Radiation Exposure/Urinary Complications

Radiation Safety When Imaging for Stone Disease

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Overview: patients concerned about exposure to radiation from computed tomography (CT); exposure ideally as low as reasonably achievable (ALARA); goals to limit radiation while maintaining diagnostic accuracy and choosing appropriate study; ionizing radiation associated with damage to DNA, mutations, and cancers; most important risk factors for cancer doses greater than 50 to 100 mSv and young age; increase in lifetime cancer risk higher in children than in adults exposed to radiation

Exposure to radiation: background — annual background dose of radiation in United States 2.4 to 3.8 mSv; largest component from sun exposure, so exposure greater at higher altitudes; medical exposure — exposures associated with commonly ordered tests include 0.6 to 0.7 mSv from film of kidney, ureters, and bladder (KUB), 3 mSv from intravenous pyelography, 15 mSv from CT of abdomen and pelvis, 30 mSv from triple-phase CT, and 24 mSv from aortography and dissection protocol for CT; wartime and industrial exposure — theoretical risk for cancer from ionizing radiation derived from studying survivors of atomic bombs and workers in nuclear industry; mean exposure of survivors of bombs in Hiroshima and Nagasaki 40 mSv; mean annual exposure of workers in nuclear plants 19.4 mSv; increased risks for solid cancers, leukemias, and lymphomas observed in these groups

Cancers: theoretical risk for 30,000 excess cancers and 15,000 excess deaths estimated based on frequency of CT in 2007; greater lifetime risks conferred by exposure at younger ages because early exposure allows longer time for DNA to repair itself aberrantly; repeated exposures common in young patients with urinary tract stones or those followed after percutaneous nephrolithotomy (PCNL), motivating exploration of alternatives; following National Comprehensive Cancer Network (NCCN) guidelines for surveillance protocols for stage I nonseminomatous germ cell tumor of testis results in theoretical lifetime risk for cancer of 1% to 2%; risk for cancer caused by follow-up CT imaging 15 times risk for recurrence after retroperitoneal lymph node dissection (RPLND), prompting questions about increased role for RPLND; American College of Radiology (ACR) conducting Image Gently campaign and discouraging CT, especially in children

Statements by ACR: statement on imaging — medical imaging examinations directly linked to greater life expectancy and declines in cancer mortality, and generally less expensive than invasive procedures they replace; medical benefit of imaging must outweigh associated risk; one relevant dilemma for urologists whether to image for stone before ureteroscopy, or perform many negative ureteroscopies in patients with suspected stone disease; ACR statement on studies in Archives of Internal Medicine — conclusions of studies on survivors of atomic bombs and nuclear industry workers rely largely on data that equates radiation exposure and effects experienced by bomb survivors to present-day patients receiving CT; however, survivors of atomic bombs experienced instantaneous exposure to whole-body radiation, while CT performed in controlled environment in which radiation limited to single organ or part of body; known biologic effects very different in these 2 scenarios

Value of CT: although CT still gold standard for imaging stone disease, urologists recently attempting to limit its use; CT most sensitive and specific examination for stones, quick and easy to perform, and requires no intravenous contrast; unlike ultrasonography, CT not operator-dependent and does not require presence of skilled technologist

Roles for CT: useful for assessing renal colic, preoperative planning for PCNL, and postoperative evaluation of residual stone burden; CT provides better imaging than KUB or ultrasonography for obese patients or those with uric acid stones; CT can distinguish ureteral stones from pelvic phleboliths; CT useful for viewing all stones except those associated with protease inhibitors such as indinavir (Crixivan)

Patient selection: CT useful to inform choice between shockwave lithotripsy (SWL) and PCNL by providing Hounsfield density, assess infundibulopelvic angle and lower pole to determine whether stone fragments can pass, accurately determine number and size of stones, and look for retrorenal colon, enlarged spleen or liver, and other anatomic features that could interfere with passage of needle during PCNL; CT allows surgeon to measure skin-to-stone distance, which predicts success of SWL; using CT may help determine best procedure for patient and minimize number of future procedures

Overuse of CT: in addition to urologists, emergency and primary care physicians obtain CT for stones; 20-fold increase in orders for CT for urolithiasis observed in 25-yr period ending in 2006; study found that 108 patients with acute stone episodes received CT 1.7 times per year with mean effective dose

Educational Objectives

The goals of this program are to improve diagnosis and treatment of stone disease and posterior urethral complications in patients with prostate cancer. After hearing and assimilating this program, the clinician will be better able to:

1. Conduct a frank discussion about exposure to radiation with a patient who has renal stones, encompassing lifetime risks, the need for accurate diagnosis, and the statements recently issued by the American College of Radiology.
3. Discuss alternative imaging techniques and emerging technologies aimed at decreasing the dose of radiation required to diagnose and treat patients with urinary tract stones.
4. Discuss diagnosis and treatment of postoperative and postradiotherapy complications in the posterior urethra in patients previously treated for prostate cancer.
5. Compare the prognosis of posterior urethral complications encountered after surgery vs radiation therapies for prostate cancer.

