SOCIETY OF URORADIOLOGY GUIDELINES FOR RESIDENT CURRICULUM AND TRAINING IN GENITOURINARY RADIOLOGY

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SUR RESIDENT CURRICULUM COMMITTEE

1. MISSION STATEMENT

The Society of Uroradiology (SUR) advances genitourinary tract imaging, image guided interventions, and the study of the normal and abnormal genitourinary tract as a clinical specialty. The Society therefore has specific interest in all aspects of the practice of genitourinary tract imaging, including the training of physicians for such clinical practice. SUR members have made significant contributions to imaging diagnosis of the genitourinary tract through teaching, research, and peer reviewed publications. The Society provides a unique repository of knowledge and experience relevant to the training of residents in the practice of imaging diagnosis and treatment of genitourinary tract disorders.

The mission of the SUR Resident Curriculum Committee is to provide Radiology Residency Program Directors, Residency Training Coordinators and all relevant educators in Radiology with a set of recommendations for the education of Radiology residents in genitourinary imaging during residency training. Though drawn from the subspecialty expertise and perspective of the SUR, these recommendations are intended to address the requisites for competent practice of genitourinary imaging in clinical Radiology practice.

Along with aspects specific to genitourinary imaging, diagnosis, and treatment, these recommendations include general elements of radiology residency education (such as professional conduct, ethics, communication and consultation skills, quality improvement, cost effectiveness etc). Basic anatomic and pathophysiologic understanding of genitourinary disorders, technical skills, and optimum selection, performance and interpretation of imaging studies appropriate for such disorders are emphasized. It is not the intention to create a textbook, but rather a guide for the necessary and sufficient fund of knowledge for

training, and a repository of resource materials that are current and updated and in keeping with this mission.

The goal of these recommendations will be to assist educators in the effective training and preparation of residents for the practice of clinical genitourinary tract imaging diagnosis. We aim to provide a solid fund of knowledge and learning skills needed to engage in lifelong learning. In so doing, the educators are simultaneously preparing their trainees for standardized testing of competence including the American Board of Radiology written and oral examinations. The result should be to elevate the qualifications of each candidate by virtue of this fund of knowledge and proficiency.

The recommendations of the committee are to be codified in a living document that must be continuously revised to reflect new developments in genitourinary imaging. These recommendations may include but may not be limited to: basic principles of genitourinary tract function and disease, imaging methods and the details of performance necessary for accurate genitourinary tract diagnosis and treatment, methods for assessment of the medical literature, activities that should be learned and performed in residency and afterward, and preparation for continuous medical education following residency training.

2. GUIDELINES FOR EVALUATION OF COMPETENCY

The Residency Review Committee for Diagnostic Radiology of the Accreditation Council for Graduate Medical Education has developed definitions for six general competencies in the teaching and practice of Diagnostic Radiology. All training programs should provide instruction to residents in compliance with the required evaluations. This information can be found at www.acgme.org . The six areas are: patient care, medical knowledge, practice based learning and improvement, interpersonal and communications skills, professionalism, and systems-based practice.

In genitourinary radiology, evaluation of competency includes:

1. PATIENT CARE

a) Technical skills (refer to Appendix List of Modalities)

b) Patient care: formulating a plan for patient triage that includes imaging and proper management

c) Timely and effective communication with referring health care providers

2. MEDICAL KNOWLEDGE

a) Diagnostic Radiology Fund of Knowledge (recognition of imaging abnormalities with synthesis of clinical and radiological information to arrive at the correct diagnosis or differential diagnosis)

b) Medical knowledge base appropriate to the needs of the patient and referring physician

c) Knowledge of principles of Radiation Physics and Dosimetry (including radiation dose for key imaging exams)

d) Knowledge and use of Resource Materials (Refer to Appendix - Core Reference List of texts, references, websites, sources for life long self-learning)

e) Continuous learning in GU Radiology

3. PRACTICE BASED LEARNING AND IMPROVEMENT

a) Principles of Quality Improvement

b) Self assessment programs and lifelong learning

4. INTERPERSONAL AND COMMUNICATION SKILLS

a) Communication, Consultation in Radiologic Practice

b) Record Keeping, Radiologic Reports, Case Presentation

c) Knowledge of HIPAA regulations

d) Understanding of the essentials of obtaining verbal and written Informed Consent

e) Teaching effectively to residents, medical students and other health care professionals

5. PROFESSIONALISM

a) Professional Conduct, Medical Ethics, and Integrity

6. SYSTEM BASED PRACTICE

a) Understand cost effectiveness in selection of imaging studies

b) Understand the efficient and proper selection of studies in sequence to maximize diagnostic yield while minimizing cost as well as minimizing risk to the patient

c) Learn to rely on evidence based medicine for clinical decision-making

d) Optimize patient care in consultation with other health care providers to choose the most effective imaging studies

3. BENCHMARKS BY YEAR OF TRAINING

Introduction:

The Genitourinary (GU) Radiology residency training program spans a minimum of 4 academic years. The curriculum is designed to achieve graded responsibility and an increasing fund of knowledge in GU Radiology. The goal is for each resident to achieve independent competency and to acquire the tools with which to continue self-education and life-long learning techniques. Furthermore, the level of practice should be consistent with national community standards as outlined in the American College of Radiology (ACR) Practice Guidelines.

It is difficult to isolate the practice of GU Radiology into packets of skills and knowledge for each year and each clinical rotation that can be used in the varied environments and institutions that provide residency training. What follows is a general guide for residents and program directors for meeting the expectation thresholds for each academic year. Sometimes the order in which these skills are acquired will vary. For example, learning about CT or MRI might precede training in fluoroscopy or radiography. However, all of these benchmarks should be met by the time of completion of residency training.

Emphasis throughout the four-year residency program should be on understanding the pathophysiology of diseases and disorders, and its appearance across all appropriate imaging modalities.

<u>Year 1</u>
Goal: To prepare the resident to be able to safely practice with supervision during the week days and independently while on call by the end of the first year.

Objectives:
Contrast Material:

1. Understand the physical properties of iodinated contrast media and the physiologic mechanisms of contrast media excretion.
2. Learn to screen patients who are at risk from injection of intravascular radiographic contrast material. Understand the classification, symptoms, and signs of contrast reactions and clinical management including appropriate use of pharmacologic agents and their mode of administration and doses after appropriate patient assessment.

a) Consult the ACR Manual for Contrast Media, Version 5.0).

b) Be prepared to answer patient and staff questions concerning when contrast media should or should not be utilized and how to treat contrast reactions.

3. Understand the indications for premedication and the appropriate regimen to premedicate contrast sensitive patients including dosages, and dose scheduling.

Knowledge Based Objectives:

1. Review the anatomy of the male and female genitourinary systems.
2. Understand the appearance of GU structures on the basic imaging modalities using not only plain film radiography such as intravenous urography (IVU), voiding cystourethrography (VCUG), retrograde ureterography (RU), but also in ultrasound, computed tomography (CT), and magnetic resonance imaging (MRI), including on dedicated CT urography and MR urography examinations.
3. Learn conventional imaging protocols of the urinary tract e.g. IVU, RU, VCUG, retrograde urethrography (RUG), and hysterosalpingography. For IVU, the resident should know:

a) indications and contraindications for use of abdominal compression.

b) routine views and additional films required to achieve the tailored urogram

4. Be able to interpret, identify and/or manage the following with imaging:

a) plain abdominal films for bowel gas pattern and recognition of masses and calcifications

b) renal colic and renal stone disease

b) hydronephrosis and ureteral obstruction

c) urothelial abnormalities including collecting system, ureter, and bladder

d) renal cysts and tumors

e) medullary sponge kidney

g) benign prostatic hyperplasia

h) bladder diverticula, bladder rupture, neurogenic bladder

i) urethral strictures, urethral diverticula

j) cancer of the cervix, uterus, and ovaries hysterosalpingographic appearance of intravasation, hydrosalpinx, salpingitis isthmica nodosum. uterine synechiae, filling defects such as polyps and submucosal leiomyomas, the endometrial cavity exposed to diethylstilbestrol (DES), and congenital anomalies

k) basic cross sectional urinary tract anatomy on CT/CT Urography and MRI/MR Urography

5. Understand the relationship between contrast administration and pathophysiology of diseases/conditions including:

a) dynamic bolus enhancement on cross sectional imaging studies and IVU

b) arterial phase CT or MR used for tumor diagnosis

c) arteriovenous shunt diagnosis

d) parenchymal phase CT for inflammatory manifestations of renal parenchyma

e) tissue viability and revascularization in trauma

6. Learn that imaging during the different phases of contrast excretion offers not only information about morphology but also function (e.g. - disparity in the phases between the two kidneys indicating either obstruction or abnormal perfusion with IVU, CT, MRI, angiography, etc).

