Objectives *for* Urology Residency Education

Guidelines for Educational Units

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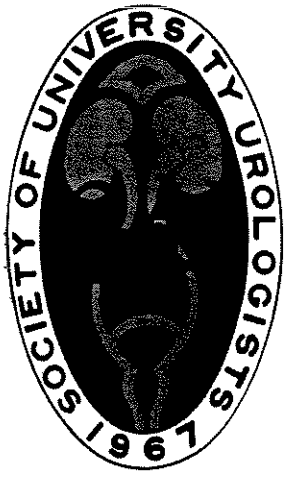

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PART III
RADIOLOGIC EVALUATION AND TREATMENT

EXCRETORY UROGRAPHY, INCLUDING THE PLAIN FILM

Stephen Rous, MD

1.0 GENERAL OBJECTIVES

Demonstrate knowledge of the physiologic principles upon which excretory urography is based; demonstrate an understanding of the indications for excretory urography; demonstrate an understanding of the clinical information to be gained from excretory urography

2.0 PHYSIOLOGICAL PRINCIPLES

2.1 Describe the physiologic mechanism by which the kidney handles the injected contrast medium

2.2 Describe the difference between ionic and nonionic contrast media, and list the advantages and disadvantages of each

3.0 INDICATIONS FOR EXCRETORY UROGRAPHY, INCLUDING THE PRELIMINARY PLAIN FILM (KUB)

3.1 List the indications and contraindications for excretory urography in the following clinical conditions:

- 3.11 Gross hematuria
- 3.12 Microhematuria
- 3.13 Suprapubic pain
- 3.14 Low abdominal pain
- 3.15 Dysuria
- 3.16 Following a patient with known renal calculus disease
- 3.17 When the calculus is in the kidney
- 3.18 When the calculus is in the ureter
- 3.19 When the patient has abdominal or flank pain of uncertain etiology
- 3.110 Bacteriuria
- 3.111 Fever of unknown origin
- 3.112 Known metastatic tumor with unknown primary

4.0 CLINICAL INFORMATION GAINED FROM AN EXCRETORY UROGRAM, INCLUDING THE PRELIMINARY PLAIN FILM

4.1 Describe how an excretory urogram can provide helpful clinical information in the following cases:

- 4.11 Congenital anomalies of the upper urinary tract
- 4.12 Hematuria, gross or microscopic
- 4.13 Flank pain
- 4.14 Low abdominal pain
- 4.15 Fever of unknown origin

5.0 CAUSES OF A LOSS OF RENAL OUTLINE ON THE PLAIN FILM

- 5.1 Technical factors
- 5.2 Congenital absence
- 5.3 Displaced ectopic kidney

5.4 Paranephric hematoma
5.5 Paranephric abscess
5.6 Tumor
5.7 Postnephrectomy

6.0 THE CAUSES OF RENAL CALCIFICATION

6.1 Infections
- 6.11 Tuberculosis
- 6.12 Hydatid cyst
- 6.13 Xanthogranulomatous pyelonephritis
- 6.14 Abscess

6.2 Carcinoma
6.3 Aneurysm
6.4 Nephrocalcinosis
- 6.41 Hyperparathyroidism
- 6.42 Renal tubular acidosis
- 6.43 Medullary sponge kidney
- 6.44 Renal papillary necrosis
- 6.45 Oxalosis; primary, secondary or mild metabolic
- 6.46 Milk alkali syndrome
- 6.47 Hypercalciuria; absorptive, renal or resorptive
- 6.48 Sarcoidosis
- 6.49 Hypervitaminosis D
- 6.410 Acute cortical necrosis
- 6.411 Chronic glomerulonephritis
- 6.412 Chronic transplant rejection

7.0 THE TYPES OF RENAL CALCULI THAT MAY BE SEEN ON EXCRETROY UROGRAPHY

7.1 Opaque
- 7.11 Calcium phosphate
- 7.12 Calcium oxalate
- 7.13 Magnesium ammonium phosphate
- 7.14 Calcium carbonate
- 7.15 Combinations of the above

7.2 Poorly opaque
- 7.21 Cystine

7.3 Nonopaque
- 7.31 Uric acid; xanthine and matrix stones

8.0 THE CAUSES OF GAS IN THE URINARY TRACT

8.1 Gas inside the bladder
- 8.11 Vesico-intestinal fistula
- 8.12 Cystitis
- 8.13 Following instrumentation
- 8.14 Penetrating wounds

8.2 Gas in the bladder wall
- 8.21 Emphysematous cystitis

8.3 Gas in the ureters and the pelvic-calyceal system
- 8.31 Any cause of gas in the bladder
- 8.32 Ureteric diversion
- 8.33 Fistula
- 8.34 Infection (emphysematous pyelonephritis)

9.0 THE CAUSES OF NONVISUALIZATION OF ONE OR BOTH KIDNEYS DURING EXCRETORY UROGRAPHY

- 9.1 Absent kidney(s)
- 9.2 Ectopic kidney(s)
- 9.3 Chronic obstructive uropathy
- 9.4 Infection
- 9.5 Tumor
- 9.6 Renal artery occlusion
- 9.7 Renal vein occlusion
- 9.8 Multicystic kidney(s)

10.0 THE CAUSES OF UNILATERAL SMALL, SCARRED KIDNEY

- 10.1 Chronic pyelonephritis/reflux nephropathy
- 10.2 Tuberculosis
- 10.3 Lobar infarction
- 10.4 Renal dysplasia
- 10.5 Persistent fetal lobulation; often a normal sized kidney but is in the differential diagnosis of a small, scarred kidney

11.0 THE CAUSES OF UNILATERAL SMALL, SMOOTH KIDNEY

- 11.1 With a dilated collecting system
  - 11.11 Postobstructive atrophy
- 11.2 With a small volume collecting system
  - 11.21 Ischaemia due to renal artery stenosis
  - 11.22 Radiation nephritis
  - 11.23 End result of renal infarction
  - 11.24 Congenital hypoplasia (with five or fewer calyces)

12.0 THE CAUSES OF BILATERAL SMALL, SMOOTH KIDNEYS

- 12.1 Generalized arteriosclerosis
- 12.2 Chronic glomerulonephritis
- 12.3 Chronic papillary necrosis
- 12.4 Arterial hypotension
- 12.5 Obstructive uropathy or renal artery stenosis

13.0 THE CAUSES OF A UNILATERAL LARGE, SMOOTH KIDNEY

- 13.1 Compensatory hypertrophy
- 13.2 Obstructed kidney
- 13.3 Pyonephrosis
- 13.4 Duplicated kidney

13.5 Tumor
13.6 Crossed fused ectopia
13.7 Multicystic kidney
13.8 Acute pyelonephritis
13.9 Trauma
13.10 Renal vein thrombosis
13.11 Acute arterial infarction
13.12 Adult polycystic disease (a small percent of these cases are unilateral)

14.0 THE CAUSES OF BILATERAL LARGE, SMOOTH KIDNEYS

14.1 Proliferative and necrotizing disorders
- 14.11 Acute glomerulonephritis
- 14.12 Polyarteritis nodosa
- 14.13 Wegener's granulomatosis
- 14.14 Goodpasture's disease
- 14.15 Systemic lupus erythematosis

14.2 Deposition of abnormal proteins
- 14.21 Amyloidosis
- 14.22 Muitiple myeloma

14.3 Abnormal fluid accumulation
- 14.31 Acute tubular necrosis
- 14.32 Acute cortical necrosis

14.4 Neoplastic infiltration
- 14.41 Leukemia and lymphoma

14.5 Inflammatory cell infiltration
- 14.51 Acute interstitial nephritis

14.6 Miscellaneous
- 14.61 Renal vein thrombosis
- 14.62 Acute renal papillary necrosis
- 14.63 Polycystic disease
- 14.64 Acute urate nephropathy
- 14.65 Sickle-cell anemia
- 14.66 Bilateral hydronephrosis
- 14.67 Medullary sponge kidneys
- 14.68 Acromegaly and gigantism

15.0 THE CAUSES OF LOCALIZED BULGE OF THE RENAL OUTLINE (benign)

15.1 Cyst
15.2 Tumor (benign)
15.3 Fetal lobulation
15.4 Dromedary hump
15.5 Splenic impression
15.6 Enlarged column of Bertin
15.7 Localized hypertrophy
15.8 Abscess
15.9 Nonfunctioning moiety of a duplicated system
15.10 Hamartoma (angiomyolipoma)
15.11 Myoma, lipoma, hemangioma, fibroma