Faculty Disclosure

In adherence to ACCME Standards for Commercial Support, Audio-Digest requires all faculty and members of the planning committee to disclose relevant financial relationships within the past 12 months that might create any personal conflicts of interest. Any identified conflicts were resolved to ensure that this educational activity promotes quality in health care and not a proprietary business or commercial interest. For this program, the following has been disclosed: Dr. Eisner is a consultant for Boston Scientific, Olympus/Gyrus ACMI, and PerSys Medical, and receives financial support (the nature of which is unspecified) from Ravine Group. Dr. Mundy and the planning committee reported nothing to disclose.
of 29.7 mSv/yr; 20% of patients received more radiation than survivors of atomic bombs; in study of 5500 patients evaluated for urolithiasis, 4% received CT 3 to 18 times over ensuing 6-yr period; radiation dose similar to that of nuclear workers, and in some cases several times doses received by nuclear workers or survivors of atomic bombs

**Tools for change:** include changes in practice by physicians and emerging technologies; CT — traditional CT uses filtered-back projection (FBP) algorithms to construct images; FBP quick but not dose-efficient because lowering dose of radiation results in loss of quality of image; newer software programs use partial iterative reconstruction (IR) to lower dose of radiation during CT without compromising diagnostic accuracy; IR likely to become standard of care; contribution of urologists — other simple techniques available to decrease exposure during CT; for example, when assessing stones, changing image field to exclude bottom portion of heart and pubic symphysis decreases exposure to radiation by 20%; communicate with radiologist to learn current scanning protocols and explore alternatives; to evaluate hematuria, using 2-phase scan (eliminating nephrographic phase) achieves 25% reduction in radiation dose

**Partial IR:** new algorithm for image reconstruction provides significant reduction in dose of radiation without requiring additional time; full IR currently used for positron emission tomography; all major manufacturers of CT equipment implementing partial IR; pilot study comparing IR with standard FBP on 156 abdominal CT scans found that IR lowered dose of radiation by 25%; renal stones detectable without using high doses of radiation; in another pilot study using newer algorithm for 30 patients with stones, detection of stones possible using <1 mSv in many patients; radiation exposure from CT ultimately may approach that of 2-view KUB; IR techniques may allow routine imaging of pregnant patients

**Exposure for urologists:** study evaluated numbers of procedures per year needed to reach limit of recommended dose of radiation for several types of procedures, including stent changes, ureteroscopy, and PCNL; found PCNL required smallest number of cases (114 per year) to reach maximum recommended exposure to fingers; however, fluoroscopy time of ≈7 min in study above average; for most procedures, annual exposure to physician well below recommended limit; ocular exposure to physicians also calculated for urologic procedures; if performing 250 ureteroscopies per year, 50 yr required to reach recommended limit of exposure; if performing 120 PCNL per year, 160 yr required to reach limit; risks for urologists theoretical and low; high-volume surgeons may consider wearing lead glasses

**Exposure for patients:** “air pyelogram” injects air instead of contrast during PCNL; developers of technique believe that air travels to posterior calyces and therefore does not obscure stones; use of air results in 50% reduction in duration of exposure to radiation; pregnancy — ureteroscopy preferred technique during pregnancy; perform procedure with as little fluoroscopy as possible; other techniques ureteroscopy without fluoroscopy, and ureteroscopy in conjunction with ultrasonography to minimize fluoroscopy

**Posterior Urinary Complications in the Treatment of Prostate Cancer**

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**Posterior urethral complications:** sources of complications include strictures, trauma including iatrogenic trauma, and end-stage disease; exponential increase in complications of treatment of other pelvic organs in last 5 to 10 yr, especially prostate cancer; more complications following treatment of carcinoma of rectum now observed due to introduction of chemoradiation before surgery; discussion today focuses on bulbo membranous strictures, contractures of bladder neck, and urethral fistulae; difficult to determine incidences of contractures of bladder neck and strictures of sphincter because only symptomatic cases treated, and routine follow-up of these conditions not performed; problems after radical prostatectomy (RP) similar whether RP done robotically, as open procedure, or laparoscopically; however, outcomes in patients treated with external energy sources and combinations of treatments differ from those in patients treated surgically

**Anatomy after radical prostatectomy:** in most cases, funneling of bladder neck present because of change in prostate; prostate no longer above levator sling, but rather sits within levator sling and compressed by it; below that, anastomosis at apparent bladder neck at upper end of urethra varies in length depending on whether urethra transected at, above, or below level of verumontanum; below that, prostatic urethra above sphincter incorporated into anastomosis; sphincter mechanism below that; single filling or voiding study cannot verify this anatomy; to distinguish stricture from sphincter mechanism, must observe patients during voiding or do endoscopic evaluation; funnel forms part of contracture; contractures usually at or above level of anastomosis; in normal, healthy patients after prostatectomy, funnel considerably wider; detailed evaluation sometimes required to identify problems; smallest flow of blood occurs at junction of proximal and middle thirds of bulbar urethra