Technical Skills:

1. Interview patients prior to radiographic contrast injection
2. Be familiar with fluoroscopic techniques and safe operation of the fluoroscopic unit
3. Learn to perform IVU, VCUG and routine cystography, and RUG
4. Learn to compose a concise GU dictated report. Begin to function as a consultant to referring physicians and patients involved in GU studies.

References for 1st Year:

1. ACR Practice Guidelines for the Use of Intravascular Contrast Media, Version 5.0
2. Textbook of Uroradiology, 3rd Ed., Dunnick NR, Sandler CM, Newhouse JH, Amis Jr ES, Lippincott Williams & Wilkins, Philadelphia, 2001

Year 2

Goal: To add to your GU disease and imaging modality knowledge while gaining more confidence.

Objectives:

1. Review the general developmental anatomy of the GU system.
2. Refine the technique and performance of IVU
3. Expand the understanding of the causes and effects of renal colic, renal stone disease, and hydronephrosis
4. Expand the understanding of renal cysts and tumors to include:
   a) the Bosniak Classification system (or another similar system) for evaluating cystic renal masses and implications for management of complex renal cysts
   b) the imaging and staging of malignancies of the genitourinary organs including renal, urothelial, prostate, endometrial, cervical, and ovarian cancers

c) the multi-cystic renal diseases including genetic syndromes including autosomal dominant adult polycystic renal disease

4. Recognize a large variety of congenital abnormalities of the GU tract, especially those which are most common-e.g. fusion anomalies (such as horseshoe kidney, crossed fused renal ectopia, ectopic kidneys including pelvic and thoracic), partial and complete duplications of the collecting systems, renal tubular ectasia (medullary sponge kidney or MSK), renal agenesis, and Hutch diverticula.

5. Understand use of conventional GU imaging and transrectal ultrasound of the prostate (TRUS) to image the lower GU tract, especially the

a) zonal anatomy of the prostate as seen on TRUS

b) technique of TRUS, diagnosis, basic principles of the pathophysiology, and management of prostate cancer, prostatic intraepithelial neoplasia, benign prostatic hyperplasia, and prostatitis

c) A basic understanding of Gleason grading of prostate cancer and of prostate cancer staging

6. Understand diagnosis, classification, and management of GU trauma and principals of imaging, including

a) identification of the bulbomembranous urethral junction on urethrography, as well as common abnormalities including urethral trauma, rupture, and strictures

a) bladder, ureteral, and renal injuries

b) techniques of retrograde urethrography, conventional cystography, and CT (including CT cystography) in patients with suspected urethral or bladder trauma

7. Understand ultrasound imaging diagnosis, management, and prognosis of testicular and extratesticular disorders.

8. Understand US techniques and diagnosis of female pelvic disorders including

a) pelvic inflammatory disease e.g. tuboovarian abscess, endometriosis
b) ovarian cysts and malignant masses
c) uterine fibroids and adenomyosis

9. Understand the protocol for performance of loopograms, vaginograms, and retrograde ureteropyelograms, and the postoperative anatomy of the continent diversion, loop diversion, repaired urethral strictures, and artificial urinary sphincters
10. Understand the importance of the timing of the scans for dedicated contrast enhanced CT and MR imaging of the kidneys to include the nephrographic, corticomedullary, and excretory phases.
11. Be aware of the approximate patient radiation doses of GU radiographic x-ray procedures, especially IVU, renal stone CT, conventional CT, and CT urography
12. Further refinement of dictation skills, so that dictations are becoming concise but complete

References for 2nd Year:

Clinical Urography, 2nd Ed., Pollack H, et. al., Chapter 4, Development and Congenital Disorders

Dunnick, N.R., Sandler, C.M., Newhouse, J.N., Amis, Jr., E.S., Textbook of Uroradiology, 3rd ed., Philadelphia, PA: Lippincott Williams & Wilkins, 2000.

Year 3:

Goal:

Add to general knowledge acquired in the first two years and learn more advanced and less common techniques and disorders.

Objectives:

1. Learn about the different types of renal and ureteral injuries and their classification as well as the recommended non-surgical and surgical management and injury prognosis.

2. Understand the anatomy of urinary diversions and reservoirs and how they differ.
3. Increase awareness of the CT manifestations of genitourinary tract disease.

a) Knowledge of different types of renal neoplasms (including subtypes of renal cancer) and their CT appearances

b) Understand the technique of CT urography and be able to recognize the CT urographic appearances of a variety of malignant and benign urinary tract abnormalities.

4. Understand normal MRI findings of the adrenals, kidneys, bladder, prostate, and female pelvic organs and MRI spectroscopic findings in the normal prostate.
5. Learn the anatomy and disorders of the retroperitoneum, including

a) retroperitoneal fibrosis
b) lymphoma
c) liposarcoma and other mesenchymal tumors
d) extra renal angiomyolipoma as distinguished from retroperitoneal liposarcoma

6. Understand and learn diagnosis of the multiple manifestations of renal and retroperitoneal inflammatory disease as seen on US, CT / CT Urography, MR/MR Urography and their clinical management including

a) acute pyelonephritis
b) renal and perirenal abscess
c) xanthogranulomatous pyelonephritis
d) emphysematous pyelitis and pyelonephritis

6. Understand patterns of genitourinary differential diagnosis such as for renal masses, uni- or bilateral renal enlargement, filling defects, ureteral deviation (both medial and lateral), bladder enlargement, bladder displacement, etc.
7. Become familiar with ultrasound guided prostate biopsy
8. Become more familiar with the indications for and utility of renal mass biopsy, including limitations of biopsy in differentiating among various renal neoplasms.

8. Understand the various options for treatment of renal neoplasm, including open surgery, laparoscopic nephrectomy, partial nephrectomy, and percutaneous ablation, including awareness of selection and exclusion criteria for and commonly encountered complications of percutaneous ablation, as well as findings on follow up imaging studies following ablations that indicate successful ablation versus recurrent tumor
9. Understand patterns of genitourinary differential diagnoses, such as for renal masses, uni- or bilateral renal enlargement, filling defects, ureteral deviation (both medial and lateral), bladder enlargement, bladder displacement, etc.
10. Learn about the technique for performing ultrasound guided prostate biopsy.
11. Begin to use the independent workstation for image reformatting and reconstruction, particularly for CT, CTU, and CT angiography (CTA), as well as MR, MRU, and MR angiography (MRA).

Reference for 3rd year:

Clinical Urography, 3rd Ed., Pollack, et al.

Year 4 (and 5, if you need it!)
Goal:
Review all the knowledge and skills you have accumulated in the first three years and fill the gaps in your knowledge. Focus on getting as much case management experience as possible.

Objectives:
1. Understand congenital anomalies, inflammatory, and neoplastic conditions as they appear on hysterosalpingography
2. Understand effects of vasculitic conditions of the kidneys as they appear on CT, MR, and angiography.
3. Review cases in the ACR teaching file and peer reviewed teaching files available on the internet. The best sites should

present as unknown cases, asking for you to make a diagnosis and suggest recommended imaging and clinical management, summarizing the correct diagnosis and management at the end.
4. Attend available department case conferences or other didactic presentations, including interdepartmental conferences, grand rounds, guest lecturers, etc. Emphasize independent thinking before seeking direct staff supervised patient management.
5. Develop proficiency at image reconstruction and reformatting for CT,CTU, CTA, MR, MRU, MRA, etc.
6. Understand the basic principles of radiofrequency ablation, thermocoagulation, and other minimally invasive procedures, along with the appropriate imaging guidance and post treatment surveillance.