16.0 THE CAUSES OF LOCALIZED BULGE OF THE RENAL OUTLINE (malignant)

- 16.1 Renal cell carcinoma
- 16.2 Transitional cell carcinoma
- 16.3 Squamous cell carcinoma
- 16.4 Wilms' tumor
- 16.5 Leukemia/lymphoma
- 16.6 Metastases from a primary outside of the kidney
- 16.7 Oncocytoma (usually benign but may be malignant)
- 16.8 Sarcoma

17.0 THE CLASSIFICATION OF RENAL CYSTS

List and describe

- 17.1 Renal dysplasia
  - 17.11 Multicystic kidney
  - 17.12 Focal and segmental cystic dysplasia
- 17.2 Polycystic disease
  - 17.21 Infantile polycystic disease
    - 17.211 Polycystic disease of the newborn
    - 17.212 Polycystic disease of childhood
  - 17.22 Adult polycystic disease
- 17.3 Cortical cysts
  - 17.31 Trisomy 13 and 18
  - 17.32 Tuberous sclerosis
  - 17.33 Simple cyst
  - 17.34 Multilocular cyst
- 17.4 Medullary cysts
  - 17.41 Medullary sponge kidney
  - 17.42 Medullary cystic disease
  - 17.43 Papillary necrosis
  - 17.44 Pyelogenic (calyceal) cyst
- 17.5 Miscellaneous intrarenal cysts
  - 17.51 Inflammatory
    - 17.511 Tuberculosis
    - 17.512 Calculous disease
    - 17.513 Hydatid cyst
- 17.6 Neoplastic
- 17.7 Traumatic
- 17.8 Extraparenchymal renal cysts
  - 17.81 Parapelvic cysts
  - 17.82 Perinephric cysts

18.0 THE CAUSES OF RENAL MASS IN THE NEWBORN AND YOUNG INFANT

- 18.1 Hydronephrosis
- 18.2 Multicystic kidney
- 18.3 Polycystic kidneys
- 18.4 Renal vein thrombosis
- 18.5 Nephroblastoma or mesoblastic nephroma
- 18.6 Renal ectopia

19.0 THE CAUSES OF HYDRONEPHROSIS IN A CHILD

19.1 Uretero-pelvic junction obstruction
19.2 Bladder outflow obstruction
19.3 Ureterovesical obstruction
19.4 Ureterovesical reflux without obstruction
19.5 In association with urinary tract infection
19.6 Neurogenic causes

20.0 LIST AND DISCUSS THE CAUSES OF THE DIFFERENT APPEARANCES OF NEPHROGRAMS

20.1 Immediate faint persistent nephrogram
- 20.11 Proliferative; necrotizing disorders
- 20.12 Renal vein thrombosis
- 20.13 Chronic, severe ischaemia

20.2 Immediate distinct persistent nephrogram
- 20.21 Acute tubular necrosis
- 20.22 Other causes of acute renal failure
- 20.23 Acute superimposed on chronic renal failure
- 20.24 Acute hypotension

20.3 Increasingly dense nephrogram
- 20.31 Acute obstruction
- 20.32 Acute hypotension
- 20.33 Acute tubularnecrosis
- 20.34 Acute pyelonephritis
- 20.35 Multiple myeloma
- 20.36 Renal vein thrombosis
- 20.37 Acute glomerulonephritis
- 20.38 Amyloidosis
- 20.39 Acute papillary necrosis

20.4 Rim nephrogram
- 20.41 Severe hydronephrosis
- 20.42 Acute complete arterial occlusion

20.5 Striated nephrogram
- 20.51 Acute ureteric obstruction
- 20.52 Infantile polycystic disease
- 20.53 Medullary sponge kidney
- 20.54 Acute pyelonephritis

21.0 THE UROLOGIC APPEARANCES OF RENAL PAPILLARY NECROSIS

List and explain
21.1 Enlargement
21.2 Partial sloughing
21.3 Total sloughing
21.4 Necrosis in situ

22.0 THE X-RAY FINDINGS WITH UNILATERAL RENAL ARTERY STENOSIS

List and explain

22.1 Unilateral delay in function (visualization)
22.2 Small, smooth kidney
22.3 Disparity in size between the kidneys
22.4 Increased density of opacified calyces
22.5 Ureteric notching by collateral vessels

23.0 LESIONS OF THE RENAL ARTERY RESPONSIBLE FOR HYPERTENSION

23.1 Arteriosclerosis
23.2 Fibromuscular dysplasia
23.3 Thrombosis/embolism
23.4 Arteritis
23.5 Neurofibromatosis
23.6 Trauma
23.7 Aneurysm
23.8 Arteriovenous fistula
23.9 Extrinsic compression

24.0 RENAL PARENCHYMAL DISEASES ASSOCIATED WITH HYPERTENSION

24.1 Acute and chronic glomerulonephritis
24.2 Chronic pyelonephritis
24.3 Adult polycystic disease
24.4 Diabetic glomerulosclerosis
24.5 Connective tissue disorders
24.6 Radiation therapy
24.7 Hydronephrosis
24.8 Analgesic nephropathy
24.9 Renal vein thrombosis

25.0 X-RAY FINDINGS WITH RENAL VEIN THROMBOSIS—UNILATERAL OR BILATERAL

25.1 Large, nonfunctioning kidney(s), which over a period of several months becomes small and atrophic

26.0 REASONS FOR A RADIOLUCENT FILLING DEFECT IN THE RENAL PELVIX OR IN A CALYX

26.1 Extrinsic with a smooth margin
- 26.11 Cyst
- 26.12 Vascular impression
- 26.13 Renal sinus lipomatosis
- 26.14 Collateral vessels

26.2 Inseparable from the wall and with smooth margins
- 26.21 Blood clot
- 26.22 Papilloma
- 26.23 Pyeloureteritis cystica

26.3 Arising from the wall with an irregular margin
- 26.31 Transitional cell carcinoma
- 26.32 Squamous cell carcinoma
- 26.33 Renal cell carcinoma
- 26.34 Squamous metaplasia

26.4 In the lumen
- 26.41 Blood clot
- 26.42 Lucent calculus
- 26.43 Sloughed papilla
- 26.44 Air

27.0 THE CAUSES OF A DILATED CALYX

27.1 With a narrow infundibulum
- 27.11 Stricture
- 27.12 Extrinsic compression by an artery
- 27.13 Hydrocalycosis; may be congenital

27.2 With a wide infundibulum
- 27.21 Postobstructive atrophy
- 27.22 Megacalyces
- 27.23 Polycalycosis

28.0 THE CAUSES OF NONVISUALIZATION OF A CALYX

28.1 Technical factors
28.2 Tumor
28.3 Obstructed infundibulum
28.4 Duplicated kidney
28.5 Infection
28.6 Partial nephrectomy

29.0 THE CAUSES OF A DILATED URETER

29.1 Obstruction
- 29.11 Within the lumen
  - 29.111 Calculus
  - 29.112 Blood clot
  - 29.113 Sloughed papilla
- 29.12 Within the wall
  - 29.121 Edema or stricture due to calculus
  - 29.122 Tumor
  - 29.123 Tuberculous stricture
  - 29.124 Schistosomiasis
  - 29.125 Postsurgical trauma
  - 29.126 Ureterocele
  - 29.127 Megaureter
- 29.13 Outside the wall
  - 29.131 Retroperitoneal fibrosis
  - 29.132 Carcinoma of cervix, bladder or prostate
  - 29.133 Retrocaval ureter

29.2 Vesico-ureteral reflux

29.3 No obstruction or reflux
- 29.31 Postpartum
- 29.32 Following relief of obstruction
- 29.33 Urinary tract infection

30.0 RETROPERITONEAL FIBROSIS

List and discuss the findings
- 30.1 Ureteric obstruction of varying severity
- 30.2 Tapering lumen or complete obstruction, usually at L4-5
- 30.3 Medial deviation of the ureters
- 30.4 Differential diagnosis of medially displaced ureters
  - 30.41 Pelvic lipomatosis
  - 30.42 Following abdomino-perineal resection
  - 30.43 Retrocaval ureter
  - 30.44 Retroperitoneal fibrosis
  - 30.45 Normal variant

31.0 FILLING DEFECT IN THE WALL OR THE LUMEN OF THE BLADDER

List the causes
- 31.1 Prostate
- 31.2 Neoplasm
- 31.3 Blood clot
- 31.4 Calculus
- 31.5 Ureterocele
- 31.6 Schistosomiasis
- 31.7 Endometriosis

32.0 BLADDER CALCIFICATION

List the causes
- 32.1 In the lumen
  - 32.11 Calculus
  - 32.12 Foreign body
- 32.2 In the wall
  - 32.21 Transitional cell carcinoma (or other type of carcinoma)
  - 32.22 Schistosomiasis
  - 32.23 Tuberculosis

