive horseshoe kidney patients monitored over a 10 year period.

58% remained asymptomatic.

13% had recurrent infections.

13% had episodic pain.

16% % had symptomatic stones.

TABLE 1. *Data in 51 Patients with Horseshoe Kidney.*

DATUM	NO. OF PATIENTS	PERCENTAGE
Sex:		
Males	28	54.9
Females	23	45.1
Major presenting signs & symptoms:		
Pain	17	33.3
Infection	12	23.5
Incidental finding (asymptomatic)	12	23.5
Passage of calculi	7	13.8
Diagnosis elsewhere	3	5.9
Method of initial diagnosis:		
Radiologic (intravenous or retrograde pyelograms)	42	82.3
Anatomic (autopsy)	6	11.8
Clinical (palpation)	3	5.9
Accessory features:		
Infection	21	41.2
Obstruction	18	35.3
Calculi	16	31.4
Uremia	3	5.9
Rovsing syndrome	3	5.9
No complications	14	27.5

Horseshoe kidney: symptomatic

- Most symptoms are related to hydronephrosis, infections or nephrolithiasis.
- 30% of patients have recurrent UTIs, “20% - 80%” have nephrolithiasis (as compared to 9-10% of the general population).
- Classic constellation of symptoms: vague abdominal pain radiating to the lower lumbar region, nausea and vomiting. Exacerbated by hyperextension of the spine.
  - Does not appear to be resolved by division of the isthmus.

Horseshoe kidneys lie outside the pelvic inlet and do not confer an increased risk during pregnancy or delivery.

Horseshoe kidneys do not appear to have a higher progression rate to renal insufficiency.

Review of the UNOS database for transplant recipients in 2000 showed no horseshoe kidney patients who underwent renal transplantation.

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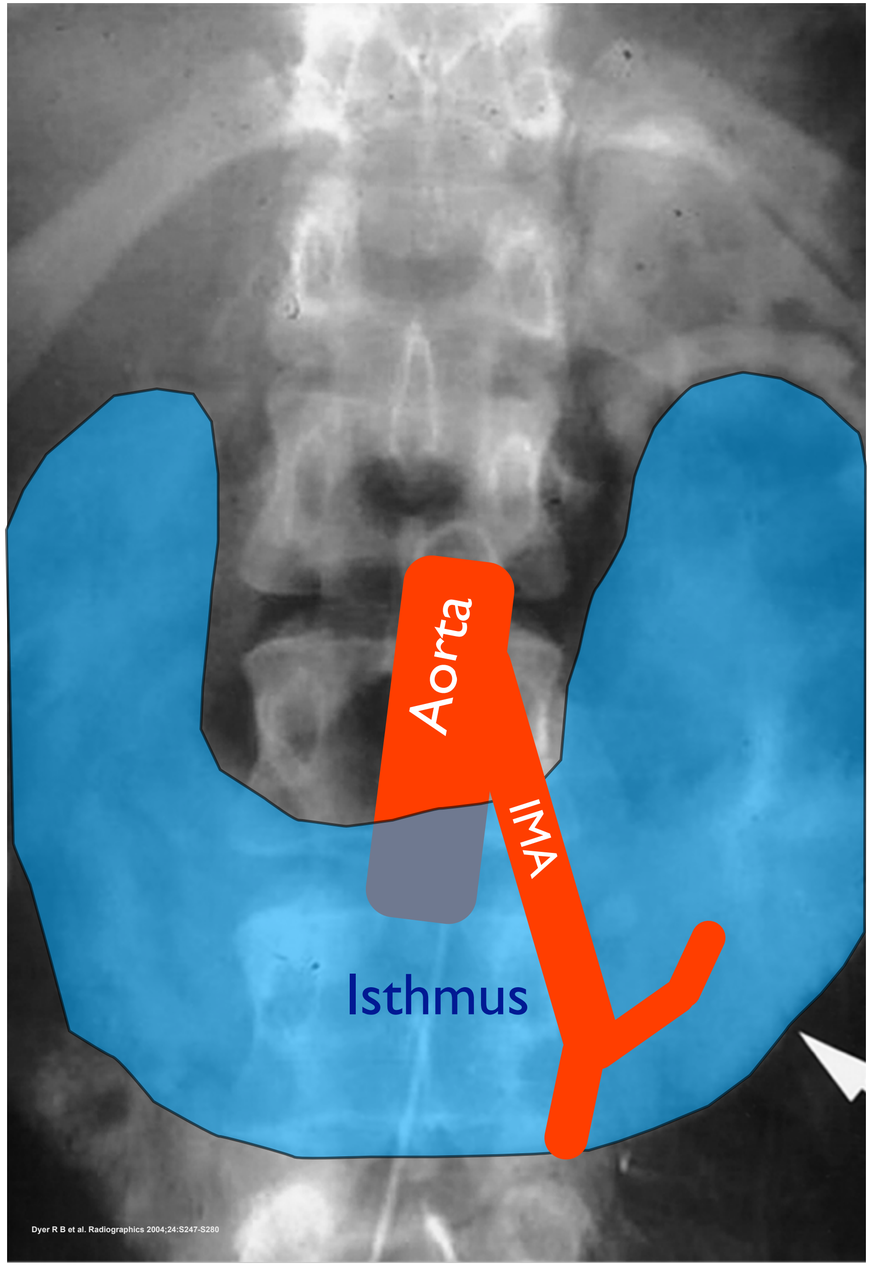
  → Infection
  - Surgical management (heminephrectomy, isthmus division, partial nephrectomy, donor nephrectomy)

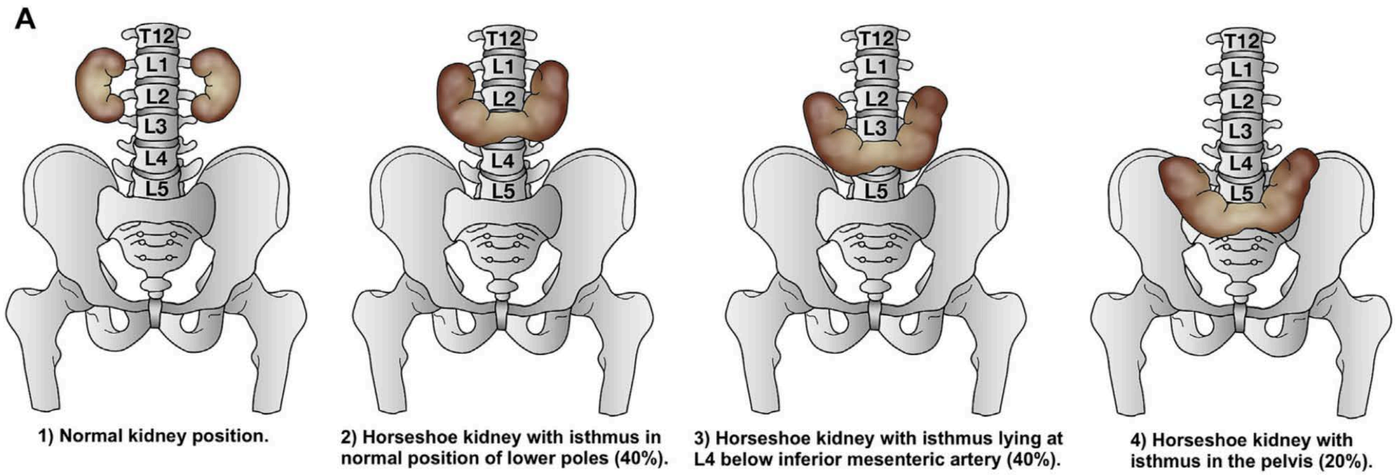
Critical Features # 1

Relationship to inferior mesenteric artery.

“Renal ascent is stopped by the junction of the aorta and inferior mesenteric artery.”

Kidneys are generally lower in the abdomen.

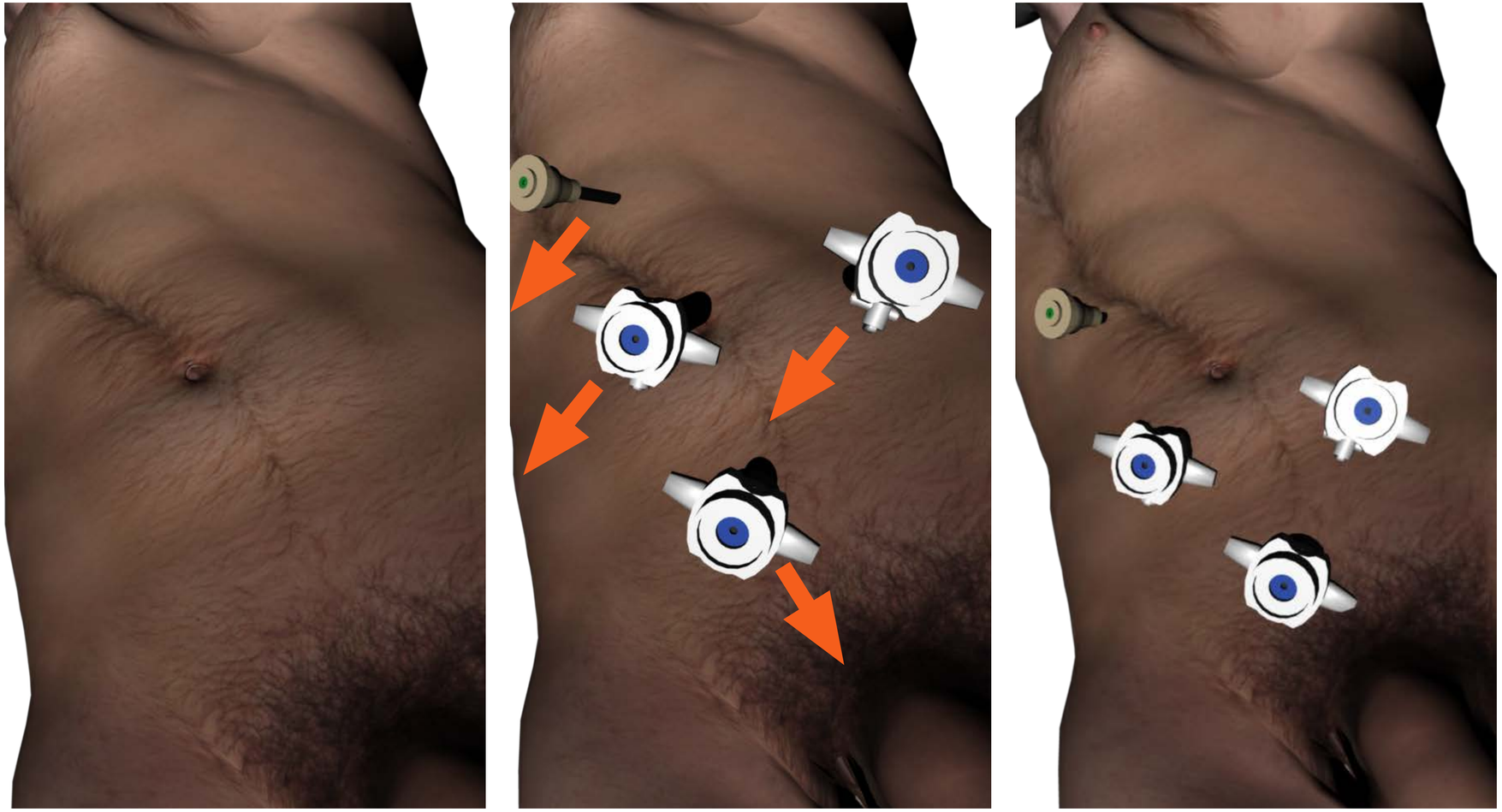




In truth, the kidneys are lower than normal in roughly 60% of cases.

The isthmus lies just below the IMA in 40%.

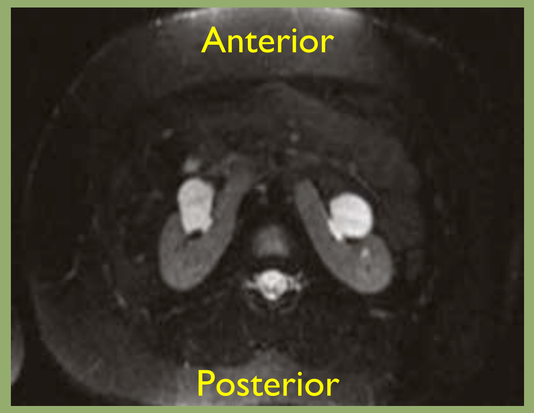
Journal of Pediatric Urology (2016) 12, 275e280

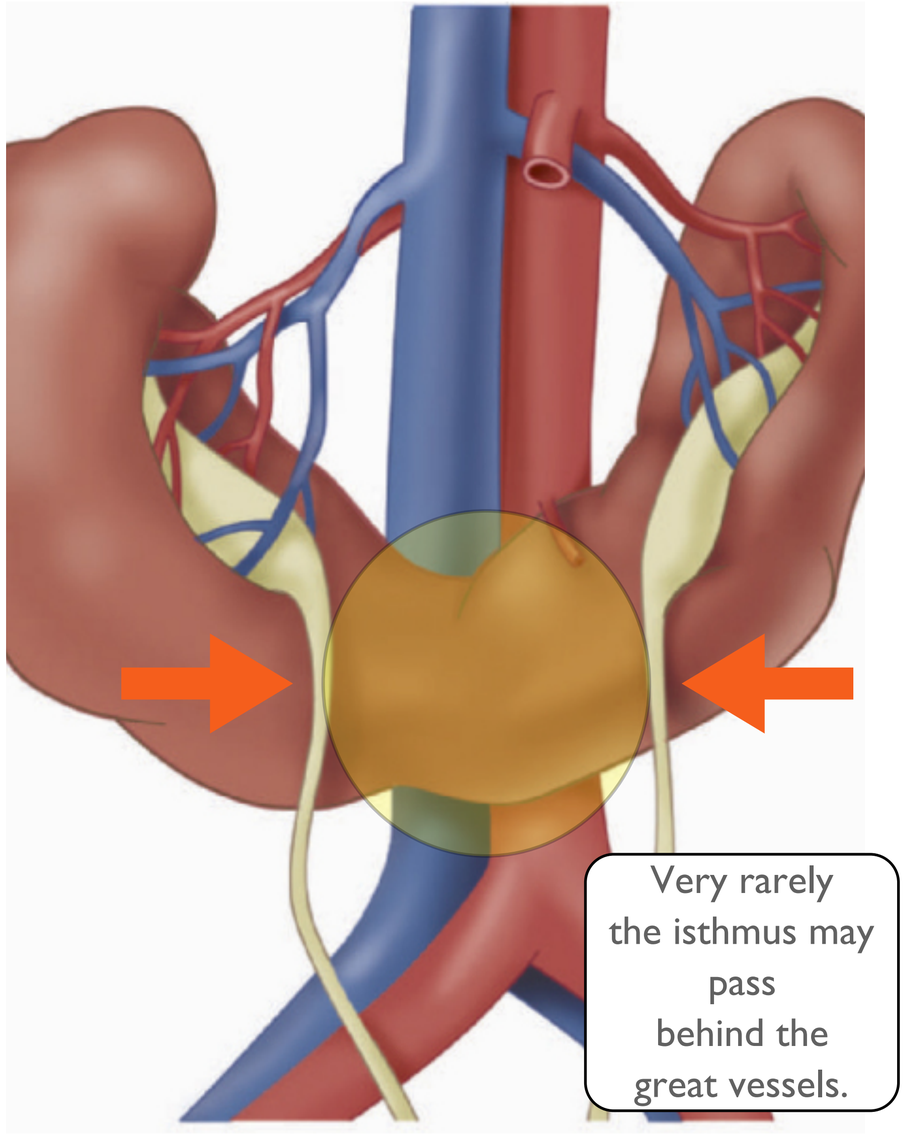


Trocar shifts lower and away from umbilicus

Critical Features #2

Anteriorly oriented renal pelvis and ureters.





Critical Features #3

Multiple renal vessels in 70% and variable vessels to isthmus. Vessels are smaller and originate lower.