4. APPENDIX A: Curriculum Syllabus by Topic

In depth knowledge of all of the following listed items, particularly the more unusual or rare entities is not expected, but by the end of residency training, the resident should recognize and have mastered a majority of the categories on this list incorporating them into his or her fund of knowledge (Adapted from ACR Index for Radiologic Diagnoses, Revised 4th Edition, 1999)

1.0 ANATOMY AND EMBRYOLOGY OF THE GU TRACT
1.1 EMBRYOLOGY OF THE GENITOURINARY SYSTEM, ADRENAL
1.2 Congenital Anomalies
1.2.1 Renal
1.2.1.1 Anomalies of number
1.2.1.1.1 agenesis
1.2.1.1.2 supernumerary kidney
1.212 Fusion anomalies
1.2121 Horseshoe kidney
1.2122 Crossed fused ectopia
1.213 Position anomaly
1.2131.1 malrotation
1.2131.2 pelvic, inferior ectopia

1.2131.3 intrathoracic kidney
1.22 Ureteral
1.221 Blind ureter
1.222 Duplication
1.222.1 partial
1.222.2 complete
1.222.3 with ectopia
1.222.3.1 ectopic ureterocele
1.223 Ectopic insertion
1.224 Obstructions
1.224.1 UPJ obstruction
1.224.2 Obstructive megaureter
1.224.3 Ureteral stricture
1.23 Bladder
1.231 exstrophy
1.232 urachal anomalies
1.233 duplication
1.234 congenital diverticula
1.24 Urethra
1.241 epispadias
1.242 hypospadias
1.243 duplications
1.244 urethral obstructions
1.244.1 posterior valves
1.244.2 anterior valves
1.244.3 meatal stenosis
1.244.4 diverticulum
1.25 Male genital
1.251 cryptorchidism
1.252 agenesis seminal vesicles
1.253 utricular cysts
1.26 Female
1.261 vaginal agenesis
1.262 uterine anomalies
1.262.1 agenesis
1.262.2 unicornuate uterus
1.262.3 fusion anomalies
1.262.3.1 septate uterus
1.262.3.2 bicornuate uterus
1.262.3.3 uterus didelphys
1.27 Intersex States
1.3 NORMAL ANATOMY
1.3.1 RENAL
1.3.2 URETER
1.3.3 BLADDER
1.3.4 URETHRA

1.3.5 MALE GENITAL
1.3.6 FEMALE GENITAL
1.3.7 ADRENAL
1.3.8 RETROPERITONEUM

2.0 PROCEDURES – DIAGNOSTIC AND THERAPEUTIC
(basic principles of computers, digital imaging, PACS, and teleradiology should be understood)
2.1 contrast media (pharmaceuticals)
2.1.1 History
2.1.2 Principles, physiology ionic contrast
2.1.3 nonionic contrast
2.1.4 MRI contrast media
2.1.5 Radiopharmaceuticals for urinary tract evaluation
2.1.6 Contrast for hysterosalpingography
2.161.1 oil based (not used much any more)
2.161.2 water soluble
2.1.7 Pathophysiology, incidence, classification and treatment of contrast reactions
2.2 DIAGNOSTIC PROCEDURES
2.21 Radiography – kidney
2.211 plain radiography
2.212 intravenous urography
2.213 retrograde pyelography
2.214 antegrade pyelography
2.22 Radiography – lower urinary tract
2.221 plain radiography
2.222 cystography
2.223 voiding cystourethrography
2.224 retrograde urethrography
2.225 conduitograms, diversions
2.2251 continent diversion
2.23 Radiography – genital
2.231 cavernosography, cavernosometry
2.232 hysterosalpingography, selective salpingography
2.24 Ultrasonography
2.241 real time, gray scale imaging
2.242 Doppler waveform and color Doppler principles, resistive indices
2.243 Renal, ureteral – ureteral jets
2.244 Bladder
2.245 Scrotum and contents
2.245 Spermatic cord, gubernaculum testis, tunica vaginalis propria, tunica vaginalis communis
2.246 Female genital
2.2461 obstetric

2.2462 transvaginal
2.247 adrenal
2.248 transrectal prostatic
2.249 penile gray scale, Doppler (impotence)
2.25 Computed tomography
2.26 Magnetic resonance imaging including adrenal mass, renal mass, prostate, bladder, GYN anomalies and masses
2.27 Arteriography, venacavography
2.271 renal – including selective, digital arteriography
2.272 renal venography, renal vein sampling
2.273 pudendal, penile arteriography
2.274 testicular venography
2.275 adrenal venography, venous sampling
2.28 Nuclear medicine diagnostic procedures
2.281 kidney
2.2811 transplant
2.2812 diuretic
2.2813 hypertension
2.3 THERAPEUTIC PROCEDURES
2.3 Radiofrequency ablation kidney, bladder, prostate, recurrent neoplasm
2.3 Cryoablation kidney, bladder, prostate, recurrent neoplasm
2.3 Ethanol ablation, kidney, recurrence
2.3 Focused ultrasound ablation, kidney, prostate
2.3 Guided laser ablation uroepithelial tumors, kidney collecting system, ureter
2.3 Brachytherapy, iridium , collecting system, ureter
2.31 Percutaneous nephrostomy
2.311 techniques of placement, management
2.312 Whitaker test
2.313 Percutaneous stone treatment
2.313 Nephrolithotripsy
2.32 Mass-biopsy, aspiration
2.321 cyst aspiration, ablation
2.322 renal mass biopsy
2.323 lymph node biopsy
2.33 Angioplasty
2.34 Abscess drainage
2.35 Embolotherapy
2.351 embolization renal tumors
2.352 embolic ablation of kidney (AVM)
2.353 embolotherapy of varicocele
2.36 Gynecologic interventions
2.361 fallopian tube recanalization
2.37 Ureteral interventions, Ureteroneocystostomy
2.371 stone removal
2.372 brush biopsy
2.373 stent placement

2.373 Balloon dilation ureteral strictures, cutting balloon incision ureteral strictures
2.374 occlusion
2.38 Urethral interventions

3.0 KIDNEY
3.1 Normal anatomy and physiology
3.11 Normal variants, pseudotumors (Column of Bertin)
3.12 Normal renal size, growth
3.121 measurements-radiographic, sonography
3.2 Cystic disease
3.21 Isolated cysts
3.211 simple cortical cysts
3.212 complicated cortical cysts
3.2121 milk of calcium cysts
3.213 perinephric cysts
3.22 Autosomal dominant cystic disease
3.23 Autosomal recessive cystic disease
3.24 Multicystic dysplastic kidney
3.25 Medullary sponge kidney
3.26 Medullary cystic disease
3.27 Cysts of renal sinus
3.28 Pyelocalyceal diverticulum
3.29 Cysts associated with other diseases
3.291 acquired cystic disease (dialysis)
3.292 vonHippel Lindau
3.293 tuberous sclerosis
3.3 Renal neoplasm
3.31 Benign
3.311 mesoblastic nephroma, nephroblastomatosis
3.312 cystic nephroma
3.313 angiomyolipoma
3.314 adenoma
3.315 oncocytoma
3.316 leiomyoma
3.317 juxtaglomerular cell tumor
3.32 Malignant neoplasms
(knowledge base should include pathology: diagnostic imaging features, and staging criteria)
3.321 Wilm's tumor
3.322 Adenocarcinoma of kidney
3.3221 cystic variant
3.3222 papillary
3.323 renal sarcomas and mesenchymal tumors
3.3231 leiomyosarcoma
3.324 transitional cell carcinoma of kidney