33.0 BLADDER OUTFLOW OBSTRUCTION IN A CHILD

- 33.1 List the findings
  - 33.11 Distended bladder with incomplete emptying
  - 33.12 Possible bilateral upper tract obstruction
  - 33.13 Possible upper tract cystic disease
- 33.2 List the causes
  - 33.21 Vesical diverticulum
  - 33.22 Bladder neck obstruction
  - 33.23 Ectopic ureterocele
  - 33.24 Posterior urethral valves

33.25 Anterior urethral diverticulum
33.26 Urethral stricture
33.27 Prune belly syndrome
33.28 Calculus or foreign body
33.29 Meatal stenosis or phimosis

34.0 CALCIFICATION OF THE SEMINAL VESICLES

List the causes
34.1 Diabetes mellitus
34.2 Chronic infection
34.3 Idiopathic

VOIDING CYSTOURETHROGRAPHY

Stephen Rous, MD

1.0 GENERAL OBJECTIVES

Demonstrate an understanding of and list the indications for this examination; describe the clinical information to be gained from this examination

2.0 DESCRIBE THE TECHNIQUE FOR PERFORMING A VOIDING CYSTOURETHROGRAM AND THE SPECIFIC INDICATIONS IN EACH OF THE FOLLOWING EXAMPLES:

- 2.1 When it is done in antegrade fashion following the excretory cystogram phase of the excretory urogram
- 2.2 When it is done entirely in retrograde fashion

3.0 DISCUSS THE INDICATIONS FOR VOIDING CYSTOURETHROGRAPHY (both antegrade and retrograde)

- 3.1 In children
- 3.2 In adults

4.0 DEMONSTRATE AN UNDERSTANDING OF THE CLINICAL INFORMATIONS TO BE GAINED FROM EITHER ANTEGRADE OR RETROGRADE VOIDING CYSTOURETHROGRAPHY

- 4.1 In vesicourethral reflux
- 4.2 In ureteral ectopia
- 4.3 In renal duplication
- 4.4 In bladder outlet obstruction
- 4.5 In urethral stricture disease
- 4.6 In the various fistulae communicating with the urethra
- 4.7 In congenital anomalies of the urethra
- 4.8 In diverticula of the urethra

RETROGRADE URETERO-PYELOGRAMS

Stephen Rous, MD

1.0 GENERAL OBJECTIVES

Describe and list the indications and contraindications for retrograde uretero-pyelography and demonstrate knowledge of the clinical information to be gained from these studies

2.0 DESCRIBE THE METHODOLOGY FOR PERFORMING RETROGRADE URETERO-PYELOGRAPHY

2. 1 Describe the different types of ureteral catheter that are used and the indications for each

3.0 DISCUSS THE RATIONALE FOR AND THE KNOWLEDGE TO BE GAINED FROM URETERO-PYELOGRAPHY (or the passage of ureteral catheters without injection of contrast)

3.1 In bacteriuria of indeterminate source
3.2 In an incompletely visualized upper urinary tract (following excretory urography)
3.3 In renal or ureteral calculous disease
3.4 In mass lesions of the kidney
3.5 In filling defects within the kidney or ureter (following excretory urography)
3.6 In renal transplant patients

RETROGRADE URETHROGRAPHY

Stephen Rous, MD

1.0 GENERAL OBJECTIVES

Demonstrate an understanding of the indications for this procedure and an understanding of the clinical information to be gained from this procedure

2.0 DISCUSS THE INDICATIONS FOR A RETROGRADE URETHROGRAM

3.0 DESCRIBE THE TECHNIQUE FOR PERFORMING A RETROGRADE URETHROGRAM

- 3.1 When there is a suspected disruption of the urethra from trauma
- 3.2 When there is a known or suspected stricture of the urethra
- 3.3 When there is a known or suspected congenital abnormality of the urethra

4.0 DESCRIBE AND RECOGNIZE THE FINDINGS WHEN A RETROGRADE URETHROGRAM IS DONE

- 4.1 For a urethral disruption secondary to trauma
- 4.2 For a stricture in the urethra
- 4.3 For a urethral diverticulum
- 4.4 For a duplication of the urethra
- 4.5 For a urethro-rectal fistula
- 4.6 For a urethro-vaginal fistula
- 4.7 For a urethro-cutaneous fistula

ANGIOGRAPHY

Stephen Rous, MD

1.0 GENERAL OBJECTIVES

Discuss, in a general sense, the techniques of arteriography and venography as they apply to the kidney, the adrenal, and the pelvis; list the indications for each of these and discuss the rationale for each with the clinical information (or therapeutic benefit) to be derived from arteriography and venography for each of these anatomic areas

2.0 THE KIDNEY AND ADRENAL

2.1 List the indications and give the rationale for arteriography of the kidney

- 2.11 Prior to a planned partial nephrectomy to use as a "road map" for the surgical dissection
- 2.12 Prior to surgery on a pelvic or horseshoe kidney to ascertain with accuracy the blood supply
- 2.13 Prior to donor nephrectomy for a "road map" of the renal arteries
- 2.14 Following renal trauma to identify the source of continued bleeding
- 2.15 Following renal trauma to embolize or otherwise occlude major bleeding vessels
- 2.16 To search for bleeding vessels/A-V fistulae in cases of persistent and otherwise unexplained gross hematuria
- 2.17 To embolize or otherwise occlude these bleeding vessels/A-V fistulae
- 2.18 To identify and embolize or otherwise occlude bleeding vessels following renal biopsy or other percutaneous procedures that turn out to be catastrophes
- 2.19 To evaluate postrenal transplant vascular stenosis/A-V fistulae or otherwise unexplained hypertension, hemorrhage, poor renal function
- 2.20 To visualize the renal artery(ies) in suspected cases of renovascular hypertension, and to plan the surgical correction of same
- 2.21 For the preoperative embolization of certain large renal cancers

3.0 LIST THE INDICATIONS AND GIVE THE RATIONALE FOR VENOGRAPHY OF THE KIDNEY AND ADRENAL

- 3.1 To visualize the renal veins/vena cava for possible tumor thrombi
- 3.2 To search for possible sites of venous bleeding from varices in the kidney or a gonadal vein
- 3.3 To sample venous blood from the adrenal through an inferior adrenal vein

4.0 THE BONY PELVIS

4.1 List the indications and give the rationale for arteriography in the bony pelvis

- 4.11 To locate the source(s) of bleeding following pelvic trauma and to embolize or otherwise occlude same
- 4.12 To locate and emoblize or otherwise occlude unexplained sources of bleeding from the bladder/pelvic floor

ULTRASOUND OF THE GENITOURINARY TRACT

Martin Resnick, MD

1.0 GENERAL OBJECTIVES

Demonstrate knowledge of the basic physical principles and instrumentation of diagnostic ultrasound and demonstrate an understanding of the clinical information gained from such examinations; be able to show an understanding of the indications for ultrasound examinations; demonstrate an ability to perform an ultrasound examination and interpret the findings

2.0 PHYSICAL PRINCIPLES

- 2.1 Describe the physical principles of ultrasound waves, their generation, and the meaning of the following:
  - 2.11 Period
  - 2.12 Amplitude
  - 2.13 Velocity
  - 2.14 Frequency
  - 2.15 Wavelength
  - 2.16 Gain
- 2.2 Discuss the concept of attenuation and scattering of sound waves
- 2.3 Discuss the principles of reflection of sound waves and the formation of echo patterns and how they relate to the following
  - 2.31 Interface
  - 2.32 Acoustic impedance
- 2.4 Describe the factors related to image resolution
- 2.5 Describe the biologic effects of sound waves

3.0 PRINCIPLES OF ULTRASOUND INSTRUMENTATION

- 3.1 Transducer
  - 3.11 Linear array scanning
  - 3.12 Radial scanning
  - 3.13 Sector scanning
- 3.2 Dynamic focusing and range
- 3.3 Display modes
  - 3.31 A-mode
  - 3.32 B-mode
  - 3.33 TM-mode
- 3.4 Real time
- 3.5 Gray scale
- 3.6 Doppler spectral analysis
- 3.7 Color doppler imagining

4.0 DESCRIBE THE INDICATIONS, VALUE, AND TECHNIQUE OF CLINICAL ULTRASOUND IN ASSESSING DISORDERS OF THE ADRENAL GLAND

- 4.1 Review adrenal gland anatomy as it relates to the following
  - 4.11 Normal anatomy
  - 4.12 Cross-sectional anatomy
  - 4.13 Neighboring organs/structures