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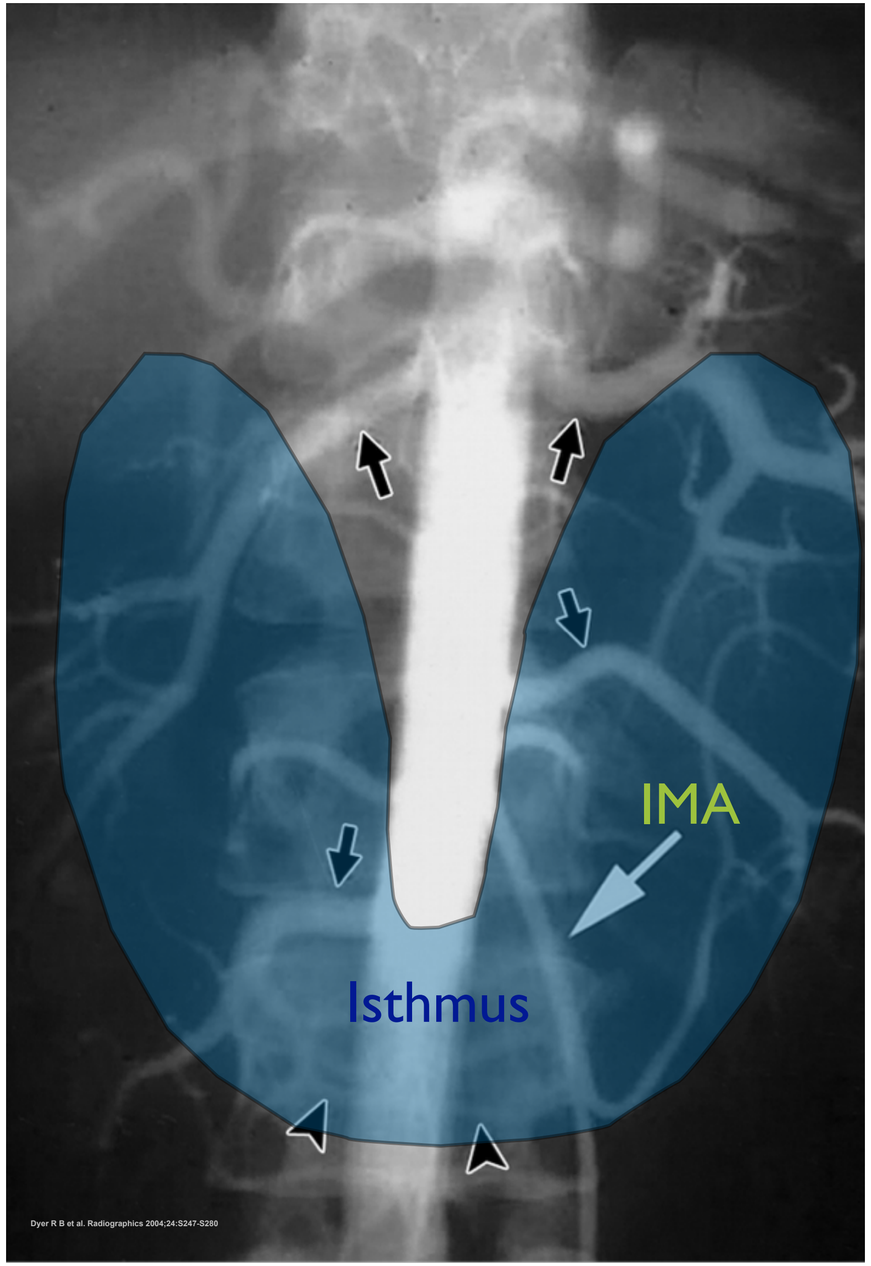
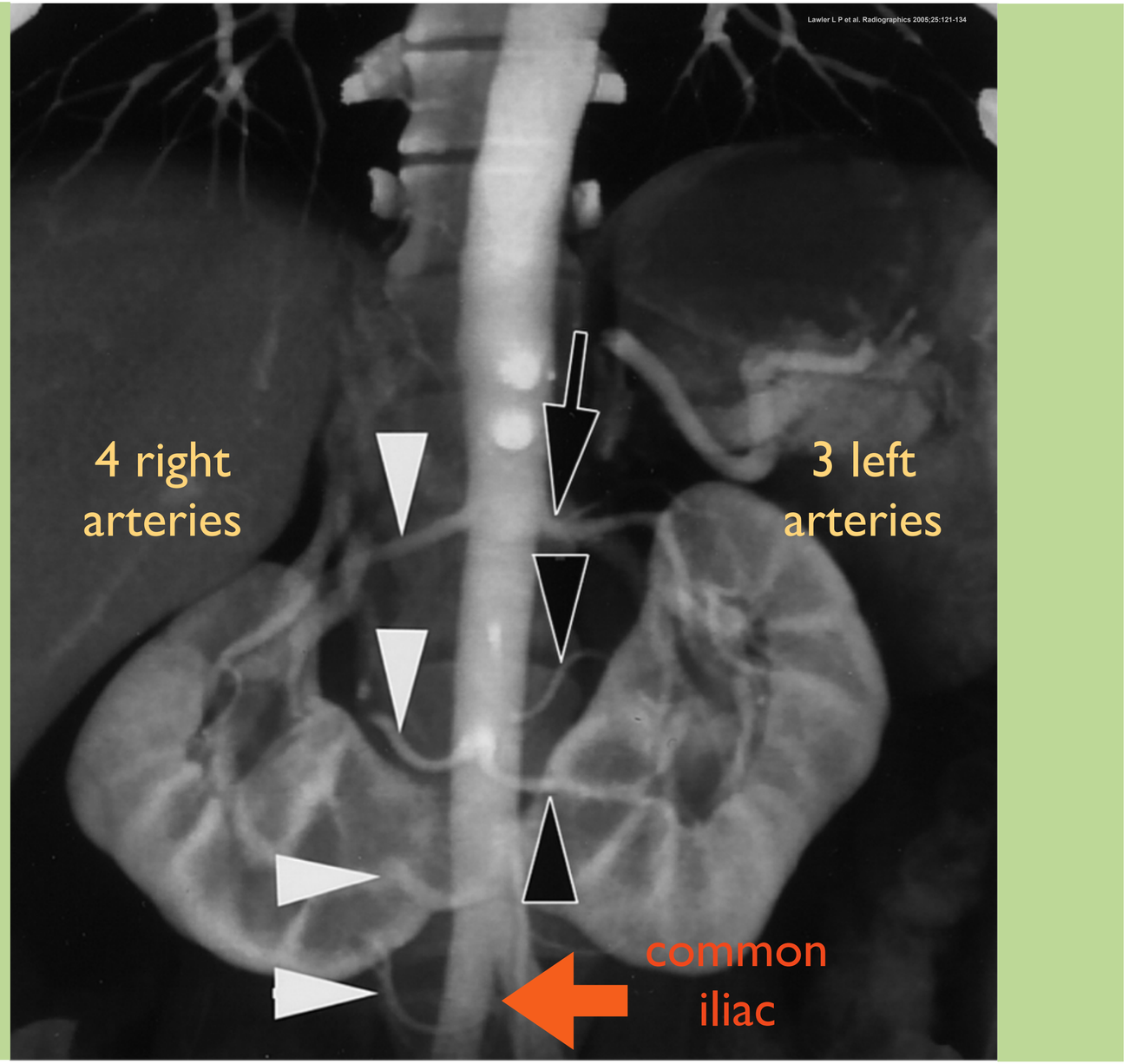
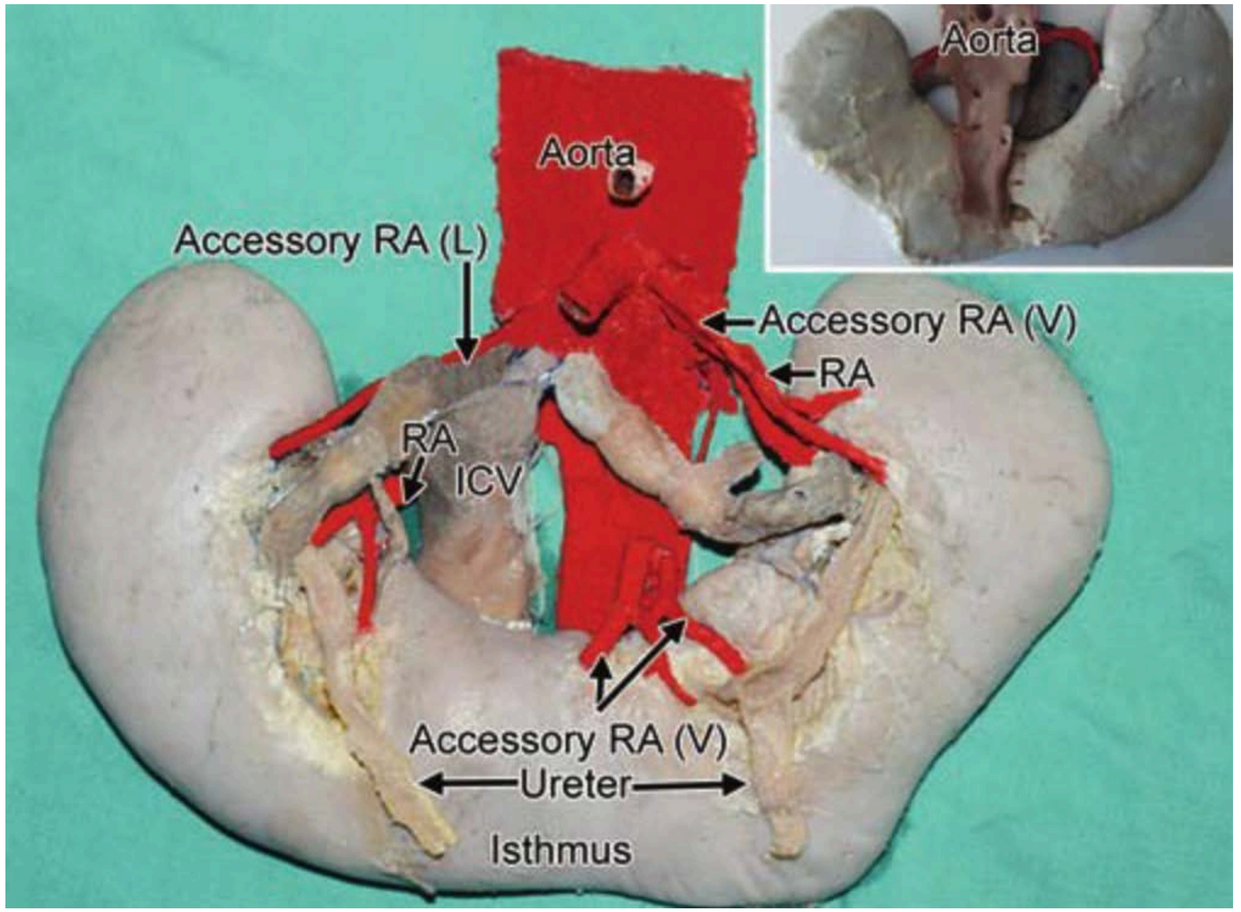



Lawler L P et al. Radiographics 2005;25:121-134
4 right arteries
3 left arteries
common iliac



Watch out for arteries entering the isthmus directly from the aorta or the iliacs.

Gupta T., et. al.: JPMER. Dec 2016,

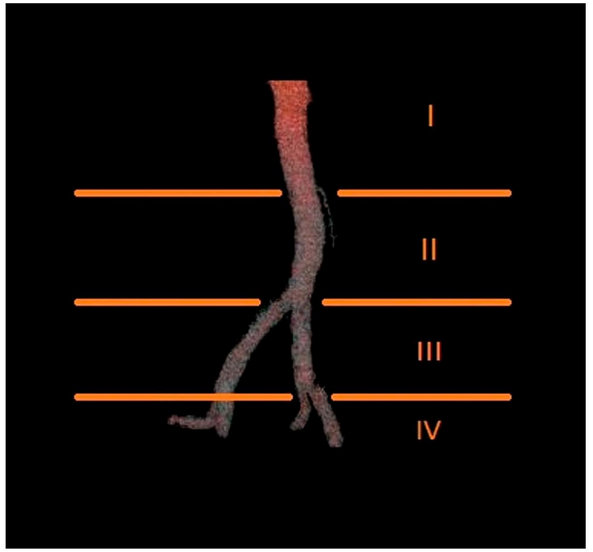


Figure 3. Diagram presenting the proposed levels of origin of renal arteries.

Horseshoe kidneys:

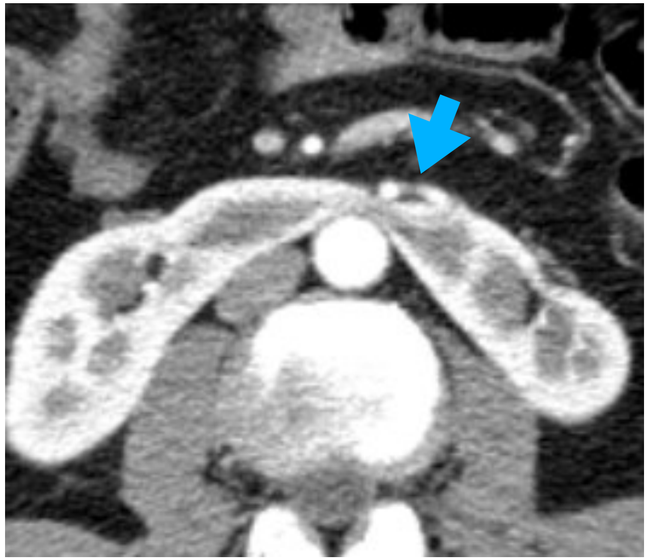
Smaller arteries
Arise lower on the aorta, common iliac or iliac
Smaller in caliber

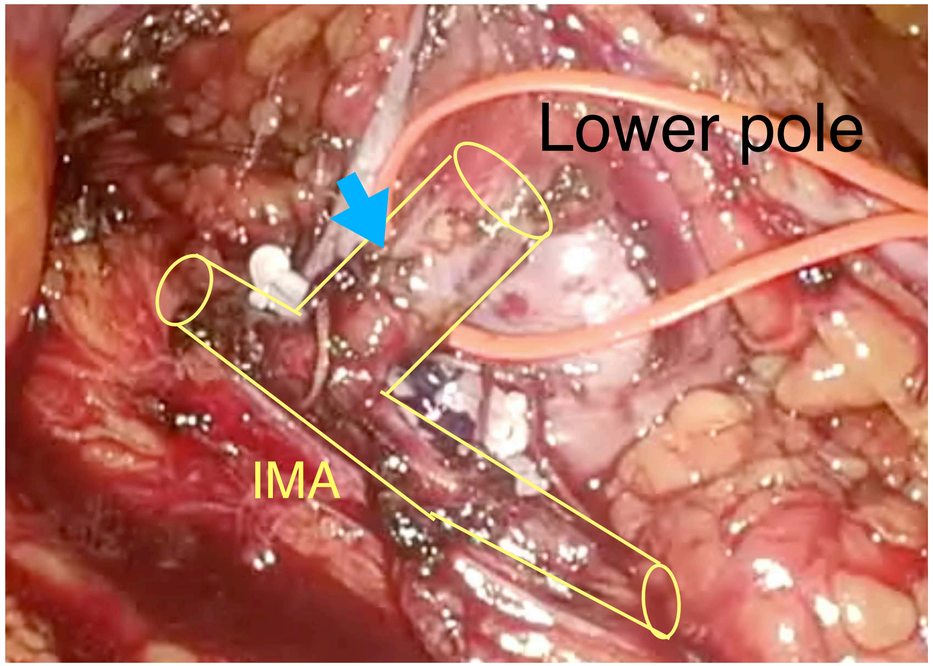
Table 2. The diameters of renal arteries according to branching level.

	Arteries Supplying Horseshoe Kidneys						Arteries Supplying Separated Kidneys					
Level of Origin of Renal Artery	N	Mean (mm)	Median (mm)	Min (mm)	Max (mm)	SD (mm)	N	Mean (mm)	Median (mm)	Min (mm)	Max (mm)	SD (mm)
I	230	4.54	4.60	0.60	8.50	1.64	596	5.53	5.70	1.00	9.80	1.61
II	108	4.28	4.20	1.40	7.40	1.35	2	4.45	4.45	2.80	6.10	2.33
III	57	3.41	3.30	1.10	6.30	1.11	0	0	0	0	0	0
IV	3	3.43	3.20	2.80	4.30	0.78	0	0	0	0	0	0

Retrospective CT angiogram study:
248 normal kidney patients vs. 88 horseshoe kidney patients.

Majos M, et. al.: J. Clin. Med. 2019, 8, 464





Tricky vascular anatomy

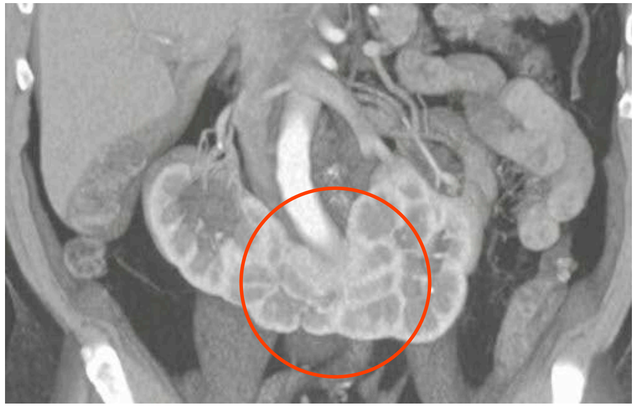
Critical Features #4

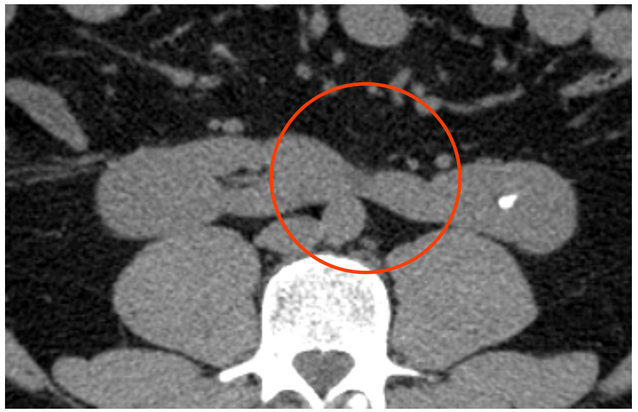
Significant variation in isthmus thickness and presence of collecting system in the isthmus.