3.33 Secondary (metastatic) neoplasms of kidney
3.331 metastasis to kidney
3.332 renal lymphoma
3.4 Inflammatory disease of the kidney
3.4 Renal papillary necrosis
3.4 Renal medullary necrosis
3.4 Lymphoproliferative disease
3.4 Retroperitoneal collagenosis
3.41 Acute infection – pyelonephritis
3.411 emphysematous pyelonephritis
3.42 Reflux nephropathy
3.43 Renal abscess
3.43a Perirenal abscess
3.43b Pararenal abscess – psoas abscess
3.431 acute
3.432 chronic
3.44 Chronic renal infections
3.441 chronic pyelonephritis, mycelia
3.442 tuberculosis
3.443 XGP
3.444 Malakoplakia
3.45 Pyonephrosis
3.46 Nonbacterial
3.461 fungal
3.462 parasitic
3.463 HIV nephropathy
3.5 Vascular disease
3.51 Normal vasculature and variants
3.52 Renal hypertension, stenosis
3.521 atherosclerotic disease
3.522 fibromuscular dysplasia
3.53 Aneurysms
3.54 AVM's, AVF's
3.55 Vasculitis
3.56 Venous anatomy and anomalies
3.57 Venous occlusion
3.571 renal vein thrombosis
3.572 renal vein varices
3.6 Stone disease and complications, treatment
3.61 Incidence, physiology stone diseases
3.62 Nephrocalcinosis, types and causes
3.621 cortical
3.622 medullary
3.63 Nephrolithiasis
3.631 different stones, radiologic properties, techniques for evaluation

3.632 urography, sonography, computed tomography of acute obstruction and stones
3.633 complications of stones
3.64 Treatment of stones
3.641 expectant
3.642 percutaneous, endourologic
3.643 ESWL
3.644 Surgical
3.7 Renal failure, medical nephropathies
3.71 Pathologic physiology acute, chronic RF
3.72 Imaging investigation
3.721 ARF, CRF
3.722 IVU, US, CT, retrograde, nuclear and MRI methods
3.73 Specific disorders
3.731 chronic obstructive uropathy
3.732 nephrosclerosis
3.733 glomerulopathies
3.734 renal papillary necrosis (analgesic nephropathy, etc)
3.735 other nephritides, include drug induced, SLE
3.8 Obstructive uropathy
3.81 Acute ureteral obstruction – physiology
3.811 imaging features
3.812 pyelosinus backflow, etc.
3.82 Chronic ureteral obstruction
3.821 imaging features
3.822 obstructive atrophy of kidney
3.9 Renal transplantation and complications
3.91 Selection of donors, surgical technique, anatomy of transplants
3.92 Evaluation rejection, ATN
3.92 Chronic rejection, avascular necrosis ureter
3.93 Urologic complications
3.931 ureteral obstruction
3.932 urinary leak
3.94 Vascular complications
3.941 vascular thrombosis
3.942 arterial stenosis
3.943 AV fistula
3.95 Peritransplant fluid collections
3.951 urinoma
3.952 lymphocele
3.953 abscess
3.954 hematoma

4.0 URETER
4.1 Normal anatomy
4.11 Normal course
4.12 Variants, herniation, simple ureterocele (congenital abnormalities, see 1.22; obstructive uropathy, see 3.8)
4.2 Ureteral dilatation
4.21 Congenital obstruction
4.211 UPJ
4.212 Primary megaureter
4.213 Congenital stricture
4.22 Vesicoureteral reflux
4.23 Nonobstructive dilatation
4.24 Hydronephrosis of pregnancy
4.25 Acquired stricture
4.3 Ureteral neoplasms
4.31 Benign
4.311 fibroepithelial polyp
4.312 papilloma
4.32 Malignant
4.321 transitional
4.322 squamous
4.323 adenocarcinoma
4.33 Secondary tumors of ureter
4.331 retroperitoneal adenopathy
4.332 extrinsic tumors
4.333 metastases to ureter
4.4 Intrinsic ureteral inflammation
4.41 Pyeloureteritis cystica
4.42 Pseudodiverticulosis
4.43 Tuberculosis
4.44 Schistosomiasis
4.5 Extrinsic diseases involving ureter
4.51 Vascular compressions
4.52 Retroperitoneal fibrosis
4.53 Endometriosis
4.54 Inflammatory bowel disease
4.55 Pelvic inflammatory disease

5.0 BLADDER
5.1 Normal physiology and function
5.11 Urodynamic techniques
5.12 Variants and abnormal position
5.121 herniation
5.122 prolapse
5.123 displacement by extrinsic mass
5.2 Functional disorder

5.21 Incontinence
5.211 stress incontinence
5.212 urge, other incontinence
5.22 Neurogenic bladder
5.3 Outlet obstruction
5.31 Compensatory hypertrophy, radiography
5.32 Diverticula
5.4 Intraluminal filling defects
5.41 Clot
5.42 Calculi
5.43 Foreign body
5.44 Fungus ball
5.5 Neoplasms
5.51 Benign
5.511 fibroepithelial polyp
5.512 leiomyoma
5.513 papilloma
5.514 neurofibroma
5.52 Malignant
5.521 transitional
5.522 squamous
5.523 adenocarcinoma
5.524 urachal carcinoma
5.53 Secondary neoplasms of bladder
5.531 metastases
5.532 extrinsic invasion
5.533 lymphoma
5.6 Inflammation
5.61 Bacterial infections
5.611 cystitis
5.6111 acute
5.6112 emphysematous cystitis
5.6113 chronic
5.6114 cystitis glandularis
5.612 tuberculosis
5.62 Other infections
5.6111 other infections
5.621 fungal
5.622 TB
5.623 Schistosomiasis
5.624 Malakoplakia
5.63 Noninfectious cystitis
5.631 interstitial cystitis
5.632 radiation, chemical cystitis
5.633 eosinophilic cystitis
5.634 cystitis cystica~~, glandularis~~

5.64 Involvement by extrinsic inflammation
5.641 endometriosis
5.642 inflammatory bowel disease
5.643 diverticulitis, Crohn's disease
5.7 Bladder fistulae
5.71 Vesicoenteric
5.711 vesicocolic
5.72 Vesicovaginal
5.73 Vesicocutaneous
5.8 Extrinsic diseases involving bladder
5.81 Pelvic lipomatosis
5.82 Retroperitoneal fibrosis
5.83 Prostatic enlargement
5.84 Uterine and adnexal masses
5.9 Urinary diversion and replacement techniques
5.91 Ileal conduit
5.92 Colonic diversions
5.93 Continent diversions
5.931 ileocecal
5.932 Kock pouch
5.932 Indiana pouch

6.0 URETHRA
6.1 Normal structure and function
6.11 Male
6.12 Female
6.13 Intersex states
congenital deformities and strictures, see 1, incontinence…
see 5.2
6.2 Neoplasms and masses
6.21 Benign
6.211 condylomata
6.212 fibroepithelial polyp
6.22 Malignant
6.221 squamous
6.222 transitional
6.3 Inflammation
6.31 Urethritis
6.311 gonococcal
6.312 nongonococcal
6.32 Tuberculosis
6.33 Schistosomiasis
6.34 Female urethral syndrome
6.341 female urethral diverticululm
6.4 Strictures, fistula
6.41 Inflammatory

6.42 Post-traumatic
6.43 Iatrogenic
6.44 Surgical treatments
6.5 Artificial urethral sphincters

7.0 MALE GENITAL TRACT
7.1 Prostate
7.11 Normal structure and function
(include zonal anatomy as seen on MRI)
7.12 Prostatic calcification
7.13 Benign prostatic hyperplasia
7.14 Malignant neoplasms
7.141 rhabdomyosarcoma
7.142 adenocarcinoma
7.15 Prostatitis
7.16 Prostatic abscess
7.2 Seminal vesicles
7.21 Normal structure and function
7.22 Congenital and acquired cysts
7.23 Neoplasms
7.231 primary
7.232 invasion by prostatic cancer
7.24 Duct obstruction (obstructive azospermia)
7.3 Testicles
7.31 Normal structure and function
7.311 undescended testis
7.312 testicular failure
7.32 Testicular cysts
7.33 Neoplasms
7.331 benign
7.332 malignant
7.3321 germ cell tumors
7.3322 nongerm cell tumors
7.3323 lymphoma
7.3324 metastases
7.333 microlithiasis
7.34 Inflammation
7.341 orchitis
7.342 abscess
7.343 Fournier’s gangrene
7.35 Testicular torsion
7.4 Scrotum
7.41 Normal structure and function
7.42 Hydrocele
7.43 Epididymitis
7.44 Varicocele

7.5 Penis and corpora
7.51 Normal structure and function
7.511 erectile physiology
7.52 Impotence
7.521 psychogenic
7.522 arteriogenic
7.523 venous insufficiency
7.523 Pelvic congestion syndrome, ovarian vein incompetence, gonadal vein incompetence
7.53 Peyronie's disease
7.54 Priapism
7.54 Leukemia
7.55 Penile implants