4.2 Review the ultrasonic characteristics of the following adrenal disorders and How clinical ultrasound is used in their assessment:

- 4.21 Congenital anomalies
  - 4.211 Absence
  - 4.212 Hyperplasia
  - 4.213 Hypoplasia
- 4.22 Primary adrenal tumors
  - 4.221 Cortical; adenoma, carcinoma, hyperplasia
  - 4.222 Medullary; neuroblastoma, pheochromocytoma, ganglioneuroma
  - 4.323 Myeloliporna
- 4.23 Metastasis from bronchogenic carcinoma, breast carcinoma, GI malignancies, renal carcinoma
- 4.24 Adrenal cysts
- 4.25 Adrenal atrophy
- 4.26 Infiltrative and infective disorders
  - 4.261 Tuberculosis
  - 4.262 Amyloidosis
  - 4.263 Carcinomatosis
  - 4.264 Fungal infections
  - 4.265 Adrenal hemorrhage

5.0 DESCRIBE THE INDICATIONS, VALUE, AND TECHNIQUE OF CLINICAL ULTRASOUND IN ASSESSING DISORDERS OF THE KIDNEY AND URETER

5.1 Review renal and ureteral anatomy as it relates to the following:

- 5.11 Normal anatomy
- 5.12 Cross-sectional anatomy
- 5.13 Neighboring organs/structures

5.2 Review the ultrasonic characteristics of the following renal disorders and how clinical ultrasound is used in their assessment:

- 5.21 Anomalies of structure
  - 5.211 Ectopia
  - 5.212 Hypoplasia
  - 5.213 Horseshoe kidney
  - 5.214 Anomalies of renal pelvis and calyces; duplication and obstruction
- 5.22 Cystic disease
  - 5.221 Infantile and adult polycystic
  - 5.222 Unilateral multicystic
  - 5.223 Simple cyst
- 5.23 Hydronephrosis and ureteral dilation
  - 5.231 Ureteropelvic junction obstruction
  - 5.232 Vesico-ureteral reflux
  - 5.233 Ureteral obstruction
  - 5.234 Uretero-vesical junction obstruction
  - 5.235 Bladder outlet obstruction
  - 5.236 Urethral obstruction
- 5.24 Renal and perirenal infections
  - 5.241 Renal carbuncle
  - 5.242 Renal abscess
  - 5.243 Perirenal abscess
  - 5.244 Acute pyelonephritis
  - 5.245 Chronic pyelonephritis

5.246 Emphysematous pyelonephritis
5.247 Xanthogranulomatous pyelonephritis
5.248 Pyonephrosis

5.25 Perirenal fluid collections
5.251 Urinoma
5.252 Hematoma
5.253 Lymphocele

5.26 Renal tumors
5.261 Benign renal adenoma
5.262 Renal adenocarcinoma (hypernephroma, renal cell carcinoma)
5.263 Wilms' tumor (nephroblastoma) and mesoblastic nephroma
5.264 Oncocytoma
5.265 Angiomyolipoma
5.266 Transitional cell carcinoma (kidney and ureter)
5.267 Sarcoma

5.27 Renal transplantation
5.271 Obstruction
5.272 Rejection
5.273 Infection
5.274 Perirenal fluid collections
5.275 Arterial and venous disorders (thrombosis, stenosis, aneurysms, arteriovenous fistula)

5.28 Acute and chronic renal failure
5.29 Renal trauma
5.30 Renal and ureteral calculi
5.31 Renal vascular disease
5.311 Renal artery stenosis
5.312 Arteriovenous malformations and fistula
5.313 Renal vein thrombosis

6.0 DESCRIBE THE INDICATIONS, VALUE, AND TECHNIQUE OF CLINICAL ULTRASOUND IN ASSESSING ANATOMICAL AND FUNCTIONAL DISORDERS OF THE URINARY BLADDER

6.1 Review the anatomy of the urinary bladder and how it relates to the following:
6.11 Normal anatomy
6.12 Cross-sectional anatomy
6.13 Neighboring organs/structures

6.2 Review bladder function and the dynamics of bladder contraction and emptying
6.21 Detrussor function
6.22 Bladder neck function
6.23 Urethral function, females
6.24 Prostatic urethra and external sphincter function, males

6.3 Review the ultrasonic techniques used for assessing bladder function
6.31 Volume residual urine and its computation
6.32 Dynamics of voiding
6.33 Bladder neck and urethral change, female
6.34 Bladder neck and prostatic urethral change, male
6.341 Transabdominal ultrasound
6.342 Transrectal ultrasound

6.4 Review the various methods of examining the urinary bladder by ultrasound
6.41 Transabdominal

6.42 Transurethral
6.43 Transrectal

6.5 Review the ultrasonic characteristics of the following disorders of the urinary bladder and how clinical ultrasound is used in the assessment
- 6.51 Congenital anomalies
  - 6.511 Duplications
  - 6.512 Diverticula
  - 6.513 Ureterocele
  - 6.514 Patient urachus
- 6.52 Primary tumors
  - 6.521 Transitional cell carcinoma
  - 6.522 Squamous cell carcinoma
  - 6.523 Adenocarcinoma
  - 6.524 Sarcoma
- 6.53 Secondary tumors
- 6.54 Tumor staging
  - 6.541 Transurethral ultrasound
  - 6.542 Transabdominal ultrasound
- 6.55 Bladder calculi

7.0 DESCRIBE THE INDICATIONS, VALUE, AND TECHNIQUE OF CLINICAL ULTRASOUND IN ASSESSING DISORDERS OF THE SEMINAL VESICLES AND PROSTATE

7.1 Review the anatomy of the seminal vesicles and prostate
- 7.11 Normal anatomy
- 7.12 Cross-sectional and sagittal anatomy
- 7.13 Neighboring organs/structures

7.2 Review the various methods of examining the prostate by ultrasound
- 7.21 Transabdominal
- 7.22 Transurethral
- 7.23 Transrectal
  - 7.231 Radial scanning
  - 7.232 Sagittal scanning
- 7.24 Perineal

7.3 Review the various methods of performing ultrasound-guided biopsies
- 7.31 Transrectal
- 7.32 Perineal
- 7.33 Radial imaging
- 7.34 Sagittal imaging
- 7.35 Bi-dimensional imaging

7.4 Review the ultrasonic characteristics of benign prostatic hyperplasia and how ultrasound is used in its assessment
- 7.41 Volume determination of prostate
  - 7.411 Volume determination of transition zone
  - 7.412 Volume determination of peripheral zone

7.5 Review the ultrasonic characteristics of prostatic carcinoma and how Ultrasound is used in its assessment
- 7.51 Volume determination
- 7.52 Staging
- 7.53 Monitoring response to therapy
- 7.54 Early detection and screening
- 7.55 Calculation of prostate specific antigen density

7.6 Review the ultrasonic characteristics of the following disorders of the seminal vesicles and prostate and how clinical ultrasound is used in their assessment:

- 7.61 Other malignant tumors of the prostate
  - 7.611 Endometrial carcinoma
  - 7.612 Transitionalcell carcinoma
  - 7.613 Tumors invading the prostate (colon, bladder)
- 7.62 Acute and chronic prostatitis
- 7.63 Prostatic cysts
- 7.64 Prostatic calculi
- 7.65 Prostatic infarct
- 7.66 Inflammation of the seminal vesicles
- 7.67 Congenital absence of the seminal vesicles
- 7.68 Abnormalities of the seminal vesicles and infertility

8.0 DESCRIBE THE INDICATIONS, VALUE, AND TECHNIQUE OF CLINICAL ULTRASOUOND IN ASSESSING DISORDERS OF THE SCROTAL CONTENTS

8.1 Review the anatomy of the scrotum and its contests

- 8.11 Normal anatomy
- 8.12 Cross-sectional anatomy
- 8.13 Relationship of intrascrotal structures

8.2 Review the ultrasonic characteristics of the following disorders of the scrotal contents and how clinical ultrasound is used in their assessment:

- 8.21 Acute scrotal and testicular disorders
  - 8.211 Acute epididymitis
  - 8.212 Orchitis
  - 8.213 Torsion
  - 8.214 Trauma,hematocele
- 8.22 Chronic scrotal and testicular disorders
  - 8.221 Chronic epididymitis
  - 8.222 Varicocele
  - 8.223 Hydrocele
  - 8.224 Spermatocele
  - 8.225 Testicular tumor
  - 8.226 Cryptorchidism
  - 8.227 Testicular abnormalities and infertility (absence, hypoplasia, atrophy, microlithiasis)

9.0 DESCRIBE THE INDICATIONS, VALUE, AND TECHNIQUE OF CLINICAL ULTRASOUND IN ASSESSING DISORDERS OF THE PENIS AND URETHRA