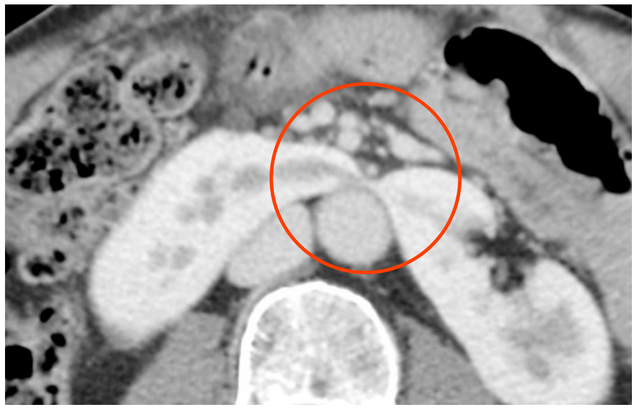
The isthmus is usually bulky and located at the L3 or L4 level.

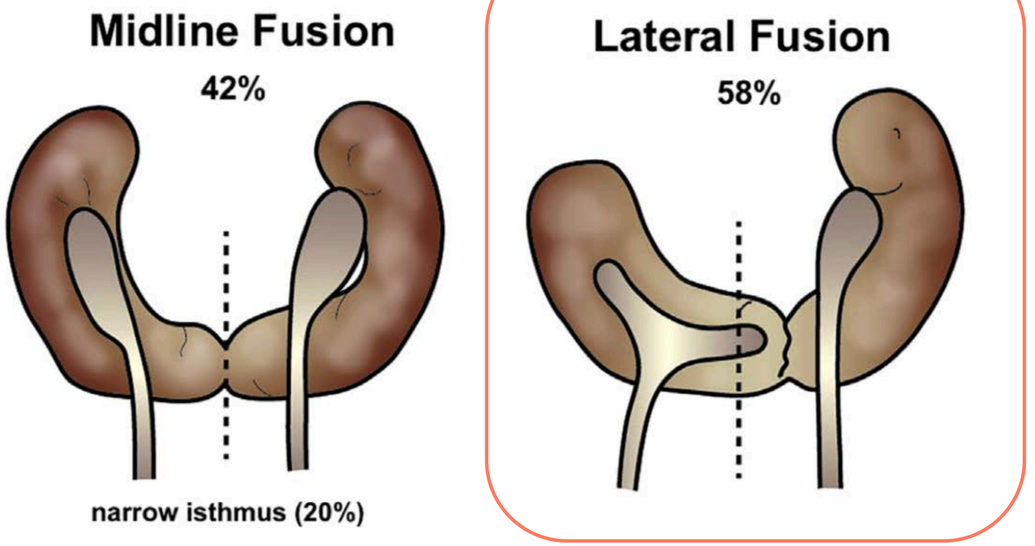
Occasionally it is just a thin fibrous band.

In some cases, the lowermost calyces overlie the vertebral column.









Watch Out!

Symmetrical or asymmetrical systems.

Asymmetrical systems are LEFT side dominant in 70%.

Vertebral column

Case Report

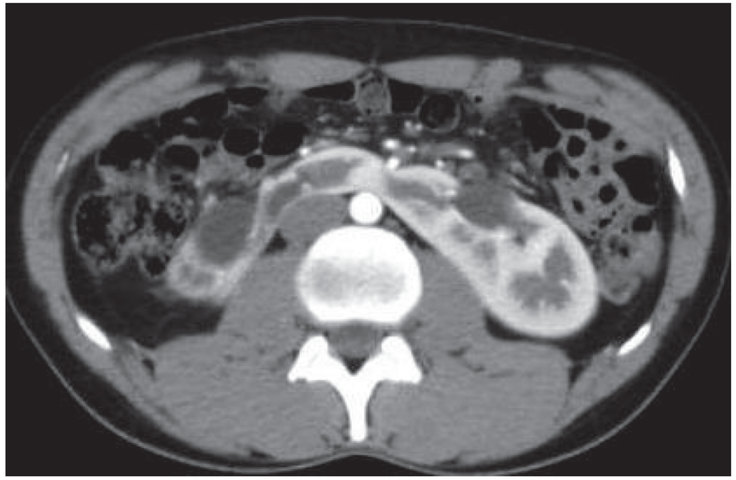
A Case of Incomplete Removal of Horseshoe Kidney by Laparoscopic Nephrectomy in an Adult Leading to Urinary Leak: An Eye Opener

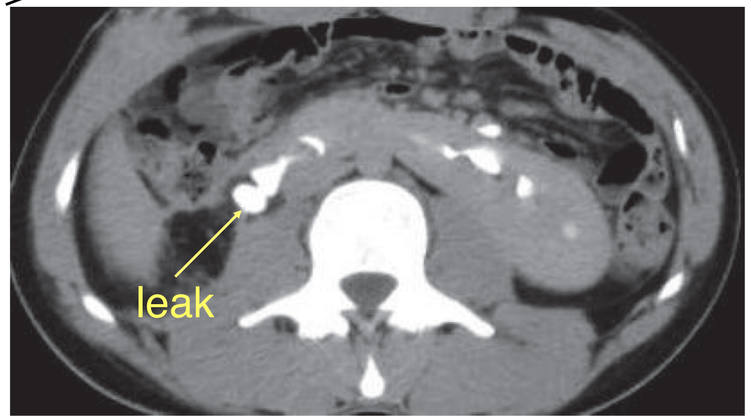
S. Venkat Ramanan, P. Velmurugan, A. R. Bhaskar Prakash, Anuj Arora, and LeelaKrishna Karri

Department of Urology, Sri Ramachandra Medical College and Research Institute, Chennai, India

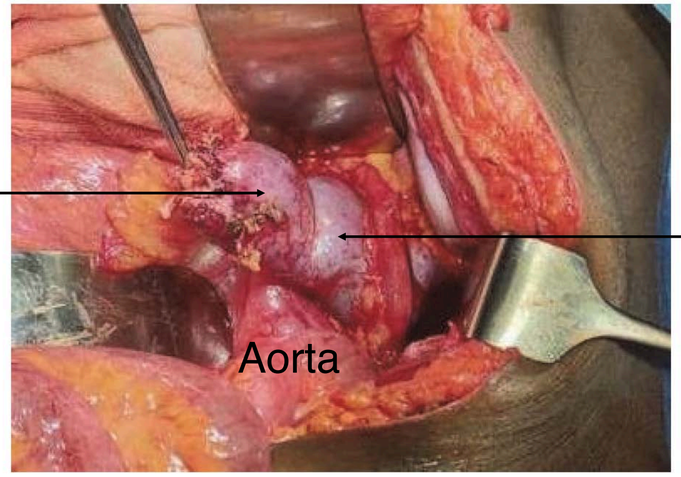
Hindawi
Case Reports in Urology
Volume 2019, Article ID 4132521, 3 pages

Laparoscopic right Nx





Residual right lower pole with fusion well to left of aorta.

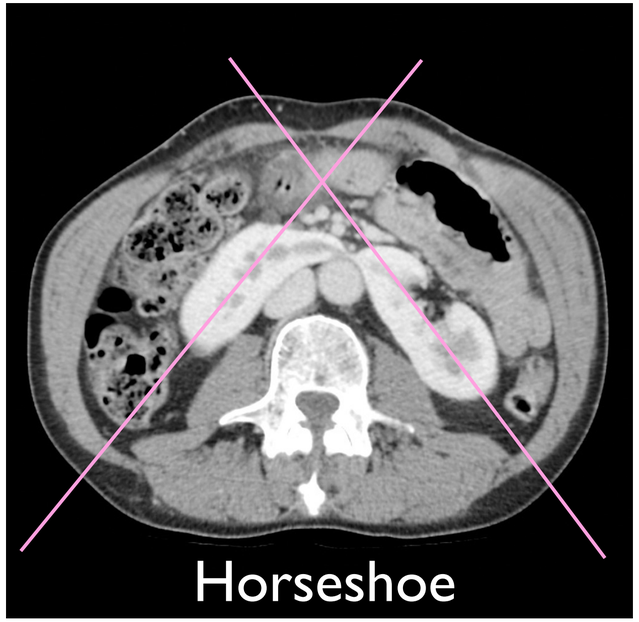


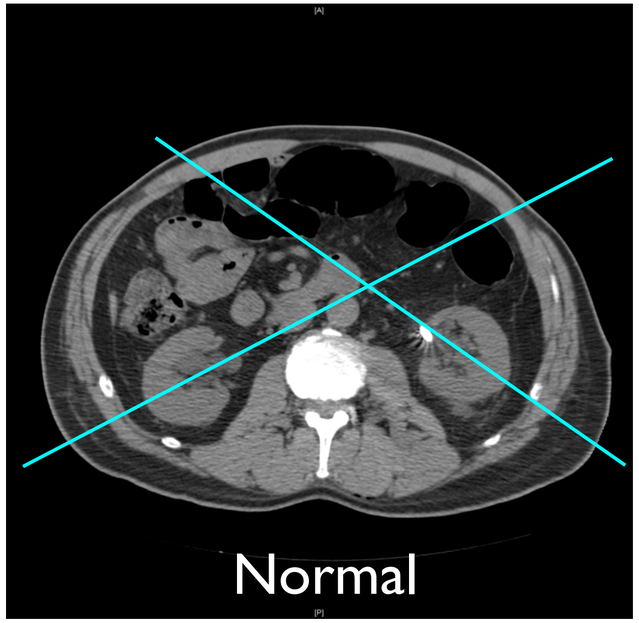
Left lower pole

Critical Features #5

The kidneys do not rotate completely antero-medially due to the fusion event.

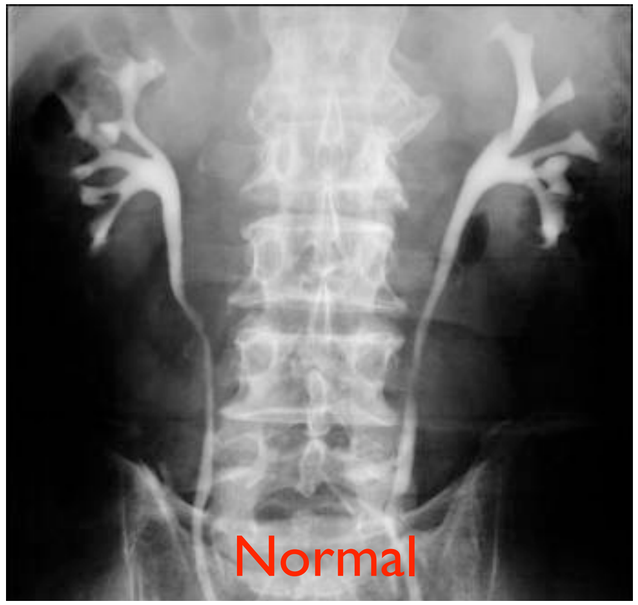
This results in kidneys that are posteriorly rotated.





Critical Features #6

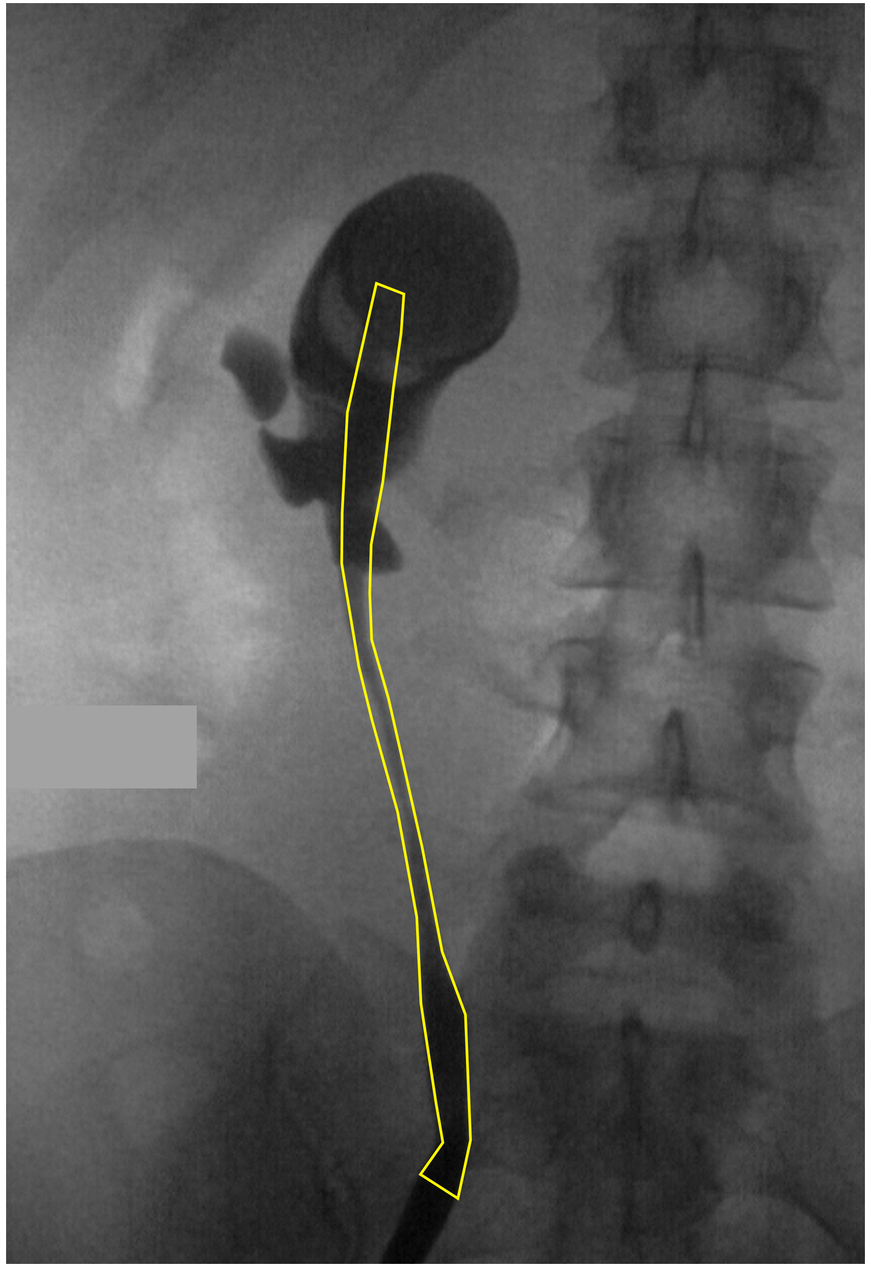
Horseshoe kidneys have the same number of calyces as normal kidneys but these calyces are atypical in orientation.



Critical Features #7

The ureter often inserts high into the renal pelvis.

The lower ureter usually enters the bladder normally.



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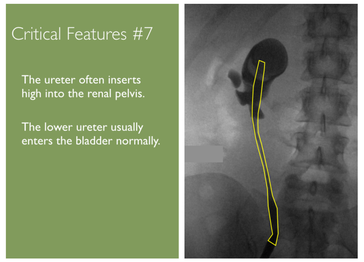
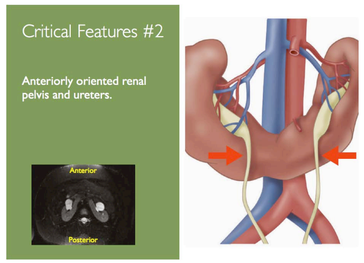




Increased risk of urinary stasis

Increased UTI risk

Nephrolithiasis

Dietary factors

Metabolic factors

Genetic factors

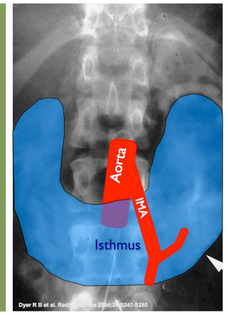
Nephrolithiasis

Critical Features #1

Relationship to inferior mesenteric artery.

Renal ascent is stopped by the junction of the aorta and inferior mesenteric artery.

Kidneys are lower in the abdomen.