8.0 FEMALE GENITAL TRACT
8.1 Uterus and fallopian tubes
8.11 Normal anatomy and function
8.12 Infertility due to anomalies
see 1.26
8.13 Neoplasms
8.131 benign
8.1311 adenomyosis
8.13 Gestational trophoblastic disease, hydatidiform mole, chorioadenoma destruens, choriocarcinoma
8.132 cervical carcinoma
8.133 endometrial carcinoma
8.14 Pelvic inflammatory disease
8.141 hydrosalpinx, pyosalpinx
8.142 salpingitis isthmica nodosum
8.143 granulomatous disease
8.2 Ovaries
8.21 Normal structure and function
8.22 Ovarian failure
8.23 Ovarian neoplasms
8.24 Inflammatory disease
8.25 Endometriosis

9.0 ADRENAL GLANDS
9.1 Normal anatomy and function
9.2 Endocrine disorders
9.21 Cushing's syndrome
9.22 Hyperaldosteronism
9.23 Virilization
9.24 Catecholamine excess
9.25 Adrenal insufficiency
9.3 Hyperplasia

9.31 Congenital hyperplasia, adrenogenital syndrome
9.32 Secondary
9.321 excess ACTH
9.322 secondary hyperaldosteronism
9.33 Primary acquired hyperplasia
9.4 Neoplasms
9.41 Cortical adenoma
9.411 nonhyperfunctioning (lipid-rich and lipid-poor)
9.412 hyperfunctioning
9.42 Medullary
9.421 neuroblastoma
9.422 pheochromocytoma
(including MEN, VHL, neurofibromatosis)
9.423 paraganglioma
9.424 ganglioneuroma, ganglioneuroblastoma
9.43 Adrenal carcinoma
9.44 Secondary neoplasia of adrenal
9.441 metastases
9.442 lymphoma
9.45 Myelolipoma
9.5 Inflammatory disease
9.51 Tuberculosis
9.52 Histoplasmosis
9.53 Abscess
9.6 Non-neoplastic masses
9.61 Adrenal cyst
9.62 Adrenal hematoma

10.0 RETROPERITONEUM
10.1 Normal anatomy, compartments
10.2 Retroperitoneal fibrosis
10.21 idiopathic
10.22 secondary
10.3 Retroperitoneal neoplasms
10.31 primary
10.32 metastatic

11.0 TRAUMA OF THE URINARY TRACT
11.1 Modification of procedures in trauma setting, pregnancy
11.11 “one-shot IVU”
11.12 trauma CT
11.121 CT cystogram
11.13 appropriate selection of patients
11.2 Renal trauma
11.21 minor injuries
11.211 contusion

11.212 hematomas
11.22 moderate injuries
11.221 lacerations
11.23 severe injuries
11.231 deep laceration
11.232 fracture
11.24 vascular injuries, arterial dissection, vascular dehiscence
11.25 sequelae of renal injuries
11.26 iatrogenic injury
11.261 post biopsy AV fistula
11.3 Ureteral trauma
11.31 UPJ avulsion
11.32 Laceration
11.33 Iatrogenic injury
11.331 endourologic laceration
11.4 Bladder trauma
11.41 contusion
11.42 rupture
11.421 intraperitoneal
11.422 extraperitoneal
11.423 interstitial
11.43 iatrogenic bladder injury
11.5 rupture of the urogenital diaphragm
11.6 extravasation into the scrotum
11.6a partial or complete rupture of the urethra, membranous, prostatic, penile urethra

5. APPENDIX B: Pediatric Uroradiology

Basic Concepts:
Training in pediatric radiology is achieved within a dedicated general pediatric rotation or within the general residency program. These two settings can complement each other. Case material and skill sets learned during the time devoted to pediatric radiology will help the resident faced with later presentations of congenital anomalies. Cases seen outside of the formal pediatric curriculum reinforce the cases seen while on the pediatric radiology rotation. Because the resident spends a limited time period within a pediatric radiology setting, pediatric GU material can be integrated into a standard GU curriculum. When interpreting images, it is also

helpful to understand the normal developmental anatomy and the changes with age. For example, knowing the changes in the size and shape of the uterus prepubertal and postpubertal.

Reducing Radiation Exposure for pediatric patients:

Residents should be taught ways in which clinically important information can be obtained while limiting radiation exposure to children. These strategies include substituting a test which has no ionizing radiation for one which does (e.g. – substituting US for IVP), shifting to a radiation based modality which has less radiation (e.g. - substituting IVP for Renal Scintigraphy), changing CT parameters in order to reduce the radiation dose without compromising diagnostic accuracy, and using techniques to limit fluoroscopic radiation exposure.

Age appropriateness:

In dealing with pediatric patients, knowledge of age appropriate interaction, immobilization, and imaging is imperative. Showing sensitivity to the patient's age shows respect to the patients and the patients' parents. Judicious use of sedation or anesthesia can be based on the patient's age or ability to cooperate, and also helps to obtain the best studies possible.

Fluoroscopy experience should include use of immobilization devices and age appropriate catheters when performing voiding cystourethrography (VCUG). The resident should learn the indications for VCUG, the system used to grade reflux, and the implications of positive and negative studies. The possible post procedural complications should be explained. The resident should receive a level of training such that he/she could not only perform the VCUG but counsel the parents appropriately before and after the examination.

Specific Clinical Settings:

Congenital anomalies:

A topic specific to pediatric patients is the evaluation of anomalies and evaluation for associated anomalies. Trainees should be aware that renal US is performed when congenital anomalies such as cardiac, GI, skeletal, are known to be associated with renal anomalies. Trainees should be aware of common syndromes with associated renal anomalies and what renal anomalies to expect.

The extended use of pediatric ultrasound mandates that the resident be taught age appropriate indications and techniques. Training should also include the use of appropriate transducers for the task. Renal US is performed when other congenital anomalies (cardiac, GI, skeletal) known to be associated with renal anomalies (agenesis, ectopia, and fusion anomalies) are present. Neonates also undergo US when prenatal imaging has detected an anomaly or hydronephrosis.

Hydronephrosis:
Many infants present with a diagnosis of prenatal hydronephrosis. Trainees should have a differential for prenatal hydronephrosis, and know the appropriate post natal tests and timing of these evaluations.

UTI and GU Reflux
Urinary tract infections (UTI) are a common pediatric problem. The etiology and evaluation is distinct from such infections in adults. The resident needs to be taught: definition of a UTI, the differences between cystitis and pyelonephritis, proper ways of obtaining urine culture, and how and when the multiple tests which are available to evaluate the genitourinary tract should be performed.

Trainees should be familiar with the signs and symptoms of reflux and the indications for a VCUG. Trainees should be able to counsel patients and families about this commonly performed procedure and possible complications, and implications of the

procedure, such as the willingness to take prophylactic antibiotics. Knowledge of technical aspects of the procedure is also imperative: age appropriate immobilization, catheter selection, comfort techniques for patients and parents. Trainees should be familiar with the grading system of reflux and how to communicate the results to the referring clinicians, especially is reflux is present and the patient is not currently taking antibiotics.

Renal cystic diseases:

Often considered and adult problem, renal cystic diseases often manifest in childhood The genetics, presentation, and course of the many cystic diseases should be covered. The resident should understand the difference between simple cysts, multicystic dysplastic kidney and autosomal recessive and dominant polycystic kidney disease, and the appropriate imaging techniques for imaging evaluation.

Tumors:

Understanding the tumors of the genitourinary tract that occur in children requires knowledge of the presentation and imaging of benign tumors. The morphology and staging of malignant tumors should be part of the curriculum, either through didactic lectures or case material. The tumors of the lower urinary tract, particularly rhabdomyosarcoma, should be covered. Adrenal tumors (neuroblastoma, carcinoma, and pheochromocytoma) that present in childhood should be covered. Trainees should also be aware of many conditions or syndromes that require surveillance for associated renal tumors, such as nephroblastomatosis, hemihypertrophy, WAGR, and aniridia.