9.1 Review the anatomy of the penis and urethra

- 9.11 Normal anatomy
- 9.12 Blood vessels
- 9.13 Cross-sectional anatomy

9.2 Review the ultrasonic characteristics of the following disorders of the penis And how clinical ultrasound is used in their assessment

- 9.21 Impotence
- 9.22 Peyronie's disease
- 9.23 Trauma to corpora and urethra
- 9.24 Urethral stricture

10.0 DESCRIBE THE VALUE INDICATIONS AND TECHNIQUE OF ULTRASOUND-GUIDED PROSTATE BIOPSY

- 10.1 Review the indications for prostate biopsy
  - 10.11 Prostate specific antigen
  - 10.12 Prostate nodule
  - 10.13 Repeat biopsy
  - 10.14 Post-treatment biopsy
- 10.2 Review the equipment required for prostate biopsy
  - 10.21 Ultrasound probe
    - 10.211 End-fire
    - 10.212 Linear array
    - 10.213 Radial
  - 10.22 Spring-loaded device and needle
  - 10.23 Biopsy guide
- 10.3 Describe the preparation required for prostate biopsy
  - 10.31 Antibiotics
  - 10.32 Enema
  - 10.33 Precautions
    - 10.331 Aspirin; nonsteroidal, anti-inflammatory drugs
    - 10.332 Anticoagulants
- 10.4 Describe the procedure of prostate biopsy
  - 10.41 Prebiopsy ultrasound examination
  - 10.42 Sextant biopsy
  - 10.43 Biopsy of abnormal areas
- 10.5 Describe postbiopsy procedure, complications, and treatment
  - 10.51 Antibiotics
  - 10.52 Complications
    - 10.521 Urinary
    - 10.522 Fever
    - 10.523 Sepsis
    - 10.524 Rectal bleeding
    - 10.525 Hematuria
    - 10.526 Hematospermia

11.0 DESCRIBE THE USE OF ULTRASOUND IN THE FOLLOWING TECHNIQUES:

- 11.1 Methodology
- 11.2 Renal cyst aspiration
- 11.3 Percutaneous nephrostomy
- 11.4 Percutaneous needle biopsy
- 11.5 Percutaneous aspiration biopsy
- 11.6 Aspiration of fluid collection
- 11.7 Antegrade pyelography
- 11.8 Extracorporeal shock wave lithotripsy

12.0 BECOME FAMILIAR WITH THE FOLLOWING APPLICATIONS OF ULTRASOUND:

- 12.1 Destruction of urinary calculi
- 12.2 Intraoperative localization of calculi
- 12.3 Doppler
  - 12.31 Varicocele
  - 12.32 Vascular flow
- 12.4 High-intensity focused ultrasound

COMPUTED TOMOGRAPHY OF THE GENITOURINARY TRACT

Ray Stutzman, MD

1.0 GENERAL OBJECTIVES

Demonstrate knowledge of basic physical principles and instrumentation of computed tomography; demonstrate an understanding of the clinical information gained from the imaging modality, and be able to show an understanding of the indications for such examinations

2.0 PHYSICAL PRINCIPLES

Describe the physical principles and instrumentation of computed tomography and the meaning of the following:

- 2.11 Hounsfield unit
- 2.12 Pixel
- 2.13 Detectors
- 2.14 Contrast resolution
- 2.15 Spatial resolution
- 2.16 Window level
- 2.17 Window width
- 2.18 Discuss width of image and its importance
- 2.19 Discuss volume averaging effect
- 2.110 Discuss difference between standard breath-hold and spiral techniques
- 2.111 Discuss resolution advantage of spiral techniques
- 2.112 Discuss 3-D reconstruction from spiral CT

3.0 DESCRIBE THE VALUE OF COMPUTED TOMOGRAPHY IN ASSESSING THE ADRENAL GLAND

- 3.1 Review adrenal gland anatomy as it relates to the following:
  - 3.11 Normal anatomy
  - 3.12 Congenital anomalies
    - 3.121 Absence
    - 3.122 Hyperplasia
    - 3.123 Hypoplasia
  - 3.13 Primary adrenal tumors
    - 3.131 Cortical; adenoma, carcinoma, hyperplasia
    - 3.132 Medullary; neuroblastoma, pheochromocytoma, ganglioneuroma
    - 3.133 Myelolipoma
  - 3.14 Secondary adrenal tumors
    - 3.141 Metastases, e.g. bronchogenic carcinoma, breast carcinoma, GI malignancies, renal carcinoma
  - 3.15 Adrenal cysts
  - 3.16 Adrenal atrophy
  - 3.17 Infiltrative and infective disorders
    - 3.171 Tuberculosis
    - 3.172 Amyloidosis
    - 3.173 Carcinomatosis
    - 3.174 Fungal infections
    - 3.175 Adrenal hemorrhage

4.0 DESCRIBE THE VALUE OF COMPUTED TOMOGRAPHY IN ASSESSING THE KIDNEY

- 4.1 Review renal anatomy as it relates to the following:
  - 4.11 Normal anatomy
  - 4.12 Cross-sectional anatomy
  - 4.13 Neighboring organs/structures
- 4.2 Review the information obtained from the scans with and without contrast media
- 4.3 Review how computed tomography is used in the assessment of the following:
  - 4.31 Anomalies of structure
    - 4.311 Ectopia
    - 4.312 Hypoplasia
    - 4.313 Horseshoe kidney
    - 4.314 Anomalies of renal pelvis and calyces, e.g. duplication and obstruction
  - 4.32 Cystic disease
    - 4.321 Adult polycystic
    - 4.332 Unilateral multicystic
    - 4.333 Simple cyst
    - 4.334 Acquired renal cystic disease
  - 4.33 Hydronephrosis and ureteral dilation
    - 4.331 Ureteropelvic junction obstruction
    - 4.332 Vesico-ureteral reflux
    - 4.333 Ureteral obstruction
    - 4.334 Ureterovesical junction obstruction
    - 4.335 Bladder outlet obstruction
    - 4.336 Urethral obstruction
  - 4.34 Renal infections
    - 4.341 Acute pyelonephritis
    - 4.342 Emphysematous pyelonephritis
    - 4.343 Xanthogranulomatous pyelonephritis
    - 4.344 Tuberculosis
  - 4.35 Renal and perirenal abscess
    - 4.351 Renal abscess
    - 4.352 Perirenal and pararenal abscess
  - 4.36 Perirenal fluid collections
    - 4.361 Urinoma
    - 4.362 Hematoma
    - 4.363 Lymphocele
  - 4.37 Renal tumors
    - 4.371 Benign renal adenoma
    - 4.372 Renal adenocarcinoma
    - 4.373 Wilms' tumor; nephroblastoma and mesoblastic nephroma
    - 4.374 Oncocytoma
    - 4.375 Angiomyolipoma
    - 4.376 Transitional cell carcinoma
    - 4.377 Sarcoma
  - 4.38 Renal transplantation
    - 4.381 Obstruction
    - 4.382 Rejection
    - 4.383 Infection
    - 4.384 Perirenal fluid collection
  - 4.39 Acute and chronic renal failure
  - 4.310 Renal trauma
  - 4.311 Renal calculi
    - 4.3111 Uric acid

4.3112 Calcium containing
4.3113 Struvite
4.312 Renal vasculature
4.3121 3-D accuracy
4.3122 Donor nephrectomy
4.3123 Laparoscopic nephrectomy

5.0 DESCRIBE THE VALUE OF COMPUTED TOMOGRAPHY IN ASSESSING THE URETER

5.1 Dilation
5.2 Calculi
5.3 Neoplasms
5.4 Anomalies, e.g. retrocaval ureter

6.0 DESCRIBE THE VALUE OF COMPUTED TOMOGRAPHY IN ASSESSING THE RETROPERITONEUM AND ITS STRUCTURE

6.1 Normal anatomy
6.2 Vascular anomalies
6.3 Metastases and lymphadenopathy
6.31 Carcinoma of the prostate
6.32 Carcinoma of the bladder
6.33 Testicular malignancy
6.34 Other; penis, urethra
6.4 Retroperitoneal fibrosis
6.5 Trauma
6.6 Tumor invasion of renal vein and vena cava

7.0 DESCRIBE THE VALUE OF COMPUTED TOMOGRAPHY IN ASSESSING THE URINARY BLADDER

7.1 Review the anatomy of the urinary bladder and how it relates to the following:
7.11 Normal anatomy
7.12 Neighboring organs/structures
7.2 Review how computed tomography is used in the assessment of the following:
7.21 Primary tumors, including staging
7.211 Transitional cell carcinoma
7.212 Squamous cell carcinoma
7.213 Adenocarcinoma
7.214 Urachal neoplasms
7.215 Sarcoma
7.22 Secondary tumors
7.23 Vesico-enteric fistula
7.24 Chronic cystitis, e.g. tuberculosis, schistosomiasis
7.25 Bladder diverticula; congenital and acquired