**Strictures:** *treatment* — instrumentation successful treatment for many patients; surgical treatment also reasonably satisfactory in most, but failure rate 15%; most challenging cases those in which stricture within 1 cm of anastomosis; optimal treatment in such cases not clear; for short strictures, may do end-to-end anastomosis, but this approach does not solve problem of proximity to vesicourethral anastomosis; patching area preferable to resecting and creating second anastomosis; after irradiation, placement of flap preferred to optimize blood supply to area; *outcomes* — patients can usually return home day after surgery; catheter removed at 2 to 2.5 wk; however, patients treated with radiotherapy (RT) require longer catheterization due to poor healing and evidence of extravasation on imaging; patients usually return to normal voiding with good flow rates and experience functional recovery based on patient-reported outcomes

**Bladder neck contractures:** *diagnosis* — urethra has normal endoscopic appearance, or ringing and squamous metaplasia; area of sphincter also appears normal, but area above it solid; must use imaging to assess length of fibrotic area; *treatment* — cases with only anastomotic narrowing may respond to dilation; however, contractures more difficult to treat when extensive funneling present; such strictures may respond to transurethral resection, but commonly recur; contractures in prosthetic urethra after external beam radiotherapy (EBRT) rarely respond to dilation or instrumentation; these patients often present with retention rather than voiding difficulty; problem more severe if patient treated with combination of EBRT plus another therapy such as brachytherapy, cryotherapy, or high-intensity focused ultrasonography (HIFU); may treat contractures of bladder neck with transperineal repair; patients commonly have functional sphincter before treatment; surgery usually destroys existing sphincter mechanism, so consider less aggressive treatment in elderly or unfit patient; however, most patients young, fit, healthy, and willing to undergo 2-stage surgery if necessary; *outcomes* — treatment less successful in patients previously treated with combination of RP and EBRT; in one-third of patients, anastomosis fails to heal or stricture recurs soon after surgery; do not reattempt surgery in these patients; for patients with contracture of bladder neck due solely to EBRT, may do salvage RP; most patients discharged by 4.5 days, but those previously treated with RT recover more slowly and regain less function

**Urorectal fistula:** *diagnosis* — 2 types of urorectal fistulae identifiable on magnetic resonance imaging (MRI); first type
Suggested Reading

1. The 2 most important risk factors for lifetime cancer risk due to exposure to radiation are:
   1. Total dose of radiation
   2. Number of exposures over 20 yr
   3. Younger age of patient
   4. Exposure to several organs or body parts
   5. Failure to use lead glasses
   (A) 1 and 2 (B) 1 and 3 (C) 2 and 3 (D) 4 and 5

2. The annual background dose of radiation for people living in the United States is approximately:
   (A) 0.6 mSv (B) 3 mSv (C) 19.4 mSv

3. The American College of Radiology has stated that medical imaging examinations are directly linked to _______ life expectancy and _______ in cancer mortality.
   (A) Longer, increases (B) Shorter, increases (C) Longer, decreases (D) Shorter, decreases

4. Computed tomography (CT) is superior to other techniques for the following purposes, except:
   (A) Distinguishing pelvic phleboliths from renal stones (B) Imaging uric acid stones
   (C) Imaging renal stones in obese patients (D) Imaging stones caused by protease inhibitors

5. The term for newer algorithms that increase the dose-efficiency of CT is:
   (A) Filtered-back projection (B) Partial iterative reconstruction
   (C) Full iterative reconstruction (D) As low as reasonably achievable

6. For the urologist, the greatest exposure to radiation occurs during performance of:
   (A) Percutaneous nephrolithotomy (B) Ureteroscopy

7. Posterior urethral complications are most likely after:
   (A) Laparoscopic radical prostatectomy (RP) (B) Robotic RP
   (C) Open RP (D) External beam radiotherapy

8. After RP, the best way to distinguish a urethral stricture from an abnormal sphincter mechanism is:
   (A) Endoscopy (B) Single filling or voiding study
   (C) Magnetic resonance imaging

9. After surgical treatment for prostate cancer, the preferred initial treatment for bladder neck contracture due solely to anastomotic narrowing is:
   (A) Transurethral resection (B) Transperineal repair
   (C) Dilation (D) Salvage RP

10. Patients treated for urorectal fistula after surgery for prostate cancer are typically hospitalized for 7 days to ensure there is no:
    (A) Leakage at the anastomosis (B) Septic event
    (C) Urinary tract stricture (D) Osteitis pubis

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