Kidneys lower in abdomen

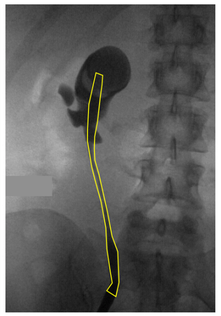
ESWL

Difficulty targeting during ESWL:
due to transverse processes, vertebral bodies, bony pelvis, bowel gas. May need prone ESWL.

Critical Features #7

The ureter often inserts high into the renal pelvis.

The lower ureter usually enters the bladder normally.



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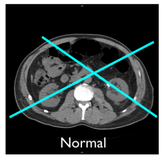


Ureteroscopy

Difficult angles during ureteroscopy. Hard to reach all calices.

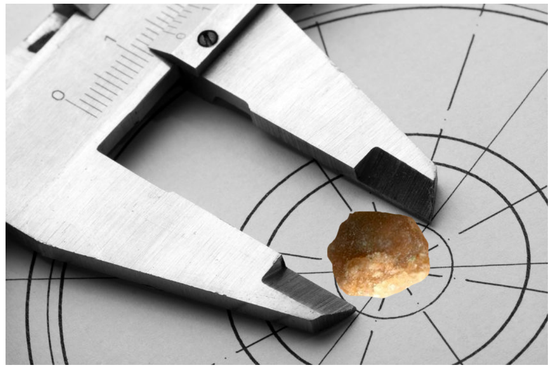
PCNL

Limitations in percutaneous access approach.

Any modality that leaves fragments behind may be less effective in the horseshoe kidney due to suboptimal urine drainage.

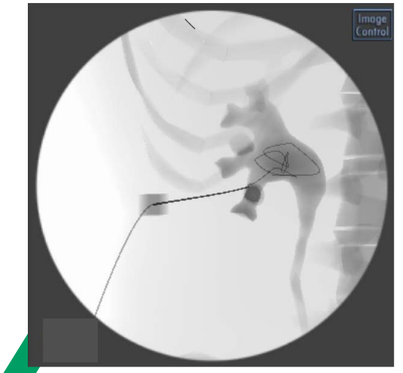
ESWL

Ureteroscopy

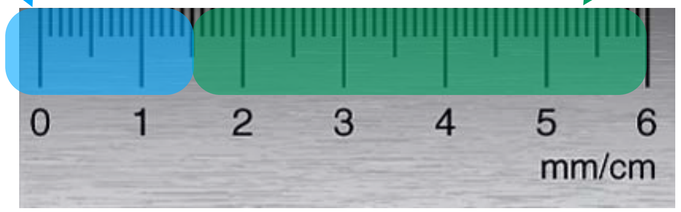


Stone Size

ESWL



PCNL



ESWL in horseshoe kidney

Traditionally has been the mainstay of therapy for stone burden ≤ 1.5 cm

Table 1
Results of SWL patients with horseshoe kidneys

Investigator, Y	Mean Stone Diameter, mm	No. of Patients	Fragmentation Rate, %	Stone-Free Rate, %	Retreatment Rate, %
Esuvaranathan,[122] 1991	12	7	Not Reported	59	50
Kirkali et al,[5] 1996	24	18	78	28	57
Smith,[123] 1989	Not Reported	14	Not Reported	79	29
Bhatia and Biyani,[2] 1994	28	27	Not Reported	70	48
Sheir et al,[7] 2003	13.5	49	Not Reported	71	71
Tunc et al,[6] 2004	22	46	Not Reported	66	Not Reported
Ray et al,[9] 2011	9.5	41	Not Reported	39.1	71

Tan YK: Management of stones in abnormal situations. *Urol Clin N. Am.* 40, 2013

Total stone free rate = 60% (39 to 79%)

Retreatment rate = 61% (29 to 71%)

PCNL in the horseshoe kidney

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DOI: 10.1089/end.2008.0051

The Presence of Horseshoe Kidney Does Not Affect the Outcome of Percutaneous Nephrolithotomy

Nicole L. Miller, M.D.,[1] Brian R. Matlaga, M.D.,[2] Shelly E. Handa, R.N., B.S.N.,[3] Larry C. Munch, M.D.,[3] and James E. Lingeman, M.D.[3]

n = 44
Primary stone free rate: 84%
Second look in 11%
Overall stone free: 93%

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Pp. 531–536
DOI: 10.1089/end.2009.0264

Percutaneous Management of Staghorn Calculi in Horseshoe Kidneys: A Multi-Institutional Experience

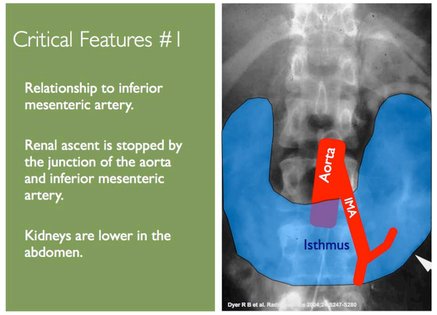
Evangelos N. Liatsikos, M.D., Ph.D.,[1] Panagiotis Kallidonis, M.D.,[1] Jens-Uwe Stolzenburg, M.D., Ph.D.,[2] Micheal Ost, M.D., Ph.D.,[3] Frank Keeley, M.D., Ph.D.,[4] Olivier Traxer, M.D., Ph.D.,[5] Norberto Bernardo, M.D., Ph.D.,[6] Petros Perimenis, M.D., Ph.D.,[1] Arthur D. Smith, M.D., Ph.D.[3]

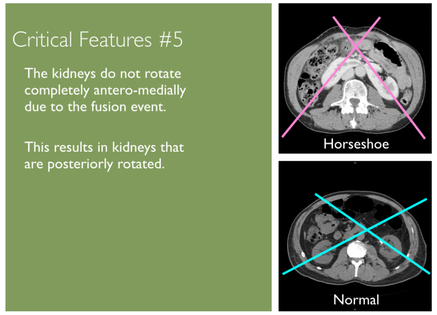
n = 17
Primary stone free rate: 82%

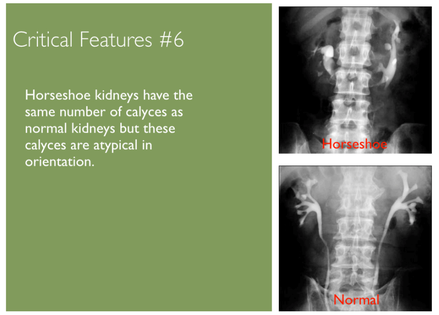
Consensus: Stone clearance rates generally equivalent to PCNL in normal kidneys.

PCNL in horseshoe: caveats #1

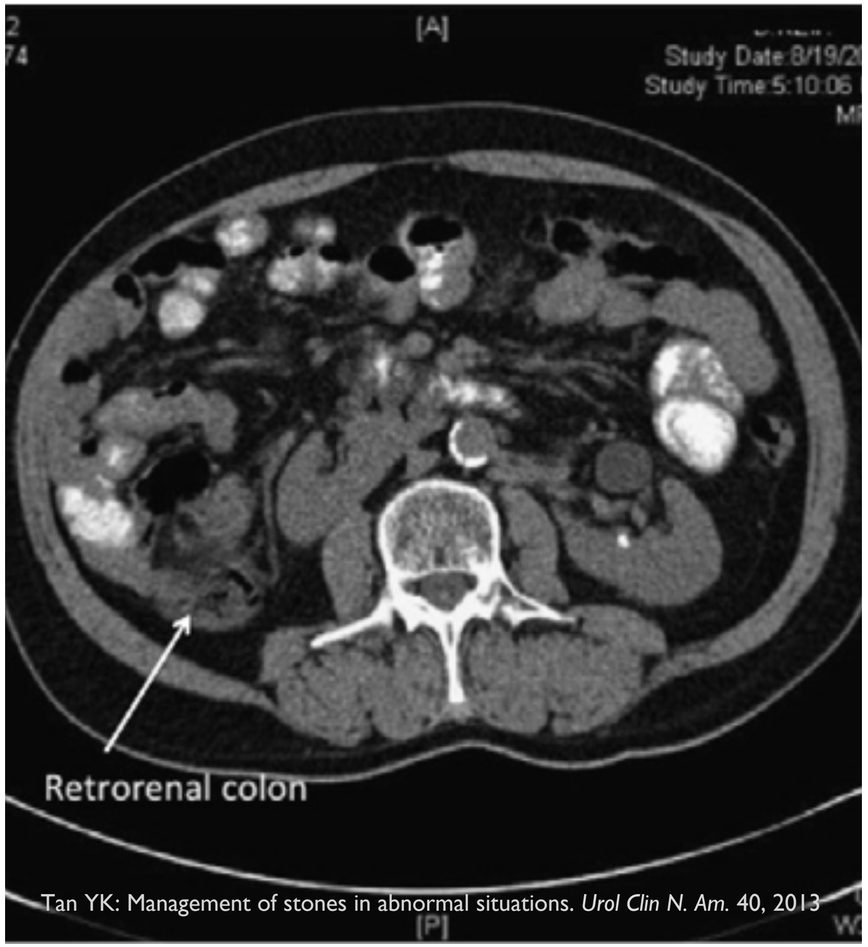
- Percutaneous access can be more technically difficult due to malrotation, lower renal units.







- Almost all require upper pole, posterior calyceal access.
- Some require CT guided or laparoscopic-assisted access.

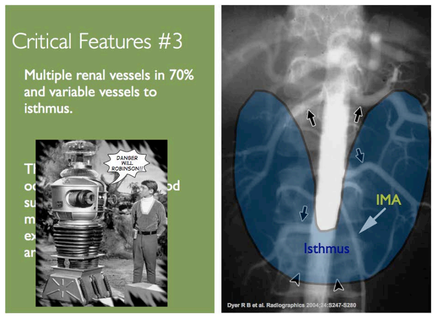


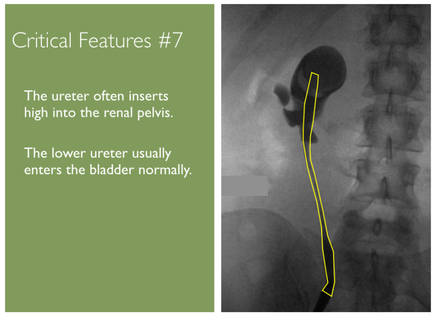
Tan YK: Management of stones in abnormal situations. *Urol Clin N. Am.* 40, 2013

Good news and bad news.....

PCNL in horseshoe: caveats #2

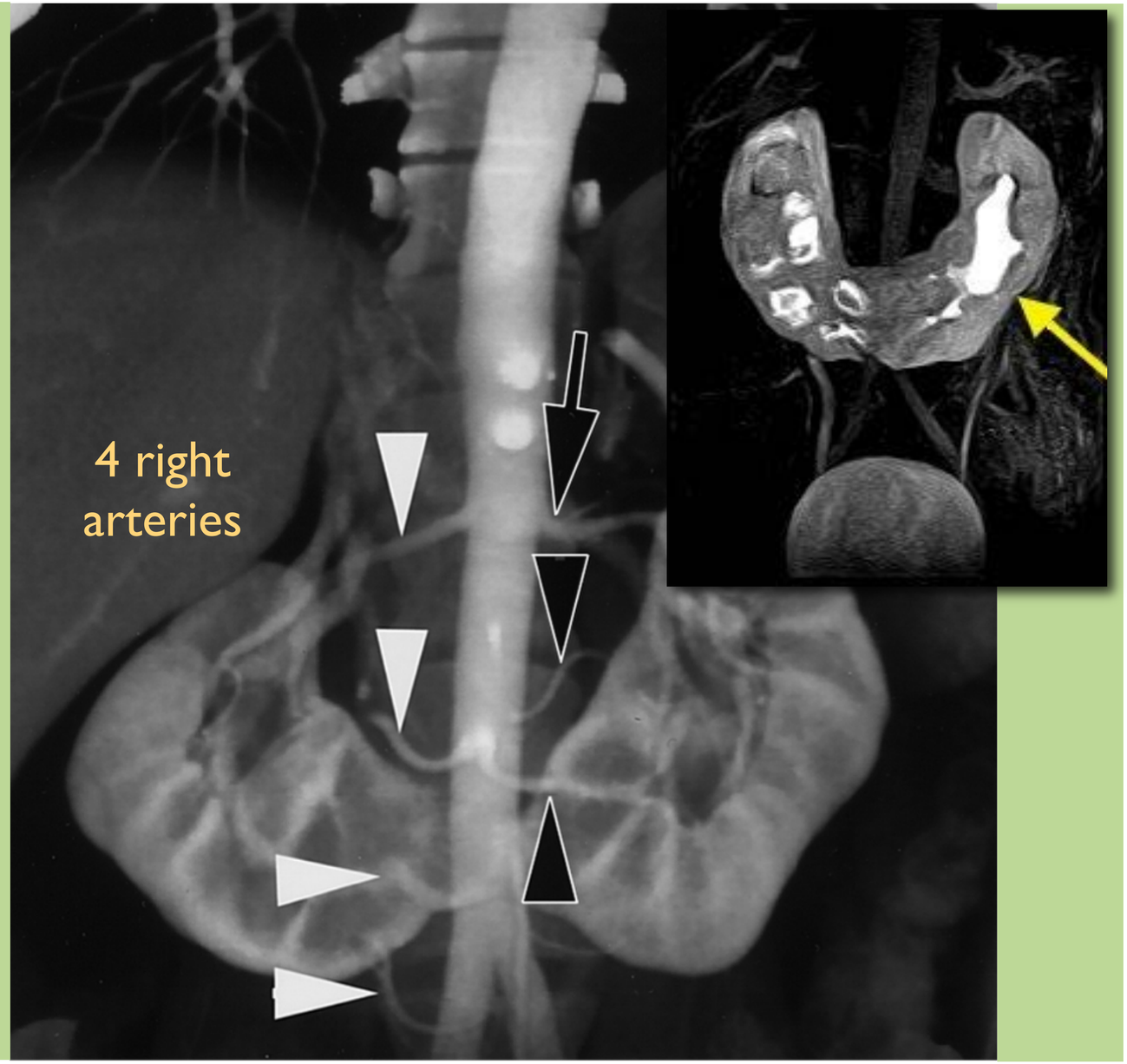
- Multiple vessels and UPJ obstruction can also complicate access to the calyx of entry and the ureter.





- This is a factor almost exclusively when attempting lower pole access. Posterior vessels into the isthmus preclude access there.
- Bleeding risk is not increased in horseshoe kidney PCNL due to medial entry point of vessels..