8.0 DESCRIBE THE VALUE OF COMPUTED TOMOGRAPHY IN ASSESSING THE SEMINAL VESICLES AND PROSTATE

8.1 Review the anatomy of the seminal vesicles and prostate
8.11 Normal anatomy
8.12 Cross-sectional anatomy
8.13 Neighboring organs/structures

8.2 Review how computed tomography is used in the assessment of the following:
- 8.21 Adenocarcinoma of the prostate
  - 8.211 Staging
- 8.22 Benign prostatic hyperplasia
  - 8.221 Volume determination
- 8.23 Other malignant tumors
  - 8.231 Transitional cell carcinoma
  - 8.232 Tumors invading the prostate
- 8.24 Tumors of the seminal vesicles
  - 8.241 Primary
  - 8.242 Secondary
- 8.25 Congenital absence of the seminal vesicles

9.0 DESCRIBE THE VALUE OF COMPUTED TOMOGRAPHY IN ASSESSING POSTOPERATIVE UROLOGIC PROCEDURES AND COMPLICATIONS

- 9.1 Fluid collections
  - 9.11 Abscess
  - 9.12 Hematoma
  - 9.13 Lymphocele
  - 9.14 Urinoma
- 9.2 Local tumor recurrence
- 9.3 Urinary diversion
  - 9.31 Conduits
  - 9.32 Continent diversions
- 9.4 Status of reconstructive surgery

10.0 DESCRIBE THE USE AND METHODOLOGY OF COMPUTED TOMOGRAPHY IN THE FOLLOWING INTERVENTIONAL TECHNIQUES:

- 10.1 Renal cyst aspiration
- 10.2 Percutaneous nephrostomy
- 10.3 Percutaneous needle biopsy
- 10.4 Percutaneous aspiration biopsy
- 10.5 Aspiration of fluid collection
- 10.6 Antegrade phelography

MAGNETIC RESONANCE IMAGING IN UROLOGY (MRI)

Mitchell Schnall, MD

1.0 BASIC MRI TECHNIQUE

MRI uses a combination of magnetic fields and radio waves to create images of the body. There is no radiation exposure associated with MRI. The images reflect the NMR signal from the 1H nuclei (also known as protons) in the body. The major source of the protons that generate the signal for MRI are part of water (H_20) and of fat (CH_3-CH_2---).

1.1 The MRI scanner

1.11 The MRI scanner consists of a large magnet that partially magnetizes (also referred to as polarizes) the protons in the body. The fraction of the protons that are magnetized is dependent on the strength of the magnet but is always small (approximately one in a million). The strength of the magnetic field is measured in a unit called a Tesla. The magnets used in MRI scanners vary in strength from .2-1.5 Tesla. The stronger the magnetic field, the better the images can be due to the larger amount of polarization. Most higher field scanners are solenoidal in shape and thus appear to be an elongated "donut" to the patient. Less claustrophobic open designs have been introduced but today are usually lower in field strength and not ideal for urologic application. Currently, higher field open magnets are being designed and may reduce patient claustrophobia. In addition to the scanner, there is a coil or probe that detects the NMR signal. This is a very important part of the system because it often will determine the strength of the signal. Use of special designed coils for each body part will provide the best examination possible. An example of this is the use of an endorectal surface coil for prostate imaging.

1.2 Image contrast

1.21 The greatest attribute of MRI is the ability to manipulate the image contrast so that structures can be distinguished from each other. The brightness on an MRI image depends on a number of factors, including the density of protons that create the NMR signal, and constants for each tissue that are referred to as relaxation times. There are two relaxation times that are referred to as T1 and T2. A specific tissue, such as prostate peripheral zone, has a specific T1 and T2 time. For most tissues, the T1 and T2 times will vary together, that is tissues with a long T1 will tend to have a long T2 and vice versa. The rate of magnetic relaxation, in general, depends on the amount of magnetic or paramagnetic "stuff' in a tissue. Thus, the simpler a structure is (urine in the bladder) the longer the relaxation. A table of relation characteristics of some common tissues is shown below.

Tissue	Relaxation Time
Urine	Long
Fat	Short
Acute hematoma	Long
Subacute hematoma	Short
Renal parenchyma	Intermediate

1.22 It is possible to weight images according to these tissue-specific parameters in order to develop better contrast in the image. There are two major types of MRI
images—T1 and T2 weighted images. The T1 weighted images will make fast relaxing structures bright and the long relaxing structures dark. T2 weighted images have the opposite effect. Thus, a T1 weighted image is characterized by bright fat and dark urine, while a T2 weighted image is characterized by bright urine.

1.3 Fat and water

1.31 Chemical shift here is another property that can be used to characterize fat and water. Chemical shift refers to a shift in the frequency of NMR signal that comes from one chemical species relative to another. This is the property that we use in analytical labs to identify and quantify the amount of substance in a sample. The frequency difference between fat and water allows us to suppress the signal from either of these by applying frequency-selected saturation. Thus, a "fat saturated" image will have no signal from the fat, which will then appear dark. An additional technique referred to as opposed phase imaging or chemical shift imaging uses the chemical shift between fat and water to allow fat to evolve out of phase with each other (thus they cancel instead of add). The cancellation from the out of phase image is very sensitive to detect small amounts of fat in structures, such as lipid in adrenal adenomas.

1.4 Contrast agents

1.41 The most common contrast agent used in MRI is a Gd-chelate. This consists of a paramagnetic metal atom (gadolinium) chelated tightly by a larger molecule, such as DTPA. The pure unchelated gadolinium salt is very toxic, however, is correctly chelated the contrast age is extremely safe. There is minimal nephrotoxicity, thus this agent can be used in patients with renal failure. In addition, allergic reactions to gadolinium are quite rare and are not associated with reaction to iodinated contrast media. Gd-chelate can be safely administered to patients with x-ray contrast allergies. Gd-chelate is not directly visible by MRI but rather dramatically shortens the relaxation times (primarily the T1) of nearby water protons. This effect is best observed on T1 weighted images. Structures with gd-chelate present will get bright. Another interesting effect is that if the Gd-chelate is too concentrated it will turn the adjacent water black. This is commonly the case in the renal collecting system where the kidney can concentrate the Gd-chelate. The kidney excretes most Gd-chelates, however, newer macromolecular agents that stay intravascular are being developed.

1.5 Three-dimensional imaging

1.51 Although all MR images are inherently three-dimensional because they are made up of multiple slices, there are techniques to collect images that are truly three- dimensional and can be viewed in any arbitrary plane. These techniques usually are used with T1 weighted techniques.

1.6 Angiography

1.61 There are many techniques to create images that accentuate blood vessels so that an angiographic projection can be developed to look similar to a conventional angiogram. The most successful of these techniques uses T1 weighted three-dimensional images that are acquired while injecting Gd-chelate.

1.7 MRI urography

1.71 Selected images of the renal collecting system and ureters can be obtained in two ways. The first uses strongly T2 weighted images to highlight urine-containing tissues. This is the same technique used to make images of the biliary
system. A second relies on excreted Gd-chelate to highlight the renal collecting system on T1 weighted three-dimentional images. Furosemide, 5 mg, is typically given with the Gd to ensure the excreted Gd is not hyperconcentrated and to assist in distention of the system.

2.0 APPLICATION OF MRI TO THE GENITOURINARY TRACT

2.1 Kidneys; indications

2.11 MRI is a sensitive and specific technique to detect and characterize renal parenchymal abnormalities. It can be considered as an alternative to CT for almost any indication, with the exception of detecting renal calculi. In particular, MRI should be considered in cases where there is a relative or absolute contraindication to iodinated contrast due to hypersensitivity or renal failure. In addition, MRI should be considered in cases where barium would obscure findings on CT. MRI is valuable in the characterization of indeterminate renal masses detected by CT or ultrasound. It may also be valuable in the detection and characterization of renal vascular disease.

2.12 Technique

A standard renal MRI examination usually contains axial T1 and T2, as well as fat suppressed T1 pre and post-contrast in the coronal and axial plane. Other sequences, such as chemical shift imaging and three-dimensional vascular imaging, may be performed as needed. Almost all of the imaging sequences used in renal imaging can be performed within a 20-25 second breath-hold when performed on a high field scanner. Patients that cannot cooperate with this breath-hold will get a suboptimal exam. Renal MRI performed on a low field open scanner will also be suboptimal because the lower signal will not support breath- hold scanning.