Adrenal Gland:

Trainees should be familiar with pediatric adrenal tumors, such as neuroblastoma, carcinoma, and pheochromocytoma. Of specific importance, the differentiating factors between an adrenal neuroblastoma and Wilms tumor should be covered, as well as

differentiating between a cystic adrenal hemorrhage in a neonate or a cystic neuroblastoma.

Bladder and lower urinary tract:
The bladder is routinely imaged during renal US. Bladder imaging may be important in understanding the findings in the kidney (e.g. - detection of a ureterocele in a child with hydronephrosis). Bladder US may help to detect the cause for the child's symptoms when the kidneys are normal. It is important to recognize mimickers that are specific to bladder such as how an incised ureterocele and inflammatory change can simulate a bladder rhabdomyosarcoma.

Gonads:
It is important for the trainee to understand the changes in the testes and ovaries with age and especially pubertal changes. For example, it is important to understand the small amount of measurable flow to an infant testis, which may be misconstrued as torsion. Undescended testis is a common clinical problem, and the trainee should have knowledge of the imaging evaluation and the implications of an undescended testis.

The trainee should have know how evaluate the painful scrotum with both gray scale US and Doppler US, and have knowledge of the differential diagnosis, including torsion of the testis or appendix testis, epididymitis, and orchitis. Some problems are seen in all age groups (e.g. - epididymitis, orchitis).

Ovarian cysts are common and can be seen in a spectrum of ages, including newborns. When on the right, they may simulate the pain caused by an inflamed or ruptured appendix. Evaluation of the pelvis in a female child may include learning to diagnose or exclude ovarian cysts or ovarian torsion.

Specific Imaging Techniques:

Radiography:
Plain films are of limited use in evaluating the GU tract in children. Suspected renal masses are better sought with US. Calcifications within the GU tract or adrenal may be seen with plain films but are better appreciated with US or non-contrast CT.

Ultrasound:
The proper selection of transducers is the key to achieving a successful scan, and the transducer should be chosen in relation to the child's size. Also, knowledge of how to obtain quality images in children is important, such as prone scanning for better evaluation of the kidneys and patient immobilization and cooperation.

When hydronephrosis is present, the bladder should be purposefully evaluated. If it is full, renal imaging should be performed after voiding because a distended urinary bladder may cause minor hydronephrosis or increase the grade of hydronephrosis.

While not widely performed, the resident should be taught about the evolving technique of sonographic cystography.

Doppler US is used to in a wide number of settings in the pediatric population. In the neonate, renal vein thrombosis may be diagnosed or excluded. In older children, spectral and color Doppler US are used in a variety of settings.

Computed Tomography:
With the newer and fast multidetector CT scanners, pediatric sedation is less of an issue/concern than in the past. Evolving techniques to decrease the radiation exposure for each GU indication should be taught.

Magnetic Resonance Imaging:
The use of this technology in pediatric radiology is widespread and growing. Indications for GU specific exams include MR urography, evaluation of infections or congenital anomalies, and staging of tumors. Although MRI has the advantage of imaging without radiation exposure, this modality usually requires long scanning times that require knowledge of age appropriate sedation/anesthesia. Faster scanning techniques are changing this paradigm. Trainees should be familiar with valuable imaging sequences and planes for each indication, and also about pediatric specific coils and appropriate use of contrast material.

Nuclear Scintigraphy:
The resident should understand the different chelates or "labels" that can be attached to the basic technetium isotope and the use of each: i.e. - which isotopes are preferred for cortical imaging and which provide functional or morphological information. The resident should understand the indications for renal scintigraphy, the techniques of performing and interpreting these examinations, and the pitfalls of these scans.

Nuclear scintigraphy is a common procedure. For this reason the resident should become familiar with how these studies are performed and in the proper indications for each examination.

6. APPENDIX C: Knowledge of Technologies and Skills for Competency

Radiology is an ever-changing science. Since the last version of this document, there have been many advances that are now part of our imaging armamentarium as follows:

New Modalities:

MRU
CTU
CT Stone Protocol
Renal Tumor Ablation
PET-CT of GU Tract
Power Doppler US and US Contrast Agents
Renal Hypertension (CTA, MRA)
Prostate (US, MR, Spectroscopy)
Renal Donor Evaluation
Renal Transplant Evaluation
Doppler US of Scrotum/Testes
Doppler US for Renal Function
US for Vesicoureteral Reflux
Low Dose CT for Pediatric Patients
Thermalablation, including RFA
Minimally Invasive Therapies

All relevant technologies should be incorporated into core training of residents as they become validated in the literature.

7. Safety: Patient Care, Radiation Protection and Safety, Contrast Media, Contrast Reactions

PATIENT SAFETY

Quality Assurance:
Adverse healthcare events are a leading cause of death and injury. Effective guidelines are required to reduce the likelihood of harm to the patient or the healthcare provider. It is estimated that at least 44,000 and perhaps as many as 98,000 Americans die each year because of medical errors. **1** It is necessary to establish a quality

assurance program that includes teaching residents principles of quality assurance with special emphasis on patient safety.
The following principles apply for Radiology residency training programs.

1. Create a culture of safety. Promote a culture that encourages the reporting of any situation that threatens or potentially threatens the safety of patients or caregivers.
2. Teach the appropriate use of personal protective equipment such as gloves, masks, gowns, surgical caps, eye protection and face shields in accordance with OSHA regulations.
3. Ensure that results of a study are transmitted in a timely manner and in a clearly understandable form to the patient's current healthcare providers.
4. Teach the trainee how to comply with Health Insurance Portability and Accountability Act (HIPAA). This is to ensure the integrity and confidentiality of patient information, and the implication of unauthorized uses or disclosure of such information. The trainee must understand the implication of non-compliance. **2 - 4**

Correcting Errors of Cognition, Practice, and Discordance:
Reduction of medical and diagnostic errors is an important goal that can reduce morbidity and mortality. Types of diagnostic errors include no-fault errors, system errors that could be due to technical failures, organization failures, or cognitive failures.

Cognitive errors, especially those associated with failures in perception and biases, collectively have been referred to as "Cognitive Disposition to Respond". These errors may be due to inadequate knowledge, faulty data gathering, faulty information processing or faulty meta-cognition etc., and may result in diagnostic errors. Cognitive training to improve meta-cognition, promote active open-mindedness, use of second opinions and use

of clinical decision support systems can potentially reduce cognitive errors substantially. The radiology residency-training program should include formal lectures and cognitive debiasing techniques in an effort to minimize diagnostic errors.

A few examples of cognitive debiasing strategies include decreased reliance on memory in favor of the use of clinical practice guidelines, algorithms and or even hand held computers. Simulation techniques utilizing clinical training videos contrasting incorrect (biased) approaches with the correct (debiased) approach are helpful. Rapid and reliable feedback should be provided so that errors are immediately appreciated, understood, and corrected.

Comment [MJ1]: Not recommend, merely acknowledge use of hand hneld devices - they are here to stay…

The trainee should be able to remember, apply, analyze, evaluate and recognize different terminologies, definitions, and methodologies and principles as they apply to the imaging findings. **5,6**.

Guidelines for communication:

The trainee must be instructed about the value and significance of timely communication of important radiologic findings and documentation thereof. This begins with direct verbal communication with the both the patient and the referring health care provider or responsible clinician. Thereafter, the radiology report should be dictated according to the ACR guidelines. The Diagnostic Radiology Report must include the demographics of the patient with relevant clinical information. The body of the report should include the description of the study and/or procedure, findings etc. and finally an impression or conclusion of the relevant findings. A differential diagnosis should be given when appropriate. It is advisable to document that the referring health care provider has been notified of important findings, or of clinically relevant results, even if the study is "negative". The

report should include a report and an alert if the patient has suffered a reaction to contrast administration.

Verification and Site/Sidedness:
The resident must learn to establish proper verification processes prior to start of the procedures to ensure proper patient identification. Pertinent documents must be reviewed and should be deemed consistent. The resident must have a clear understanding of the site/sidedness requirement prior to any procedure. This may involve what is now referred to as a "timeout" for all above described verifications, and should be documented in the report for the procedure.