Janetschek, G. and Kunzel, K. H. Br J Urol: 62, 1988

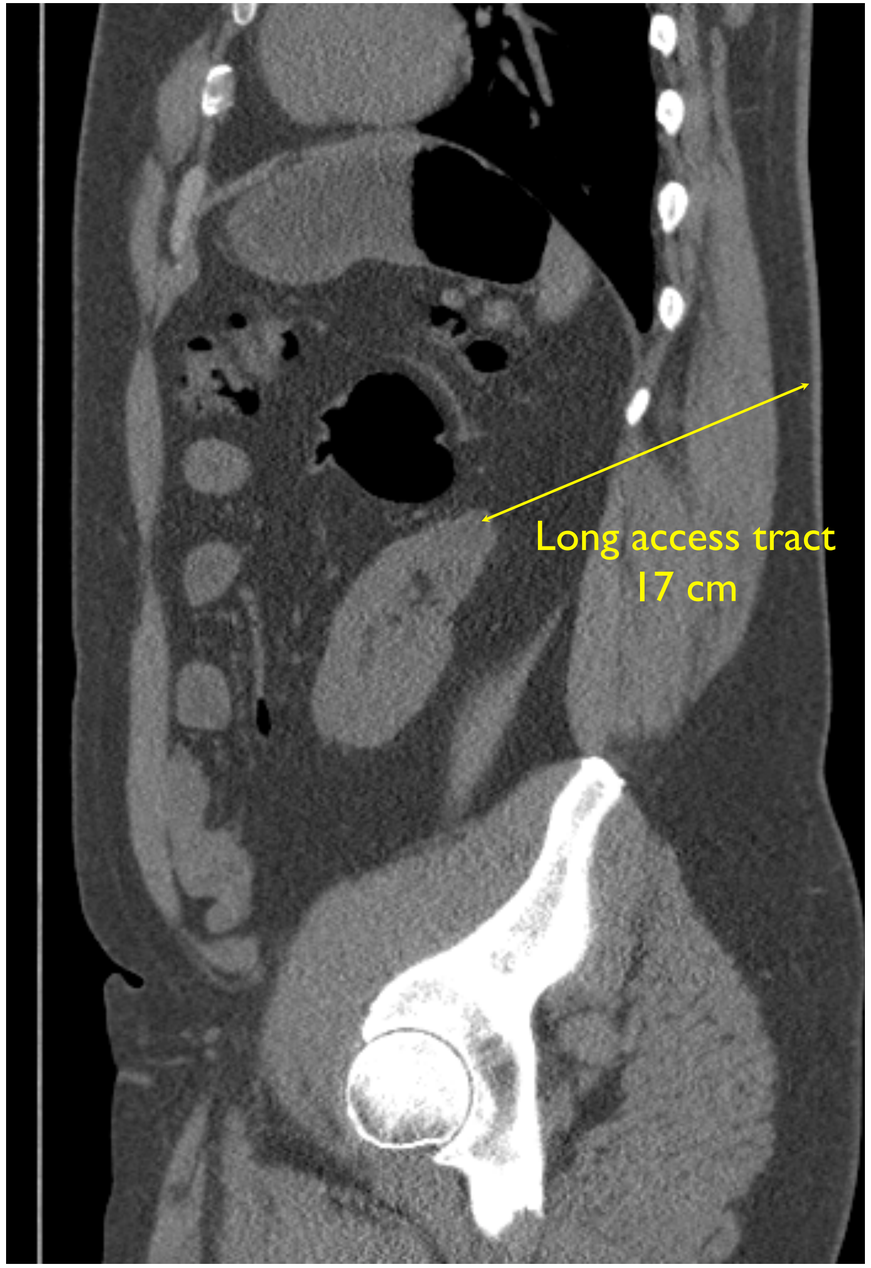

4 right
arteries

Due to kidney location, the access tract can be very long in horseshoe kidney patients, requiring special instrumentation and technique.

long nephroscopes

flexible nephroscopes

buried sheath

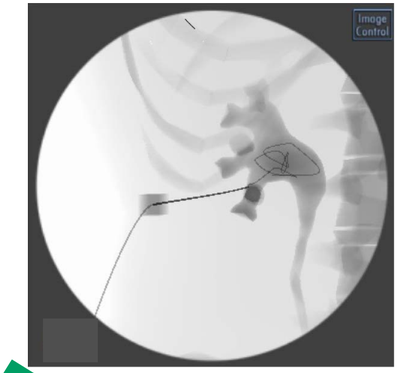


Low stone clearance rate
High retreatment rate

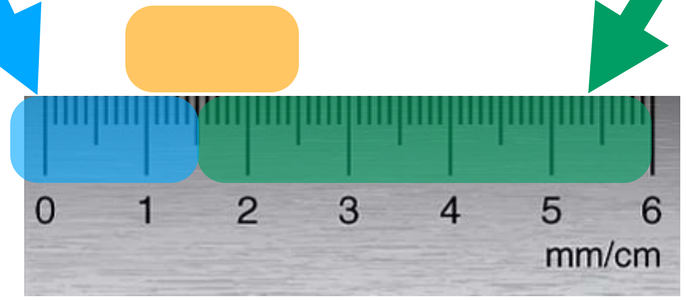
ESWL

Ureteroscopy

High complication rate

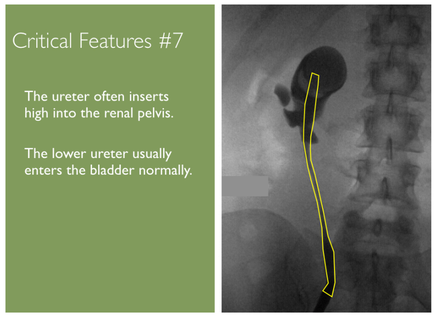


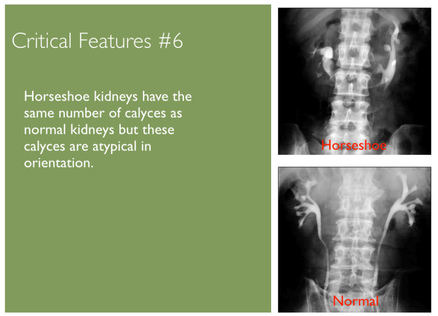
PCNL



Ureteroscopy in the horseshoe kidney

- Technically challenging.
- Usually requires:
  - flexible instrumentation
  - access sheath
- Not all calyces can be accessed.
- Staged procedures are common.
- Subsequent drainage remains a factor.

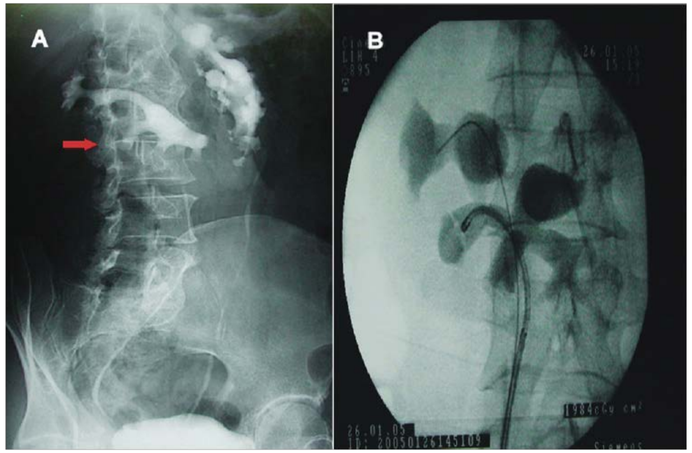




Flexible Ureterorenoscopy With Holmium Laser in Horseshoe Kidneys

Benoit Molimard, Saeed Al-Qahtani, Amine Lakmichi, Majed Sejiny, Sixtina Gil-Diez de Medina, Xavier Carpentier, and Olivier Traxer

UROLOGY 76 (6), 2010



- 17 patents
- Average stone burden 1.6 cm.
- 42% of patients required a second procedure.
- On average 1.5 procedures per patient (total of 25).
- Overall stone free rate was 88%.
- No major complications, no transfusions.
- One patient treated for pyelonephritis.

Ureteroscopic Urinary Stone Treatment Among Patients With Renal Anomalies: Patient Characteristics and Treatment Outcomes

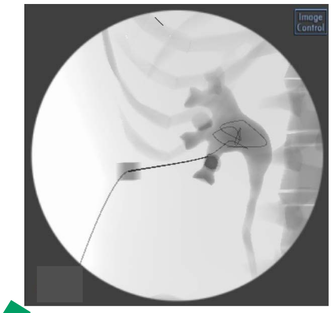
Jaap D. Legemate, Barbaros Baseskioglu, Jakub Dobruch, Jorge Gutierrez-Aceves, Oscar Negrete, Carlos Rioja Sanz, Muharrem Murat Yildiz, and Jean J.M.C.H. de la Rosette

UROLOGY 110, 2017

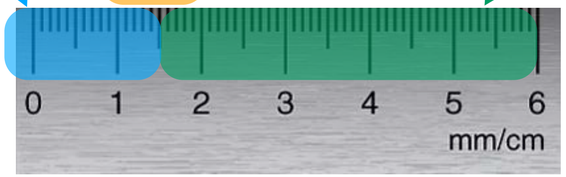
Outcomes	Horseshoe Kidney n = 43
Stone-free rate n (%)	
Renal stones overall SFR*	17 (77.3)
≤80 mm^2	10 (83.3)
>80 mm^2	7 (70.0)
	(n = 22)
Ureteral stones overall SFR	17 (85.0)
≤80 mm^2	15 (93.8)
>80 mm^2	2 (50.0)
	(n = 20)
Evaluation method n (%)†	
Computed Tomography	4 (9.3)
Ultrasound	20 (46.5)
X-ray/KUB	21 (48.8)
IVU	1 (2.3)
Retrograde study	1 (2.3)
Intraoperative confirmation	6 (14.0)
Other	2 (4.7)
Intraoperative complications n (%)	5 (11.6)
Overall	3 (7.0)
Bleeding	1 (2.3)
Perforation	1 (2.3)
Failed procedure	0 (0)
Conversion	0 (0)
Avulsion	0 (0)
Other	(n = 43)
Postoperative complications n (%)	3 (7.0)
Overall	1 (2.3)
Bleeding	0 (0)
Fever (>38.0)	1 (2.3)
UTI	0 (0)
Sepsis	1 (2.3)
Other	(n = 43)
Median length of hospital stay in days, [IQR]	1 [1-2]
	(n = 43)
Retreatment n (%)	7 (16.3)
	(n = 43)
Readmission < 3 months n (%)	5 (12.5)
	(n = 40)

Ureteroscopy

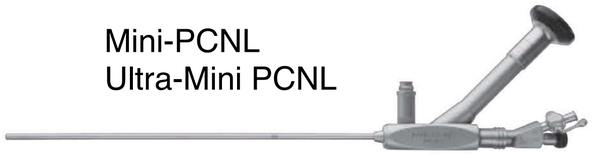
ESWL



PCNL

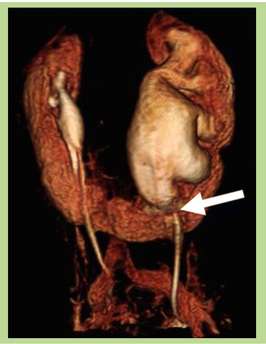


?

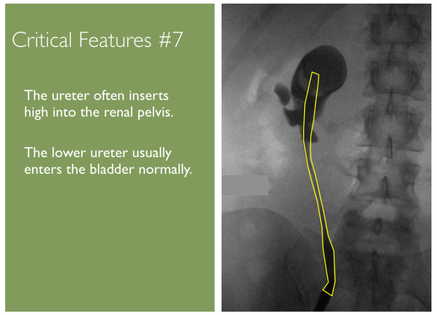


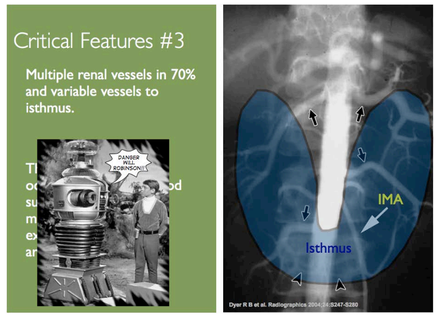
Mini-PCNL
Ultra-Mini PCNL

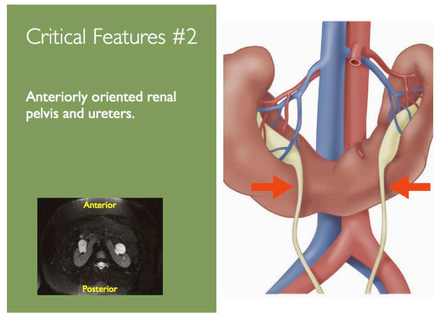
UPJ obstruction in horseshoe kidneys



- Incidence is 15 - 30% in the horseshoe population.







- Conventional open management included dismembered pyeloplasty, division of isthmus and nephropexy.
- More recent studies confirm that division of isthmus and nephropexy are not necessary in most cases.

Success Rates (1° UPJ)

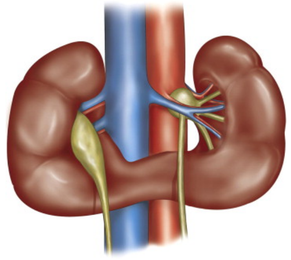
- Acucise endopyelotomy - 56 - 77 %
- Endopyelotomy - 62 - 94%
- Laparoscopic pyeloplasty - 89 - 98%
- Open pyeloplasty - 86 - 93%

Depends heavily on patient selection criteria:

Degree of hydronephrosis
Presence of crossing vessel
Degree of renal function

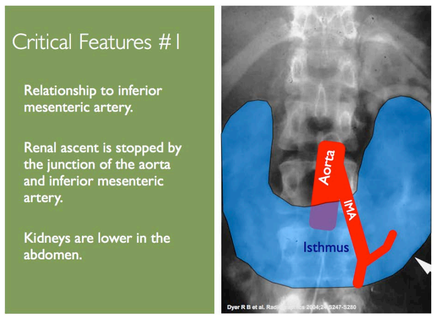
Also....with longer followup (5-10 yrs), we are seeing lots of late failures with endopyelotomy...

Crossing vessels can be seen in 87% of endopyelotomy failures.



Tips and tricks

- Lower placement of trocars.
- Transperitoneal, and sometimes transmesenteric, approach is favored due to anterior location of pelvis and ureter relative to isthmus.
- A preoperative CT angiogram may be helpful to provide a roadmap of aberrant vasculature.
- Pelvic reduction is at the discretion of the surgeon. Correction of high insertion is not....



Don't be a T-rex, spread out the trocars away from target.

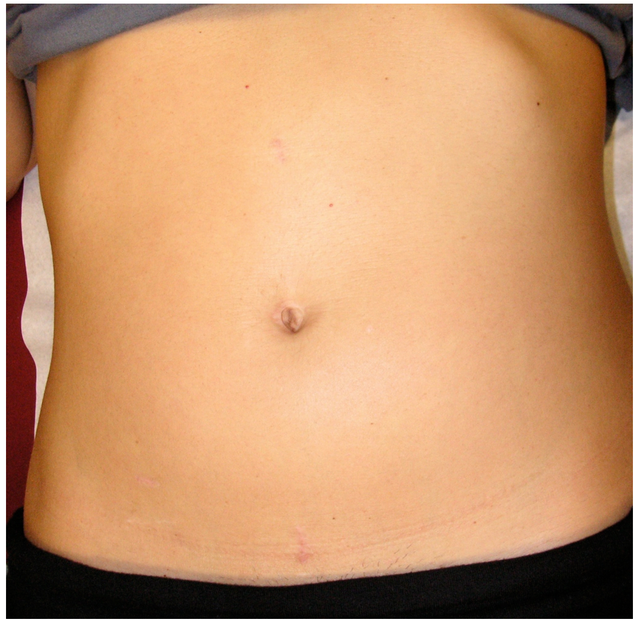
Case example

31 year old woman with right upper quadrant pain and microscopic hematuria.

Pain generally worse with alcohol intake.

No prior surgery.

- Robotic dismembered pyeloplasty and pyelolithotomy performed.
- Multiple aberrant vessels and high insertion present.
- Large stone placed into LapSac.
- LapSac exteriorized at umbilicus and stone fragmented and evacuated with nephroscope and Cyberwand.
- Smooth postop recovery. Symptom free without new stone formation at 4 years postop.

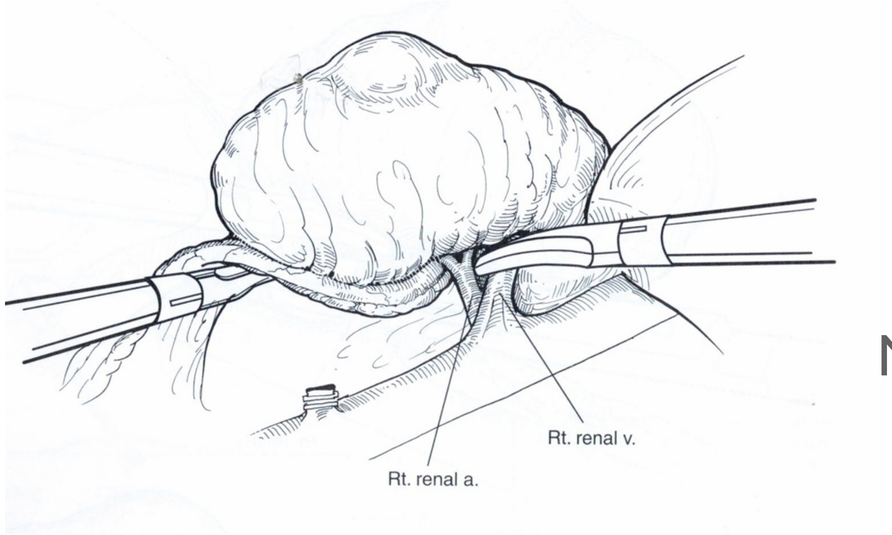


Heminephrectomy

- In some cases (malignancy, infection), heminephrectomy is indicated and can be performed using minimally invasive approaches (laparoscopic, single site laparoscopic or robotic) in horseshoe kidney patients.
- Issues:
  - Positioning of trocars.
  - Anticipate and control multiple vessels
  - Divide the isthmus
  - Be careful for short arteries feeding the isthmus from the aorta.

Heminephrectomy

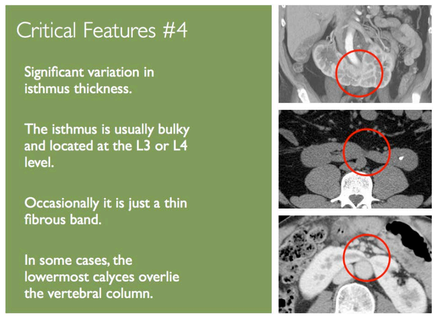
- Skill set is a fusion of skills used for laparoscopic donor nephrectomy and laparoscopic/robotic partial nephrectomy.
- Generally favor a top down approach, dealing with the isthmus as the last step once everything else is mobilized.

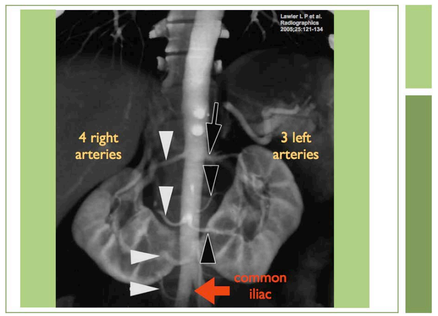


Not so effective with horseshoe kidney due to tethering at isthmus.