2.13 Renal cell carcinoma

Renal cell carcinoma can have a variable appearance on MRI. It can be bright or dark on T1 and T2 weighted images depending on the amount of hemorrhage, vascularity, and cystic component. The hallmark of RCC on MRI is contrast enhancement. MRI contrast is stronger than CT; therefore identifying solid enhancing components of renal lesion is easier on MRI than on CT. There are no absolute scales for MRI signal intensity, however, scans done during the same setting with the same technique can be directly compared. Changes in intensity of less than 5 % are considered insignificant. Coronal MRI imaging can be valuable to demonstrate the relationship of the lesion to the collecting system and renal vasculature providing a valuable tool to plan partial nephrectomy. In addition, MRI is accurate in studying the renal vein and inferior vena cava for the presence of tumor thrombus. It is important to study the renal vein and IVC at the time of planed intervention because significant growth of venous involvement in renal cell carcinoma has been demonstrated in 2-4 weeks.

2.14 Transitional cell carcinoma (TCC)

MRI does not represent the primary method for detecting TCC, however, most invasive TCC lesions can be seen at MRI. MRI is valuable for assessing the extent of these lesions and the extent of renal invasion.

2.15 Renal cysts

Renal cysts on MRI can be thought of as simple or complicated. Simple cysts are bright on T2 weighted images, dark on T1 weighted images, and show no enhancement or thin enhancing septation on post-contrast images. These lesions need no follow-up. Complex cysts have either blood products or concentrated protein in them. They can be bright or mixed signal intensity on T1 weighted images, often demonstrating a fluid level between the fluid components. In addition, these lesion can have mixed T2 signal intensity characteristics with the bright T1 component turning dark on T2 weighted images and the dark T1 component turning bright on the T2 weighted images. Again, the key to the diagnosis is the lack of enhancement. It may be difficult to tell if parts of the lesion that are bright on T1 weighted images enhance (because they are already bright on T1 weighted images), however, it is very unusual for any solid tissue to be bright on T1 weighted images. Therefore, it can be assumed that they are not the solid mass components. Occasionally, clots can form in hemorrhagic cysts. The clots are typically dark on T2 weighted images and are characterized by a lack of enhancement. Garden-variety complex renal cysts on MRI need no follow-up. Cysts with clots should be followed at six months to ensure stability.

2.16 Angiomyolipoma (AML)

The ability of MRI to demonstrate and characterize fat makes it valuable in the diagnosis of AML. The diagnosis is established by demonstrating macroscopic fat in the lesion. Any foci of bright signal (even small specks) on T1 weighted images should be considered as possible fat until proven otherwise. Fat-suppressed imaging can be used to demonstrate that the signal decreases to near zero, indicating it is due to fat. Chemical shift imaging may also be useful. When it is very subtle, water saturation imaging can be better to demonstrate the remaining fat signal. Although clear cell carcinoma contains microscopic lipids that can be detected on chemical shift imaging, its distribution is usually homogeneous and can be distinguished from and AML. MRI is indicated to establish the diagnosis of AML when other studies are equivocal.

2.17 Renal vascular lesions

Renal MRI arteriography is an accurate technique to image the renal arteries and veins. This examination should be performed on a high-field scanner equipped with state of the art gradient technology. Renal MRI can be used as a screen for renal artery stenosis. It has been shown to be more accurate that doppler sonography in that regard. Renal MRI can also detect renal AVMs and renal artery aneurysms. In addition to the vascular findings, the parenchymal enhancement pattern can suggest the diagnosis of renal ischemia or infarction.

2.18 Renal donor evaluation

MRI can serve as a one-stop-shop for renal donor evaluation. Renal MRI and MRI can evaluate renal structure and vascular supply. This technique is accurate at detecting accessory renal arteries and veins. The use of MRI urography can demonstrate the collecting system effectively.

2.2 Adrenal glands; indication

2.21 The main indication of MRI in the adrenal glands is in the differential diagnosis of adrenal masses. MRI can be helpful to diagnose adenoma, pheochromocytoma, and myelolipoma.

2.22 Adenoma

Adrenal adenomas are characterized by intracellular lipids. This can be detected on chemical shift imaging to establish the diagnosis and excluded metastatic disease. The finding of signal loss on the out-of-phase image is extremely specific for adrenal adenoma. However, approximately 10% of adenomas will not have this finding so that a negative MRI scan should lead to a biopsy.

2.23 Pheochromocytoma

Pheochromocytoma has a typical appearance on MRI. This lesion is characterized pathologically by pools of epinephrine, which look like fluid on MRI, giving these lesions their typical bright appearance on T2 weighted images. In addition to being able to suggest the diagnosis of pheochromocytomo when imaging the adrenal, it is useful to search for extra-adrenal pheo.

2.24 Myelolipoma

MRI can easily diagnose this lesion by detecting the fat content. The technique and findings are similar to those discussed under AML.

2.3 Bladder; indications

2.31 MRI of the bladder is a useful technique to stage the extent of transitional cell carcinoma (TCC). It may also be valuable in the differential diagnosis of bladder masses and distinguishing intrinsic bladder lesions from extrinsic masses.

2.32 Transitional cell carcinoma

TCC is best detected on MRI by observing enhancement during the vascular phase of a contrast injection. Other lesions, such as inflammatory disease, will also enhance. MRI can detect early noninvasive lesions. The use of T2 weighted images and contrast enhanced images in experienced hands provide an accurate means of determining the extent of bladder wall invasion. MRI can also detect extravesical extension, fistula formation and lymph adenopathy that can accompany this disease.

2.33 Leiomyoma

Leiomyoma of the bladder wall has a characteristic appearance on MRI highlighted by low signal in T2 weighted images and smooth margins. MRI can be used to differentiate this benign tumor from TCC.

2.4 Prostate; indications

2.41 MRI is indicated in the evaluation of the extent of prostate cancer and in the workup of ejaculatory dysfunction. In addition, MRI may be valuable in the evaluation of men with elevated PSA and negative prostate biopsies.

2.42 Technique

Several techniques are used to image the prostate gland with MRI. The highest resolution images are obtained by using an endorectal surface coil. A lower resolution alternative uses the external phased array. Imaging of the prostate with the body coil should not be accepted under normal circumstances.

2.43 Normal prostate

The normal prostate is low signal on T1 weighted images. On T2 weighted images the peripheral zone is bright, while the central gland is mixed in signal

due to the variable histology of the BPH (glandular is bright while stromal is dark).

2.44 Prostate cancer

MRI can detect prostate cancer as low signal in the peripheral zone on T2 weighted images. Lesions such as PIN, prostatitis and postbiopsy hemorrhage can simulate cancer. The use of MR spectroscopy has been shown to improve the specificity. High choline to citrate ratios suggests cancer. The combined use of MRI/MRS has been shown to accurately determine the disease burden on the prostate gland. MRI is also valuable to determine the stage of prostate cancer. It is accurate in detecting gross capsular penetration and seminal vesicle invasion. MRI cannot detect microscopic capsular penetration

2.45 Ejaculatory dysfunction

Patients with hypospermia, azospermia, and hematospermial with confusing clinical findings may be imaged with MRI. MRI is useful to detect mullerian cysts, seminal vesicle cysts, congenital abnormalities of the vas and ejaculatory ducts, and other lesions that could be contributing to the patient's symptoms.

2.5 Scrotum, indication

2.51 MRI of the scrotum is a very valuable imaging technique, however, most imaging questions can be resolved with the use of sonography. MRI is reserved for those cases that are indeterminate sonographically. MRI may also be useful in locating and characterizing undescended testes. Proper MRI of the scrotum uses small surface coils to obtain high-resolution images. This examination is also performed at higher field strength.

2.52 Normal testis

The normal testis is bright on T2 weighted images. The tunica albuginia is well seen. A trace hydrocele is also normal. The septation that divides the testicular lobules is seen on high-quality examinations.

2.53 Testicular cancer

MRI can be helpful to distinguish testicular cancer from other testicular lesions. The cancers are low signal within the high signal testis on T2. The seminomatous tumors are uniform, while nonseminomatous tumors tend to be heterogeneous. These lesions can often be differentiated from chronic orchitis by the lack of well-defined mass and the preservation of the lobular architecture of the testis. Epidermoid inclusion cysts have a characteristic laminated appearance on T2 weighted images and typically do not demonstrate any enhancement. It is difficult to reliably differentiate lydic tumors from testicular cancer.