Discordant Film Interpretation:
The trainee must learn the process of addressing issues related to discordant film interpretation. Several factors can result in radiology errors. The errors may be related to the patient, technical quality of the study, film identification, transcription errors, environmental factors such as ambient light, interruptions, background noise, adherence to protocol or lack there of, reading without old films, tunnel vision etc. Discordant film interpretations and radiology errors can be addressed by periodic lectures and conducting morbidity and mortality conferences as related to the genitourinary tract to discuss the medico-legal and ethical issues.

Variants and Pitfalls in Genitourinary Imaging:
Variations of genitourinary anatomy and development as well as technical artifacts inherent to the different imaging techniques may potentially present diagnostic problems and pitfalls. Correct recognition of anatomic landmarks and their variants are essential to avoid misinterpretation, errors in diagnosis, and mismanagement of patients. Therefore, familiarity with the normal anatomy and embryology is essential to avoid such mistakes. Common renal anatomic variants include persistent fetal lobation, junctional parenchymal defects, renal hilar lip, column of Bertin etc. Certain

technical artifacts (such as those commonly encountered with sonography and computed tomography, especially with multi detector CT with rapid acquisition of images in the early phase of contrast enhancement), can mask significant pathology. Familiarity with and understanding of the common MR artifacts such as chemical shift, phase cancellation and wrap around artifacts will reduce potential errors in diagnostic interpretation. **7 - 9**

Radiation Safety:

Urological procedures can involve a substantial amount of ionizing radiation. The resident must be familiar with typical radiation dosages of fluoroscopic procedures.

The trainee must be familiar with the fundamental principles of radiation safety, methods, such as appropriate use of pulsed fluoroscopy as opposed to continuous fluoroscopy, and the appropriate use of equipment required for minimizing radiation exposure in uroradiology such as gonadal shields, collimation devices, lead aprons, etc.

Basic techniques for radiation protection, shielding and other protective measures along with the proper use of radiation dosimeters must be taught to residents at the beginning of their training. Radiation badges must be worn routinely during and monitored for exposure from fluoroscopic procedures and in the interventional radiology suites. **10 – 12.**

Approximate Fetal Doses for CT Procedures **(13-15)**

Examination	**Mean mSv**	**mrem**	**Maximum MSv**	**mrem**
Abdomen CT	8.0	800	49	4900

Pelvis CT	25	2500	80	8000

Approximate Fetal Doses from Radiographic and/or Fluoroscopic Procedures **(13 -15)**

Examination	**Mean mSv**	**mrem**	**Maximum MSv**	**mrem**
Abdomen	1.4	140	4.2	420
Intravenous urogram; lumbar spine	1.7	170	10	1000
Pelvis	1.1	110	4	400
KUB	2.5	250		
Hysterosalpingogram	10	1000		

Approximate Whole Body Fetal Doses from Common Nuclear Medicine Procedures **(13 -15)**

	Activity		**Early Pregnancy**		**9 Months**	
Examination	**MBq**	**mCi**	**mSv**	**mrem**	**mSv**	**mrem**
Tc-99m						
Bone Scan	750	20	4.7	470	1.8	180
Renal DTPA	300	8	9.0	900	3.5	350

Pregnancy during Residency:
The female trainee resident must be familiar with the guidelines of occupational exposure of the pregnant resident. Though medical centers have general policies on housestaff maternity leave, there is not yet a formal guideline or consensus for radiation exposure to the pregnant resident. **11, 16**

There is a proposed program guideline for radiation exposure and work responsibilities for pregnant residents from a joint project sponsored by the American Association of Women Radiologists and the Association of Program Directors in Radiology. The goals are to minimize risk to the pregnant resident, outlines safety guidelines, and details the responsibilities of both the pregnant resident and the training program. **17**

Recognition and Treatment of Contrast Reactions:

The residents in training must be thoroughly familiar with the following:

A. Presentation and treatment of contrast material reactions including the pathogenesis of contrast media induced adverse effects and different types of contrast reactions.

B. The risk-factors that predispose patients to having contrast reactions and a knowledge of how to recognize patients at high risk to develop contrast reactions.

C. The pre-medication protocol for patients who have a risk of contrast reactions or a history of previous reactions.

D. The signs and symptoms of major forms of contrast reactions and the specific management required for each acute contrast media reaction.

E. The presenting signs and symptoms of such reactions and be familiar with the location of and proper use of equipment and medications, as well as the dosages in the emergency kits or carts.

F. Basic cardio-pulmonary resuscitation and treatment and how to call for assistance when necessary. (Advanced cardiac life support is encourages for those supervising studies requiring systemic administration of contrast materials.) **18**.

Screening and Prevention of Contrast Induced Nephropathy:

Contrast medium-induced nephropathy may range in severity from asymptomatic, non-oliguric transient renal dysfunction to oliguric severe acute renal failure that necessitates dialysis. The trainee should be familiar with:

A. The definition of contrast media nephropathy, its pathogenesis, risk factors and acute and long-term effects of radiographic contrast media induced nephropathy

B. The basic methods of prevention or amelioration of contrast media induced acute renal failure

C. A basic understanding of use of contrast media as it relates to patients who are on chronic hemodialysis.**19,20**

Contrast Extravasation:

Extravasation is a well-known complication of intravenous administration of contrast material for radiologic procedures. As part of the training, the resident should be familiar with:

- The risk factors: patient's advanced age; patients receiving chemotherapy who may develop fragility of the vein wall; compromised venous or lymphatic drainage; low muscular mass and atrophic subcutaneous adipose tissue; the use of metallic cannulas; or multiple attempts at venipuncture.
- The factors that are involved in the pathogenesis of extravasation injuries. osmolality, cytotoxicity, and the volume of extravasated contrast medium. Some types of contrast media such as hyperosmolar contrast media or large extravasated volumes may lead to severe damage to extravascular tissue.
- Injections under pressure of large volumes of contrast material such as those from power injectors may lead to extravasations into the surrounding tissues and can potentially result in compartment syndrome.
- Compartment syndrome is a condition characterized by increased pressure within a closed space with a potential to cause permanent necrosis and damage to the contents of the closed compartment.
- The resident must be able to perform a physical examination of the extremity and be familiar with the signs and symptoms of compartment syndrome, skin ulceration, blistering, evidence of altered tissue perfusion and sensory loss.
- Local treatment of extravasated contrast media includes elevation of the limb, cold compression, prevention of secondary infection and observation.
- The common indications for possible plastic surgical intervention are altered tissue perfusion and compartment

syndrome. The referring physician or health care provider caring for the patient must be notified when a patient suffers contrast extravasation **. 21,22**

Venous Air Embolism:
Venous air embolisms have been associated with central venous catheter insertions. Most complications during CT contrast examinations are related to allergic reactions to contrast material, but iatrogenic intravenous air embolism has been reported. Immediate proper treatment is essential to avoid potentially serious fatal complication, as proper treatment is critical when large volume of air is noted in the central venous system or heart.

The resident must be familiar with signs, symptoms and management of large amount of air in the venous system and potential complications of venous air embolism and adverse effects of paradoxical air embolism.

Paradoxical air embolism in which air emboli from the venous circulation reach the systemic arterial circulation by passing through an abnormal communication between the chambers of the heart, leading to a systemic manifestation such as stroke, kidney infarction or acute limb infarction. The clinical findings of embolism depend on the site of the embolus and on the organ involved. Multi-organ ischemia and infarction can occur. Treatment includes change in position, fluids, vasopressors, increased positive end expiratory pressure and where available hyperbaric oxygen therapy.

Thyroid Function and Iodinated Contrast Media:
The radiology resident in training must be familiar with the potential effects of administration of iodinated contrast material upon thyroid function. Patients with Grave's disease and multi-nodular goiter are at increased risk of thyrotoxicosis. The

prevalence of contrast-induced thyrotoxicosis is significantly higher in iodine deficient areas and in the elderly.

It is also recommended that patients undergoing therapy with radioactive iodine should not receive iodinated contrast media for at least two months prior to treatment or the uptake of therapeutic agents may be suboptimal.

Radionuclide isotope imaging of the thyroid should be avoided for 2 months after iodinated contrast injection as they will be unrewarding in a thyroid bed saturated with iodinated contrast material.