Dividing the isthmus

- Methods depend on thickness of isthmus.
  - Harmonic scalpel or ligasure for thin fibrous isthmus. Stapler also an option for medium thickness without collecting system.
  - Scissors with oversew/reconstruction for thick, "meaty" isthmus in fashion similar to MIS partial Nx.
    - Laparoscopic Satinsky clamp can be helpful for contralateral parenchymal control. In my experience, bulldog clamping of contralateral lower pole vessels is unnecessary.
  - Watch out for short posterior vessels!





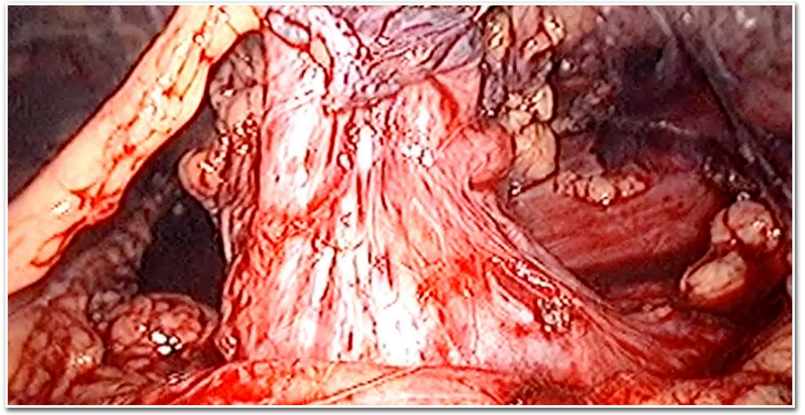
Case example

24 year old patient with horseshoe kidney and recurrent episodes of pyelonephritis.

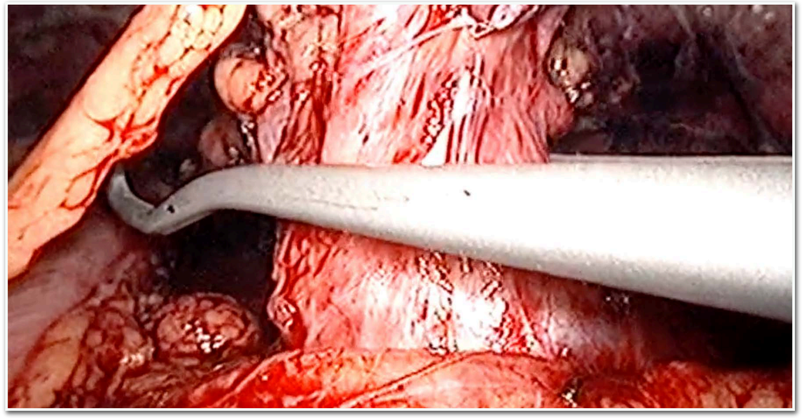
Severe episode of urosepsis necessitating PCN placement.

CT scan shows burned out, decompressed right renal moiety.

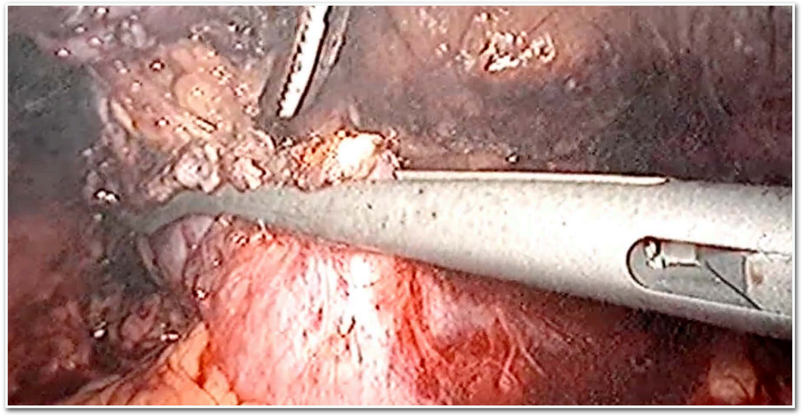
Elevation of right renal moiety.



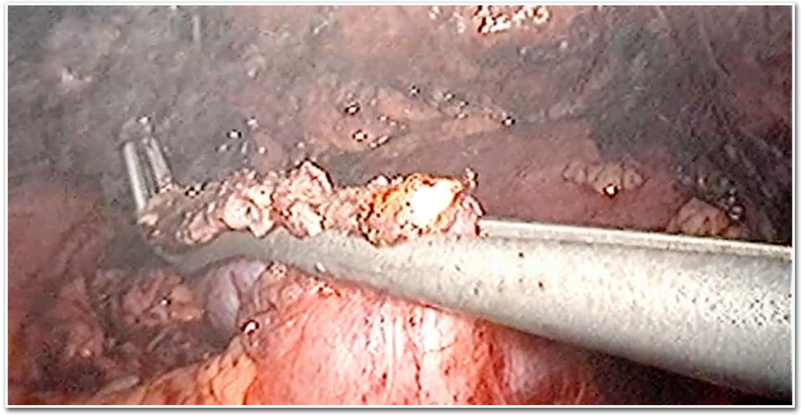
Placement of laparoscopic Satinsky clamp across isthmus.



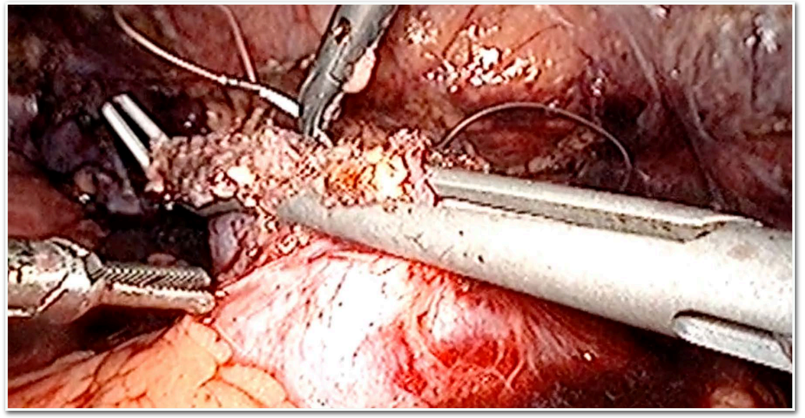
Transection of isthmus.



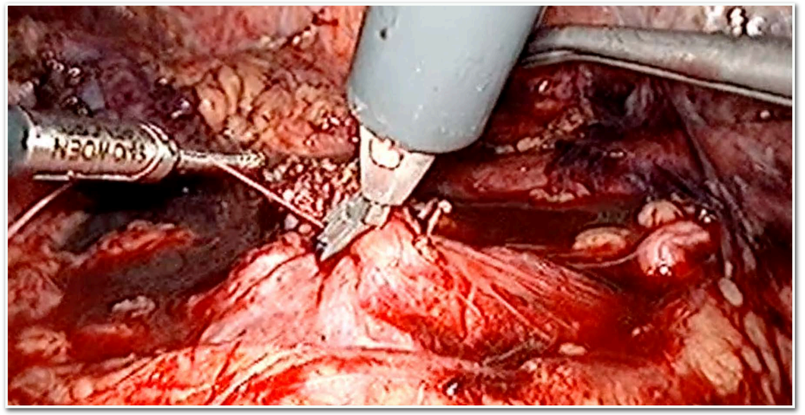
Hemostasis.



Oversewing the isthmus



Use of Lapra-Ty to tension suture line after clamp removal.



Alternative technique

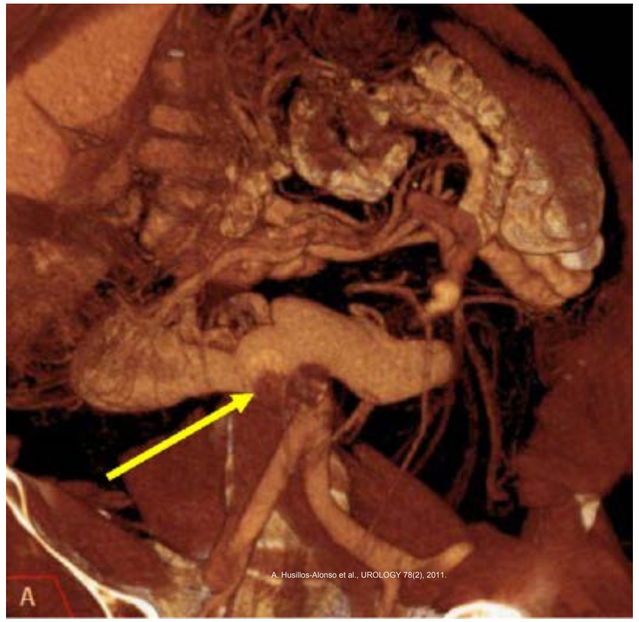
- Renal cell carcinoma risk is not increased by presence of horseshoe kidney.

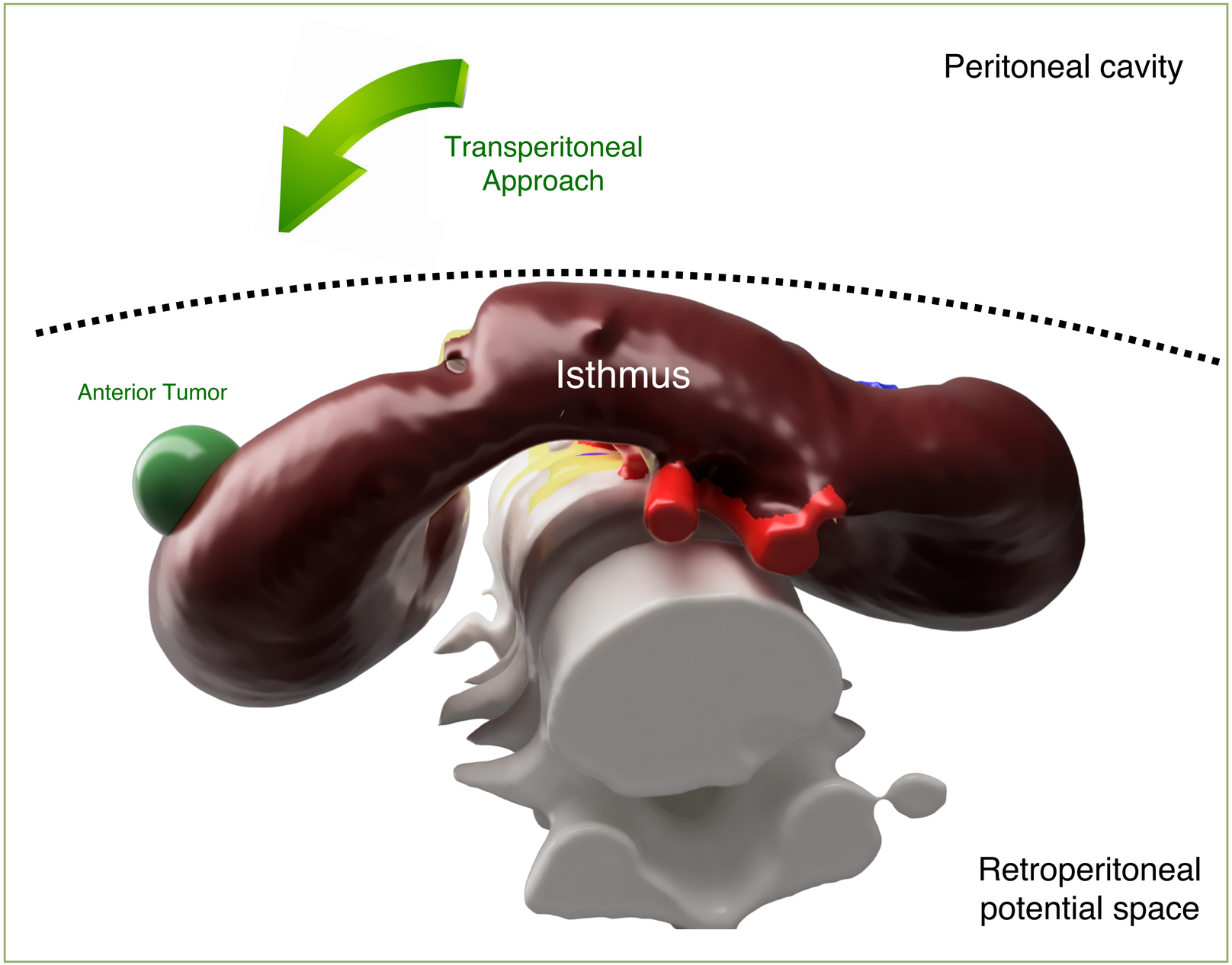
- Not infrequently, isthmus division is necessary to facilitate partial or radical nephrectomy.

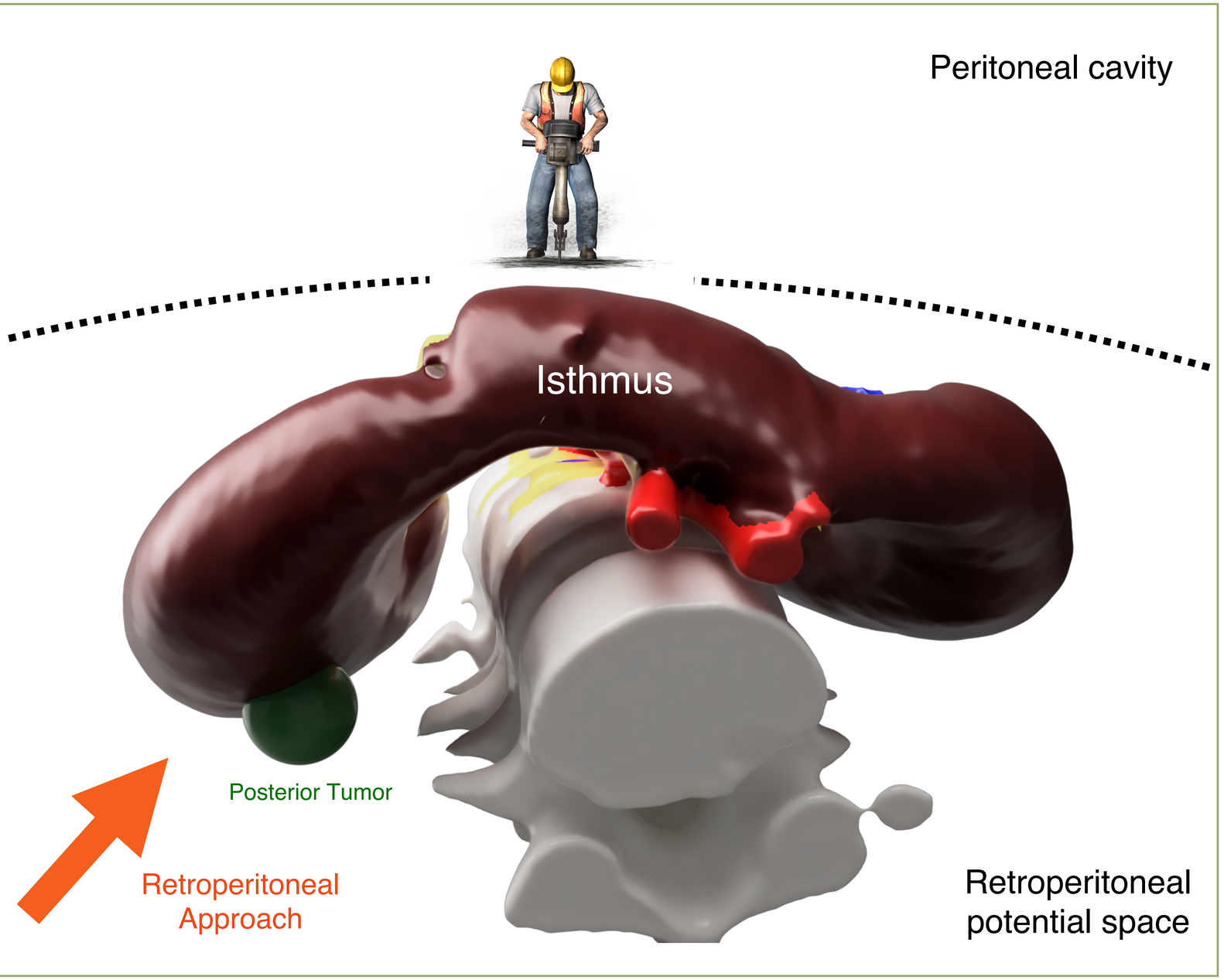
- The presence of a tumor in the isthmus can be a challenging situation as the blood supply can be indeterminate.

- Depending on the size and location of the tumor, bilateral lower pole vessels and/or posterior branches off the aorta may need to be controlled.