NUCLEAR MEDICINE PROCEDURES IN RENAL AND BLADDER DISORDERS

Abass Alavi, MD

1.0 GENERAL OBJECTIVES

To familiarize trainees about the role of functional imaging in renal and bladder disorders and discuss the indications and technical matters related to these procedures

2.0 RENAL IMAGING IN NUCLEAR MEDICINE

- 2.1 Radiopharmaceuticals
  - 2.11 Glomerular agents
    - 2.111 ^{125}I-iothalamate
    - 2.112 ^{51}Cr-EDTA
    - 2.113 ^{99m}Tc Tc-DTPA
  - 2.12 Tubular agents
    - 2.121 ^{131}I-hippuran
    - 2.122 ^{123}I-hippuran
    - 2.123 ^{99m}Tc-MAG_3
  - 2.13 Cortical agents
    - 2.131 ^{99m}Tc-DMSA
    - 2.132 ^{99m}Tc -glucoheptanate
- 2.2 Technical procedures and quantitative analysis
  - 2.21 Basic dynamic imaging technique (MAG-3, DTPA)
  - 2.22 Lasix study
  - 2.23 Captopril protocol
  - 2.24 Quantitative analysis
    - 2.241 Differential function
    - 2.242 Residual cortical activity
    - 2.243 Measurement of absolute renal function, ERPF and GFR
      - 2.2431 Clearance concept and classical methods
        - 2.24311 Clearance concept
        - 2.24312 Properties of an ideal GFR agent
        - 2.24313 Properties for an ideal ERPF agent
      - 2.2432 Value of creatinine clearance and isolated creatinine measurements
      - 2.2433 Single injection radiotracer methods
      - 2.2434 Simplified techniques with 1 or 2 blood samples
      - 2.2435 Gamma-camera methods
- 2.3 Applications in renal disorders
  - 2.31 Renal failure
    - 2.311 Acute renal failure
    - 2.312 Chronic renal failure
  - 2.32 Renovascular hypertension
    - 2.321 Causes of renovascular hypertension
    - 2.322 Clinical clues suggesting renovascular hypertension
      - 2.3221 History
      - 2.3222 Physical examination
      - 2.3223 Screening laboratory studies
    - 2.323 Rationale for using Captopril renography

2.324 Patient selection
2.325 Patient preparation
2.326 Diagnostic criteria

2.33 Obstructive nephropathy
2.331 Methodologies used to diagnose urinary tract obstruction
2.332 Acute obstruction
2.333 Chronic partial obstruction
2.334 Pathophysiology
2.335 Role of diuretic scintigraphy
2.336 Diuretic renography in relation to other studies
2.337 The Whitaker test
2.338 Preparation for diuretic scintirenogram
2.3381 Hydration
2.3382 Bladder catheterization
2.3383 Furosemide
2.3384 Diagnostic criteria
2.3385 False-positive diuretic scintirenography
2.3386 False-negative diuretic scintirenography

2.34 Renal transplant evaluation
2.341 Complications of renal transplantation
2.342 Surgical complications
2.343 Medical complications
2.3431 Acute tubular necrosis
2.34311 Clinical presentation
2.34312 Pathology
2.3432 Hyperacute rejection
2.3433 Acute rejection
2.3434 Chronic rejection
2.3435 Cyclosporine toxicity
2.3436 Renal artery thrombosis
2.3437 Renal vein thrombosis
2.3438 Renal artery stenosis
2.3439 Urological complications
2.34391 Obstruction
2.344 Nuclear imaging of renal transplants
2.345 "Specific" rejection agents (rarely used)
2.346 Functional agents
2.347 Blood flow
2.348 Tubular agents

3.0 VESICOURETERAL REFLUX

3.1 Indications
3.11 Patient preparation
3.12 Procedure
3.121 Qualitative and quantitative analysis

3.2 Patient preparation

UROLITHIASIS: ENDOUROLOGIC MANAGEMENT: PERCUTANEOUS, URETEROSCOPIC, AND LAPAROSCOPIC APPROACHES

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1.0 GENERAL OBJECTIVES

Demonstrate an understanding of the various minimally invasive approaches to treating urolithiasis and their proper application with respect to the stone's location, composition, and size; understand the proper perioperative care and potential complications associated with each approach; demonstrate an understanding of the various types of intracorporeal lithotriptors with regard to their mechanism of action and proper use

2.0 PERCUTANEOUS STONE REMOVAL

- 2.1 Understanding of intrarenal anatomy (calyceal distribution and blood supply; renal angles, etc.)
- 2.2 Indications
  - 2.21 SWL salvage
  - 2.22 Staghorn calculi
  - 2.23 Calyceal diverticulum
  - 2.24 Renal calculi plus ureteropelvic junction obstruction
  - 2.25 Morbid obesity
  - 2.26 Larger (e.g. > 2 cm) cystine stones
  - 2.27 Lower pole calculi resistant to SWL
  - 2.28 Pediatric applications
- 2.3 Instrumentation
  - 2.31 Nephroscopes; rigid and flexible
  - 2.32 Lithotriptors
    - 2.321 Laser (Holmium:YAG)
    - 2.322 Ultrasonic
    - 2.323 Electrohydraulic
    - 2.324 Pneumatic
- 2.4 Procedural details
  - 2.41 Preoperative preparation (antibiotics, etc.)
  - 2.42 Establishment of the nephrostomy tract
  - 2.43 Dilation of the nephrostomy tract
  - 2.44 Selection of irrigant
  - 2.45 Stone fragmentation and evacuation
  - 2.46 Types of nephrostomy tubes and their placement
- 2.5 Complications
  - 2.51 Intraoperative hemorrhage and its management
  - 2.52 Loss of access
  - 2.53 Pulmonary complications (including pneumothorax)
  - 2.54 Hypothermia
  - 2.55 Postoperative hemorrhage
    - 2.551 Early
    - 2.552 Late; arteriovenous malformation/pseudoaneurysm
  - 2.56 Renal pelvis laceration
  - 2.57 Hyponatremia

2.58 Urosepsis
2.59 Renal damage
2.510 Damage to adjacent organs

2.6 Results
2.61 Nonstaghorn
2.62 Staghorn

3.0 URETEROSCOPIC STONE REMOVAL

3.1 Ureteral anatomy with regard to ureteral wall thickness and points of narrowing and tortuosity

3.2 Indications
3.21 SWL salvage
3.22 Lower pole renal calculi (1-2 cm)
3.23 Ureteral calculi (> 1.5 cm)
3.24 Ureteral calculi associated with ureteral stricture
3.25 Post SWL steinstrasse
3.26 Pelvic kidney
3.27 Calyceal diverticulum (upper to middle of kidney)
3.28 Use in pregnancy
3.29 Pediatric applications

3.3 Instrumentation
3.31 Rigid ureteroscopes
3.32 Flexible ureteroscopes
3.33 Armamentarium of stone baskets and graspers
3.34 Lithotriptors
3.341 Laser
3.342 Electrohydraulic
3.343 Pneumatic

3.4 Procedural details
3.41 Patient preparation (sterile urine, concept of passive dilation of the ureter)
3.42 Patient positioning (dorsal lithotomy vs. prone)
3.43 Ureteral dilation
3.44 Stone extraction
3.45 Stent placement

3.5 Complications
3.51 Ureteral perforation
3.52 Loss of stone
3.53 Failure to fragment
3.54 Stone impaction
3.55 Ureteral avulsion
3.56 Ureteral stricture

3.6 Results
3.61 Renal
3.611 Lower pole calculi
3.612 Small stones (< 2 cm)
3.613 Large stones (> /= 2 cm)
3.62 Ureteral
3.621 Lower ureter
3.622 Upper ureter

4.0 LAPAROSCOPIC STONE REMOVAL

- 4.1 Indications
  - 4.11 Pelvic kidney
  - 4.12 Ureteral stone recalcitrant to other endoscopic approaches
  - 4.13 Calyceal diverticulum (especially if it fails percutaneous/ureteroscopic approach)
  - 4.14 In conjunction with other renal procedures (e.g. pyeloplasty)
- 4.2 Instrumentation; standard laparoscopic tray
- 4.3 Procedural details
  - 4.31 Pneumoperitoneum
  - 4.32 Trocar placement
  - 4.33 Renal stone removal (pyelotomy)
  - 4.34 Ureteral stone removal (ureterolithotomy)
  - 4.35 Exiting the abdomen
- 4.4 Complications
  - 4.41 Hypercarbia
  - 4.42 $C0_2$ embolus
  - 4.43 Hemorrhage from trocar site
  - 4.44 Extravasation
  - 4.45 Trocar site herniation
- 4.5 Results
  - 4.51 Calyceal diverticula
  - 4.52 Ureteral stones