Injection of iodinated contrast media into patients who manifest thyrotoxicosis is absolutely contraindicated. **23**

Risks and Contraindication to the use of Gadolinium based MR Contrast Media:

The vast majority of adverse reactions to gadolinium containing agents are minor. Severe anaphylactoid reactions including deaths are exceedingly rare, but have been reported. Risk factors include prior reaction to iodinated contrast media**,** persons with asthma and various other allergies. (Patients who have had adverse reaction to iodinated contrast media are more than twice as likely to have an adverse reaction to gadolinium.) Pre-medication with steroids can be used in high-risk patients.

The clinician and the facility must be prepared to address any reaction due to the injection of Gadolinium-based contrast media. **24**

Imaging and use of Contrast Media during Pregnancy:

Proper diagnosis and treatment of maternal illnesses during pregnancy may require radiographic imaging. The resident should be familiar with the potential effects of radiation dosages from routine diagnostic examination. Radiation induced teratogenesis, radiation induced malignancies and gene mutations are potential risks. Knowledge of the above potential risks is required to properly council the pregnant patient. The resident physician must be able to answer such questions to help the patient understand the potential risks and benefits of such radiographic procedures.

Iodinated diagnostic contrast media have been shown to cross the human placenta and enter the fetus in measurable quantities. There is no evidence suggesting that iodinated contrast agent is teratogenic or mutagenic in humans. While it is wise to avoid contrast medium whenever possible, judicious use of contrast agents when the studies requiring them are thought to be essential is appropriate. The benefits should outweigh the risks.

Suppression of fetal thyroid function is the most important potential harmful effect of iodinated contrast media within the fetus. Neonatal thyroid function should be checked during the first week after birth if iodinated contrast media was given during the pregnancy. No effect on the fetus has been seen after gadolinium contrast media administration.

The ACR Committee on Drugs and Contrast Media recommends the following guidelines regarding whether to perform a contrast exam:

1. That the information requested cannot be acquired via means other than an examination requiring contrast material administration.
2. That the information needed will have positive affects on the care of the patient and /or fetus during the pregnancy.

3. That the referring physician is of the opinion that it is not prudent to wait to obtain this information until after the patient is no longer pregnant.
4. That the referring physician obtains consent, making sure that the patient understands the risk and benefits of the procedure. **25**

Gadolinium based contrast agents cross the placenta and enter into the fetus when given in clinical dose ranges. There is no compelling evidence to suggest any teratogenic effect of MR Imaging or gadolinium-based contrast agents. However, the risk and safety of MRI and use of MR contrast agents has not been established for pregnant patients. Use of these agents should be avoided if possible, especially during organogenesis.

For an MRI examination to be performed during pregnancy, the ACR Committee on Drugs and Contrast Media recommends the following:

1. The information requested from the MR study cannot be acquired using other non-ionizing radiation imaging modalities (e.g., ultrasonography)
2. The information obtained will likely affect the care of the patient and /or the fetus during the pregnancy.
3. The referring physician is of the opinion that it is not prudent to wait to obtain the information until after the patient is no longer pregnant.

Informed consent should be obtained to document that the patient understands the risks/benefits of the MR and the necessity for use of iodinated and gadolinium based contrast media. **25**

Lactation:
Administration of contrast media sometimes may be indicated in patients who are breast feeding.

The literature on excretion of iodinated and gadolinium-based contrast agents into breast milk and gastrointestinal absorption of these agents is very limited. Less than 1% of administered dose is excreted in the breast milk, and less than 1% of the ingested milk by the infant is absorbed by the fetal gastro-intestinal tract.
The current ACR policy states that it is safe to breast-feed the baby in such situations. However the mother must be informed and given an option to avoid breast feeding the baby for 12 - 24 hours if there is any concern by the mother of any potential ill effects. **26**

Ultrasound Contrast Agents:
Ultrasound contrast media are not yet widely used, but are known to have a number of potentially important clinical applications. Ultrasound contrast agents are gas-filled micro-bubbles. Their effect is mainly produced by increased back-scattering intensity as compared to that from blood, other fluids, and most tissues. The resident must be familiar with the basic mechanism and physical principles of the acoustic properties of microbubble based ultrasound contrast media.

Though not yet widely available for use in the United States at this time, generally ultrasound contrast media are considered safe. The majority of reactions are minor. It is however recommended to use the lowest level of acoustic output and shortest scanning time to allow a diagnostic examination. **27**

Pharmacologic Interaction between Contrast Media and Other Drugs:
“Interaction” is the term used to describe a drug’s capacity to influence the pharmacologic action of another drug. Referring physicians and patients are required to notify the radiologists of the various medications the patient is currently taking as a variety of such medications can directly or indirectly affect the health of the patient.

It is important for the resident trainee to be aware of potentially harmful drug effects in patients who are receiving radiographic contrast media. Radiographic contrast media can occasionally be toxic to the kidneys, resulting in renal insufficiency. This can increase the risk of lactic acidosis in diabetics receiving biguanide treatment (specifically, metformin and its derivatives).

Patients who have been recently treated with interferons and interleukins are known to be at increased risk for hypersensitivity reactions (fever, rash, hypotension). In addition, administration of beta-receptor blockers may also lead to increased tendency to adverse reactions sometimes occurring days to weeks after the last administration of medication. **28**

Informed Consent:

The purpose of obtaining informed consent is to provide the patient (and when appropriate, the family), every opportunity to understand any treatment or procedure they receive, and to have all questions answered and to fully consent to the treatments and procedures.

The resident must be familiar with the process of obtaining informed consent, both in written and oral form. It is important for the physician to understand that informed consent is a process and not the simple act of signing a formal document. The trainee should understand the obligation to inform patients of all the important aspects, risks, and benefits of a treatment and/ or procedure.

The resident physician must understand that failure to obtain adequate informed consent renders the physician liable for negligence or battery, and likely constitutes medical malpractice. The process of informed consent for any invasive radiologic procedure should include:

1. Patient and site identification and verification.
2. The purpose/ nature of the procedure or treatment. Asking

the patient to recall establishing understanding, where possible adding additional stimuli, such as multimedia presentations, educational pamphlets, check lists and providing written information

3. The method by which the procedure or treatment will be performed.
4. The risks, complication, and expected benefits or effects of such procedures / treatment.
5. The risk of not accepting the procedure.
6. Any alternatives and their risks and benefits, in general principles.
7. The right to refuse to consent.
8. Documentation should include the name of the person performing procedure.
9. Note in the medical record that a discussion was held and that informed consent was obtained and should include date and time.
10. The patient must be competent and an adult (18 years of age or older). Consent by telephone (documentation and witnessed) may be obtained from the responsible next of kin or legal custodian for the patient.
11. Emergency procedures. The resident physician must be familiar with the protocol of treating patients in situations where a patient is unable to give informed consent.

The Understanding and Proper Use of ACR Appropriateness Criteria: (ACRAC):

The ACR Appropriateness Criteria contains clinical practice guidelines for appropriateness criteria using the modified Delphi technique to arrive at a consensus. It is intended to guide radiologists, referring physicians, and patients in making initial decisions about diagnostic imaging techniques, both to use them appropriately and cost- effectively.

The majority of ACR AC guidelines represent approaches to solving specific clinical problems. For every one of the several

diagnoses, an expert panel produced an annotated list of imaging studies that might be used to work-up patients presenting with these problems. The annotation to each listed procedure consists of numbers ranging from 1 to 9 which quantify the appropriateness. A higher number denotes a procedure that is more appropriate. The ACR Appropriateness Criteria are available electronically on the ACR web page at www.acr.org/ac-pda and as a PDA application for hand held computers.

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7. APPENDIX D: Core Reference Materials

This list is meant to be used as a guide. Radiology is an ever-changing science, necessitating ongoing future updates and modifications of this document

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PubMed - National Library of Medicine provides access to citations from biomedical literature
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi

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MedPix™ Genitourinary Cases Medical Image Database from Uniformed Services University http://rad.usuhs.mil/medpix/parent.php3?mode=tf2&action=pre&acr_pre=8

Online Teaching Cases
Department of Radiology, Brigham and Women's Hospital, Harvard Medical School
http://rad.usuhs.mil/medpix/parent.php3?mode=tf2&action=pre&acr_pre=8
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