- Would be an excellent indication for fluorescence imaging on the robotic platform or intraoperative doppler ultrasound.

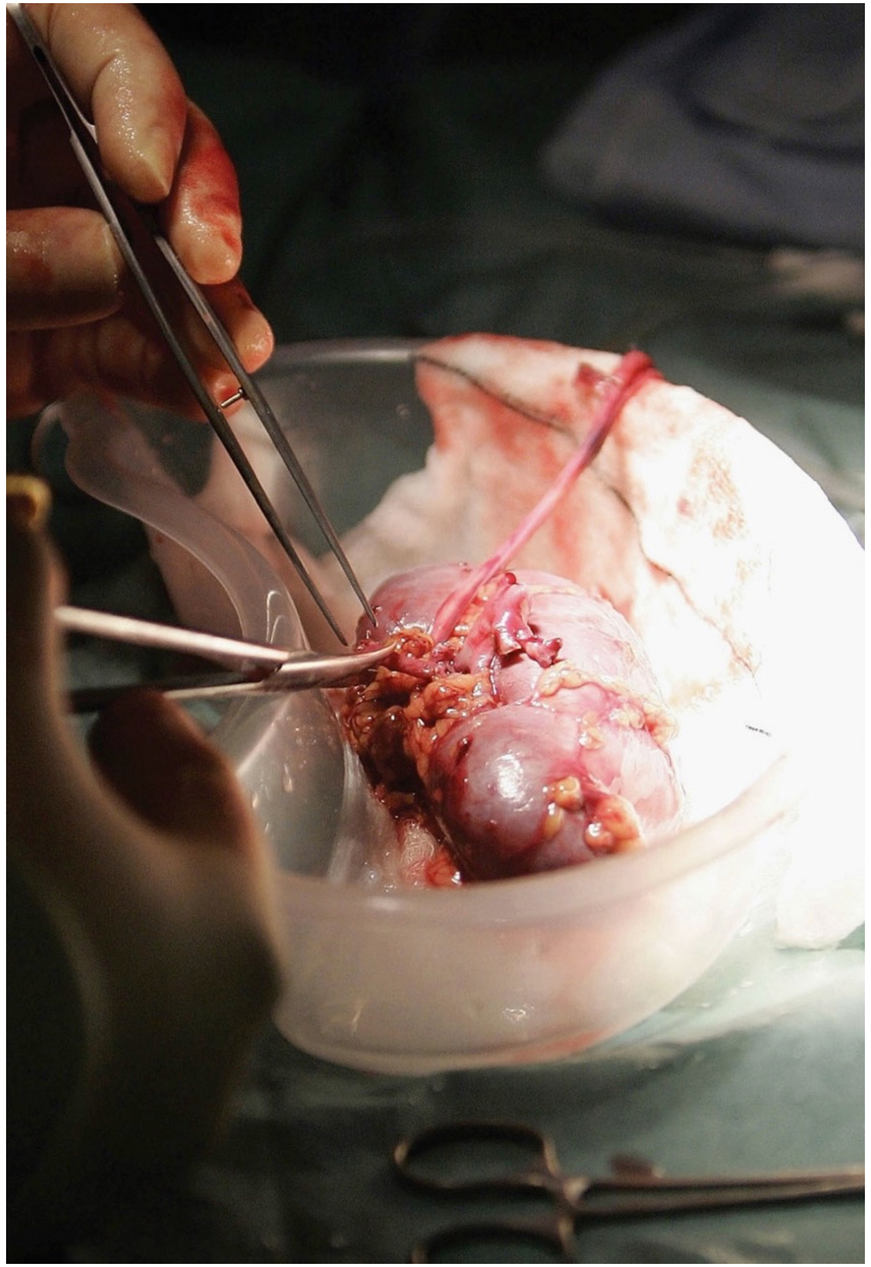



Peritoneal cavity
Transperitoneal
Approach
Anterior Tumor
Isthmus
Retroperitoneal
potential space

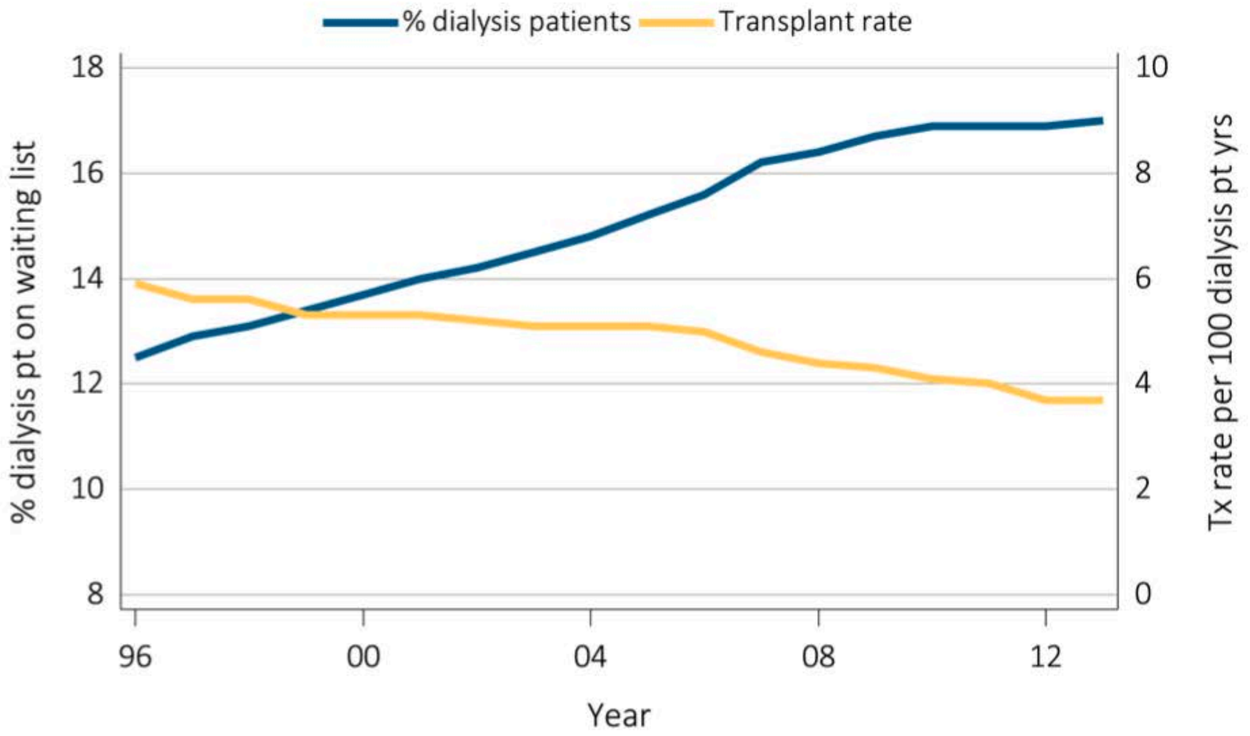

Peritoneal cavity
Isthmus
Posterior Tumor
Retroperitoneal
Approach
Retroperitoneal
potential space

Integrating all the special characteristics of horseshoe kidneys.

Living donor heminephrectomy

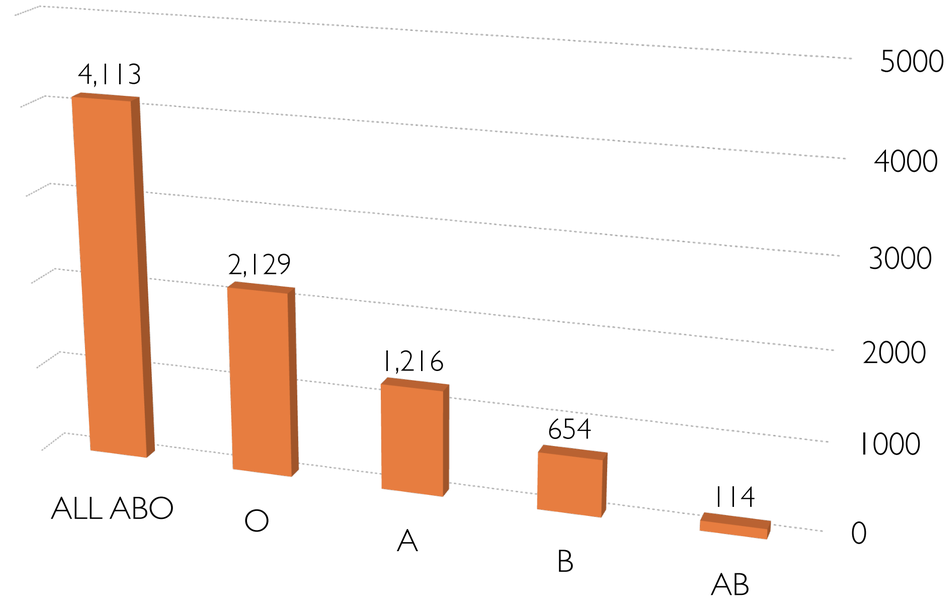


vol 2 Figure i.13 Percentage of dialysis patients wait-listed and unadjusted kidney transplant rates, 1996-2013



USRDS annual report 2015

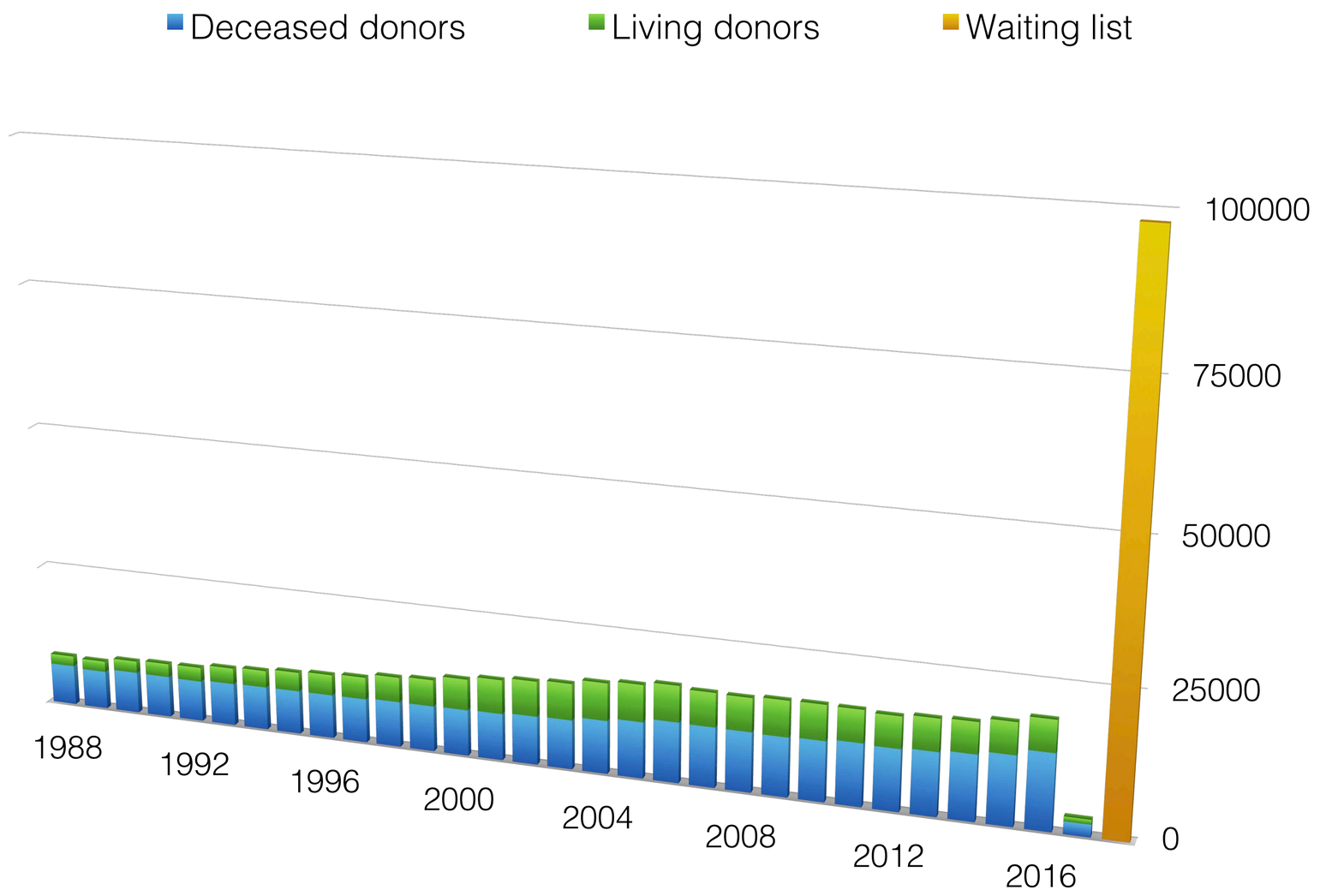
Sobering statistics



OPTN data 3/19/17

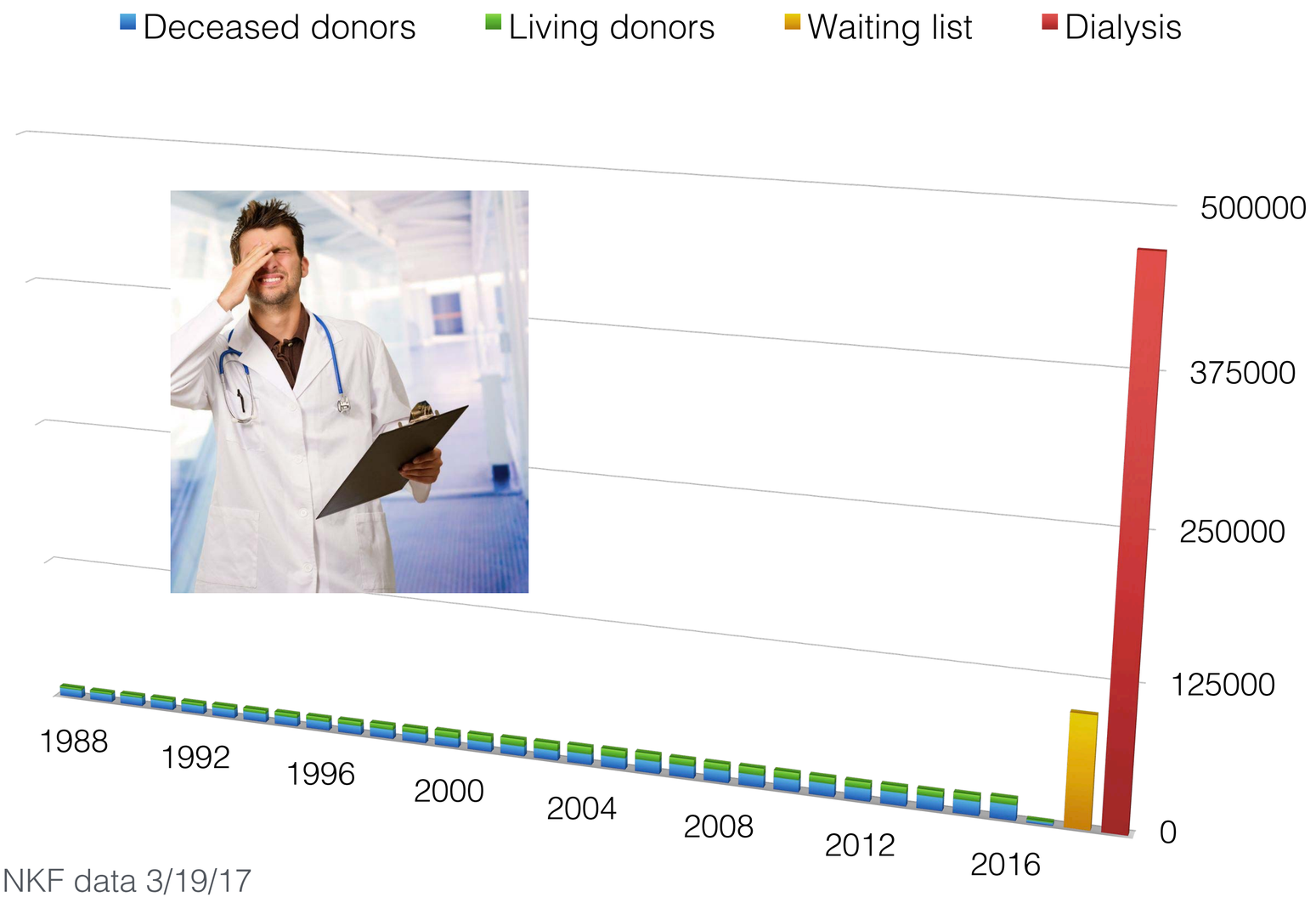
Since 1995,
84,695 patients on the kidney waiting list died before being transplanted.

Transplants by donor type



OPTN data 3/19/17

Transplants by donor type



OPTN and NKF data 3/19/17

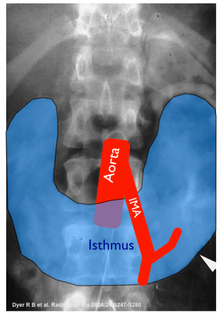
Transplant Donor Nx

Critical Features #1

Relationship to inferior mesenteric artery.

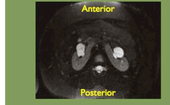
"Renal ascent is stopped by the junction of the aorta and inferior mesenteric artery."

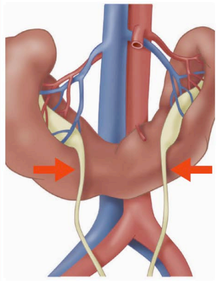
Kidneys are generally lower in the abdomen.



Critical Features #2

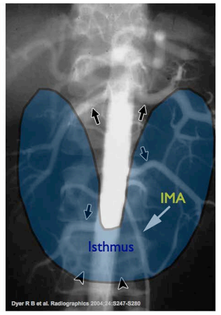
Anteriorly oriented renal pelvis and ureters.





Critical Features #3

Multiple renal vessels in 70% and variable vessels to isthmus.



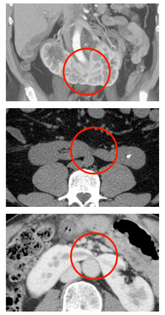
Critical Features #4

Significant variation in isthmus thickness and presence of collecting system in the isthmus.

The isthmus is usually bulky and located at the L3 or L4 level.

Occasionally it is just a thin fibrous band.

In some cases, the lowermost calyces overlie the vertebral column.



Critical Features #5

The kidneys do not rotate completely antero-medially due to the fusion event.

This results in kidneys that are posteriorly rotated.

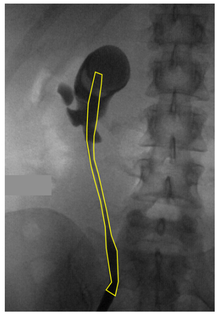
Critical Features #6

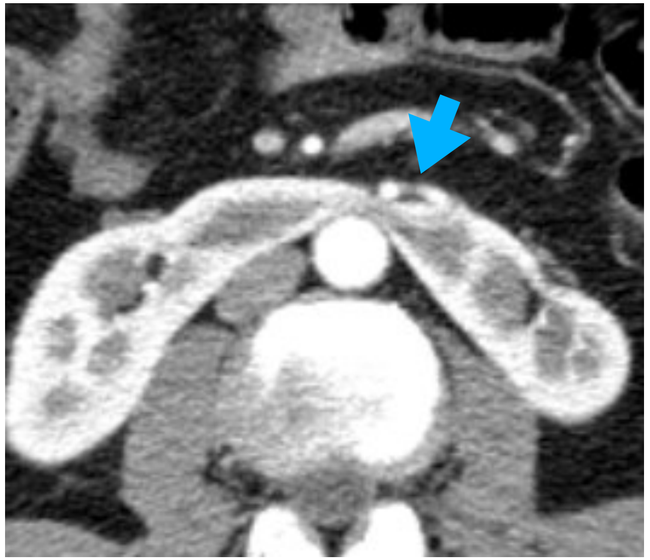
Horseshoe kidneys have the same number of calyces as normal kidneys but these calyces are atypical in orientation.

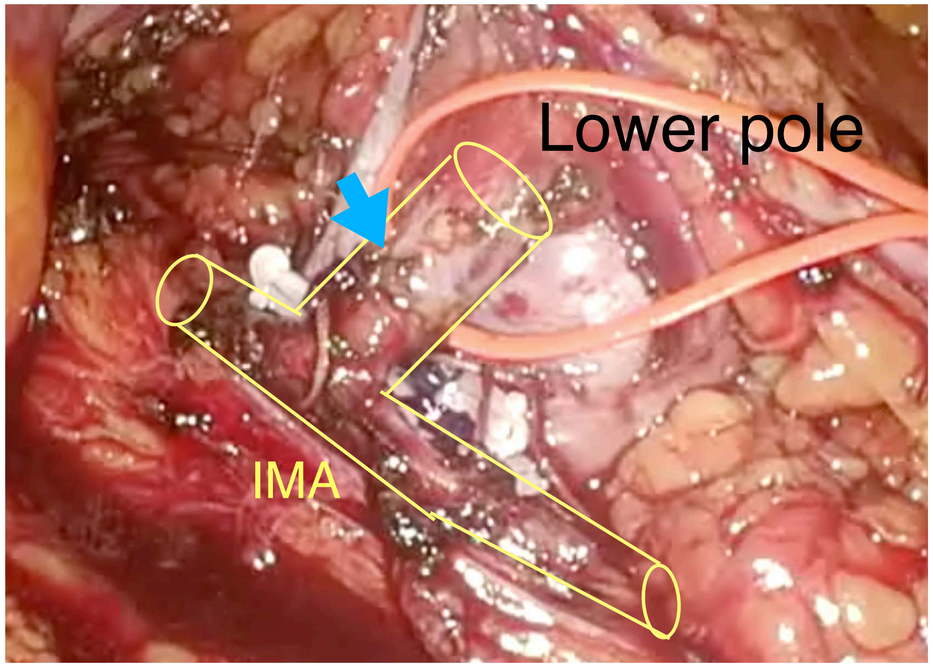
Critical Features #7

The ureter often inserts high into the renal pelvis.

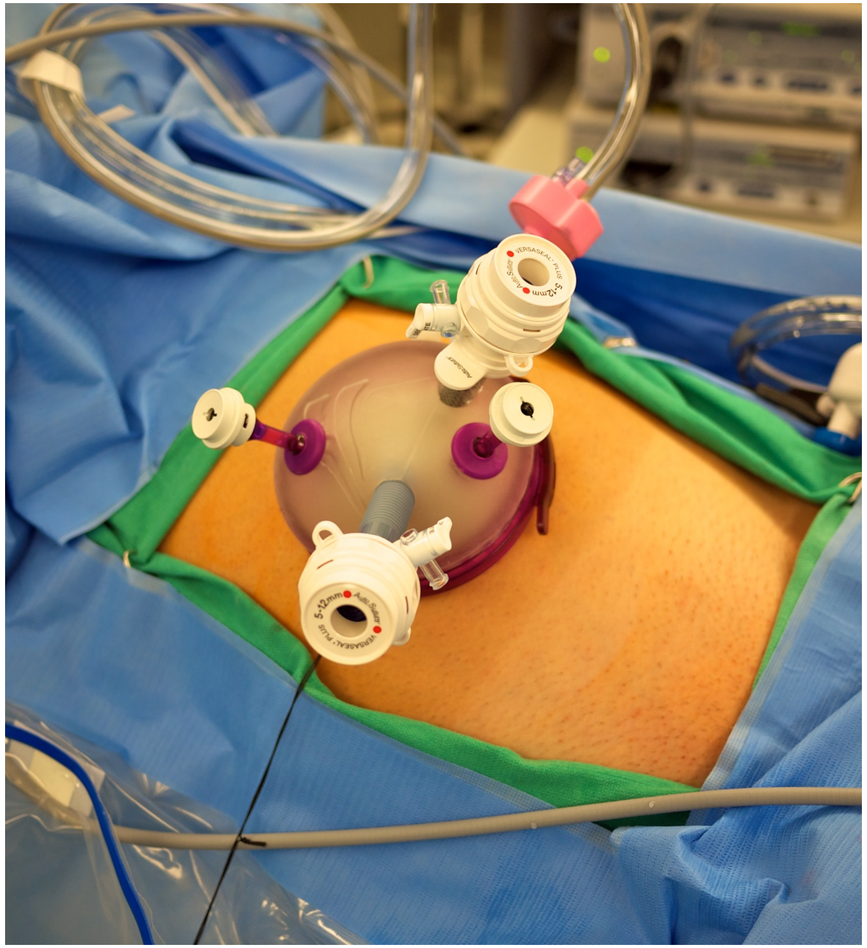
The lower ureter usually enters the bladder normally.

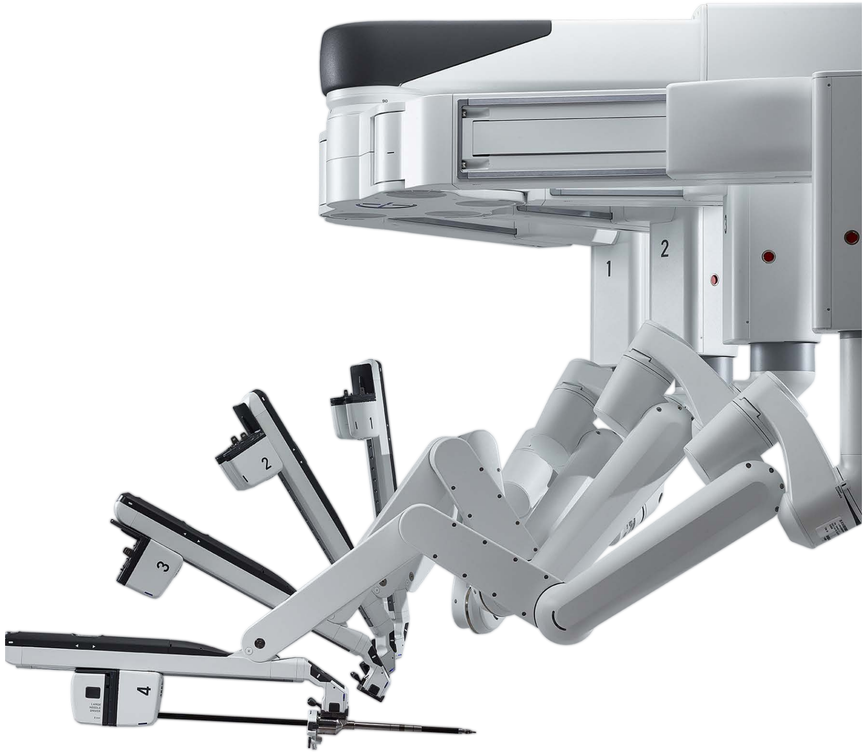






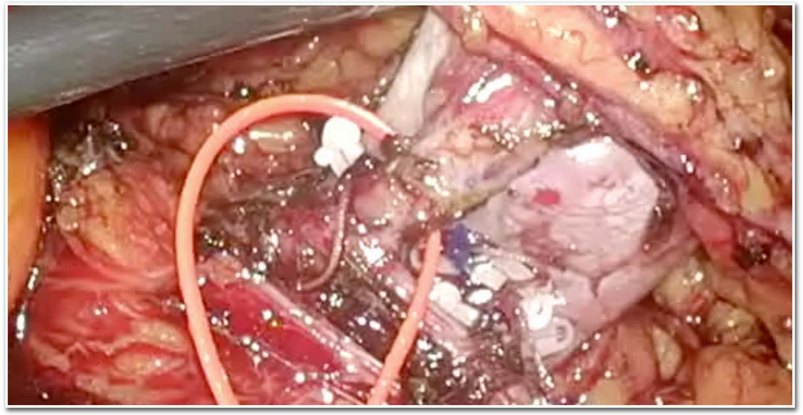
52 year old woman donating to her father.





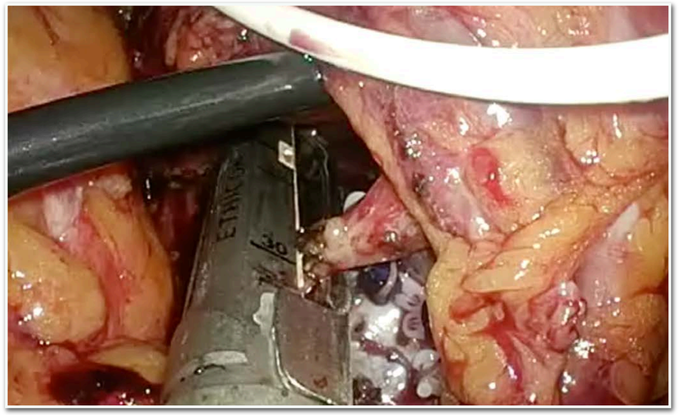
Single-site technique + robotics

Compression of the renal parenchyma at the narrowest portion of the isthmus using standard partial Nx techniques.

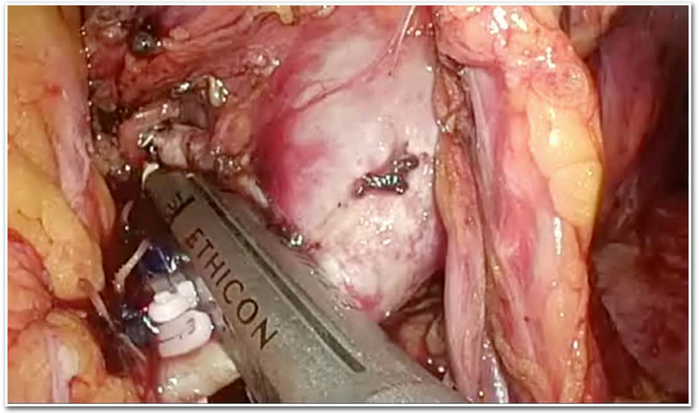


Transection of the ureter.

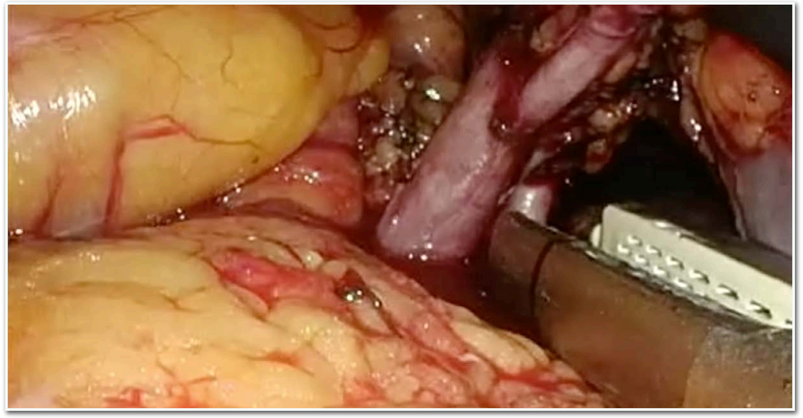
Transection of the lower pole artery arising from the IMA.



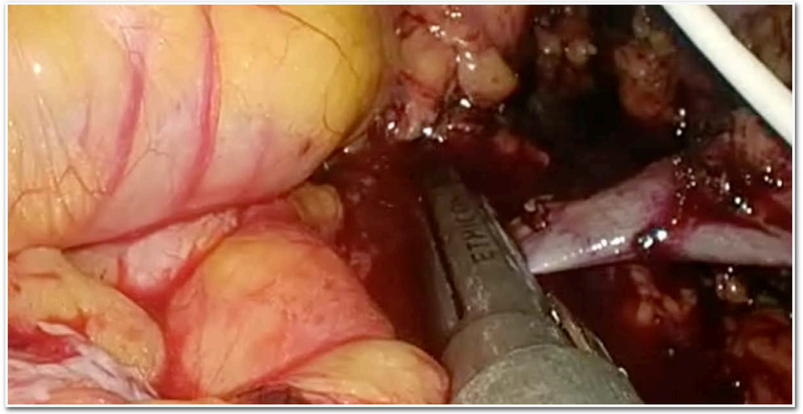
Stapling across the isthmus.



Transection of the main renal artery.

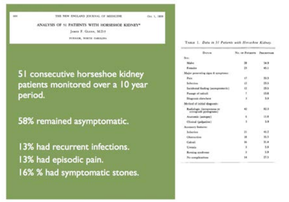


Transection of the main renal vein.

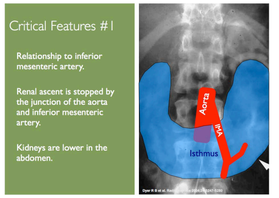


CONCLUSIONS

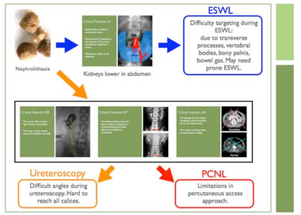
Overview of horseshoe kidneys in adults, incidence, embryology and prognosis.



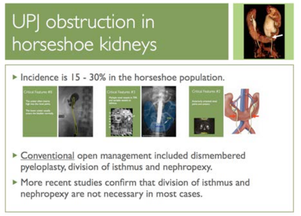
7 anatomic features of horseshoe kidneys that impact on disease and treatment.



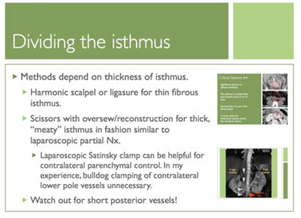
Broad look at stone disease in horseshoe kidneys and technical considerations.



UPJ obstruction is common in horseshoe kidneys but management is fairly standard.



Tips and tricks for managing heminephrectomy and isthmus division for Nx and partial Nx.




Thanks for your attention.