30th Annual In-Training Examination for Radiation Oncology Residents

March 7, 2013

1. How long after exposure of hypoxic cells to X-rays can oxygen be introduced into the system and still produce some radiosensitization?

(A) Milliseconds
(B) Seconds
(C) Minutes
(D) Hours

Key: A
Rationale: Because the oxygen effect is atrributed to an interaction between molecular oxygen and free radical species produced by radiation exposure, it follows that the "time window" for this interaction would be comparable to that of the lifetimes of the free radicals, which is on the order of micro- or milliseconds. Adding oxygen to an experimental system seconds or minutes after irradiation would produce no oxygen effect.
References: Chapter 6 in Hall and Giaccia, Radiobiology for the Radiologist, 7th Edition, 2012.

2. How will removing the flattening filter from a photon beam alter its x-ray beam characteristics?

(A) It will not affect the beam characteristics.
(B) The peak energy of the beam will be higher.
(C) The average energy of the beam will be higher.
(D) The average energy of the beam will be lower.

Key: D
Rationale: The flattening filter (FF) filters out a lot of the low energy photons. Therefore, removal of the FF results in a lower average energy (softer) beam because of the increased low energy component. The FF does not affect the peak energy.
References: Almberg SS, Frengen J, Lindmo, T Monte Carlo study of in-field and out of field dose distributions from a linear accelerator operating with and without a flattening filter. Med Phys 39 (8), 2012

3. Treatment for stage I extremity soft tissue sarcoma that is completely excised with negative margins is:

(A) observation.
(B) post-operative radiation.
(C) adjuvant imatinib and post-operative irradiation.
(D) adjuvant anthrocycline based chemotherapy and post-operative radiation.

Key: A
Rationale: Recommended therapy is observation.
References: Hansen, Eric K., et. al. Handbook of Evidence-Based Radiation Oncology. 2nd edition. Springer Scientific. 2010. Page 619.

4. According to the German Rectal Study, the 5-year risk of local recurrence for a patient with a T3-4,N+ rectal cancer receiving pre-operative chemoradiation followed by surgical resection is:

(A) 1%.
(B) 6%.
(C) 13%.
(D) 25%.

Key: B
Rationale: The local recurrence rate after pre-operative chemoradiation followed by surgical resection for a locally advanced rectal cancer is 6%.
References: Sauer R, et al. New England Journal of Medicine. Oct 21, 2004; 351(17) pp. 1731-40.

5. What approximate percentage of SCLC patients present with extensive disease in the U.S.?

(A) <20%
(B) 30-40%
(C) 60-70%
(D) >80

Key: C
Rationale: Approximately 35,000 Americans are diagnosed with small cell lung cancer annually. The incidence of extensive disease is 60-70%. This percentage of patients with ED has increased over the last 20 years, and this is at least partially due to stage migration secondary to routine use of CT scans, brain MRIs, and PET. PET alone upstages 8% of patients diagnosed with limited disease based on conventional staging (Bradley; J Clin Oncol. 22(16):3248-54, 2004; Niho; Lung Cancer. 57(3): 328-332007).

6. Management of respiratory motion should be considered if intrafraction motion is of a magnitude greater than:

(A) 2 mm.
(B) 5 mm.
(C) 8 mm.
(D) 10 mm.

Key: B
Rationale: Per AAPM Task Group 76, errors caused by motions less than 5 mm are considered small relative to other errors in radiotherapy.
References: AAPM Task Group 76 report.

7. Which of the following is needed to calculate the tumor cell cycle time *in vivo*?
(A) Percent labeled mitoses curve
(B) Growth fraction
(C) Cell loss factor
(D) Potential doubling time
Key: A
Rationale: The percent labeled mitoses technique is used to determine the overall cell cycle times and the durations of the specific cell cycle phases for amenable normal tissues and tumors in vivo. Options B, C, and D are all cell cycle kinetic parameters used to study tumor growth kinetics.
References: Chapter 22 in Hall and Giaccia, Radiobiology for the Radiologist, 7th Edition, 2012.

8. For a 12-year-old boy with Hodgkin lymphoma and stage IIA with bulk disease, the work-up and initial studies should include all of the following EXCEPT:

(A) bone scan.
(B) pulmonary function tests.
(C) bilateral bone marrow biopsies.
(D) CT of the neck, chest, abdomen, and pelvis.
Key: A
Rationale: Based on the work-up for COG AHOD 0031.

9. For a certain x-ray technique, the exposure is measured to be 10 R. Given that the *f* factor is 0.876 rad/R, what is the dose in air?

(A) 0.01141 Gy
(B) 0.0876 Gy
(C) 8.76 Gy
(D) 11.41 Gy
Key: B
Rationale: Using the f factor, the dose is (10 R* 0.876 rad/R) = 8.76 rad = 0.0876 Gy.
References: Khan FM, The physics of Radiotherapy, 3rd Edition, Chapter 8, pp. 109.

10. What is the MOST appropriate treatment of a 55-year-old patient with diffuse superficial transitional cell carcinoma of the bladder that has recurred after transurethral resection of the bladder tumor (TURBT) and intravesical BCG?

(A) Radical cystectomy
(B) Intravesical chemotherapy
(C) Systemic chemotherapy
(D) Radiation therapy and chemotherapy

Key: A
Rationale: Radical cystectomy is the treatment of choice for diffuse superficial bladder tumor, especially in the seeting of failed conservative management. Chemotherapy, whether given intravesically or systemically, will not be a curative treatment. Radiation therapy is not usually recommended for diffuse tumors.
References: Perez and Brady et al, Principles and Practice of Radiation Oncology, 5th Edition.

11. Which of the following is TRUE for adult patients treated with radiotherapy for an early stage favorable Hodgkin lymphoma?

(A) It is most beneficial for patients who achieve only partial response to chemotherapy.
(B) Extended field is best for local control.
(C) It no longer has a role in treatment due to high response to chemotherapy.
(D) The cumulative dose is 45 Gy regardless of chemotherapy response.

Key: A
Rationale: Combination of multi-agent chemotherapy like ABVD followed by lower dose involved-field radiotherapy (20-30 Gy) achieves the best outcome in patients with early stage Hodgkin lymphoma.
References: Engert A et al, N Eng J Med 2010; 363: 640-52 Eich HT et al, JCO 2010; 28: 4199-206.

12. According to the latest AJCC staging manual for lung cancer, which of the following would be classified as M1a?

(A) Malignant pleural effusion
(B) Separate tumor nodule(s) in the same lobe
(C) Contralateral supraclavicular lymph node involvement
(D) Separate tumor nodule(s) in a different ipsilateral lobe

Key: A
Rationale: Pertinent changes to the lung staging system from the 6th to 7th edition include (1) more discrete stratification of tumors by size and partitioning of larger (>7 cm) tumors into T3, (2) downstaging of multiple nodules to T3 (same lobe), T4 (same lung), and M1a (contralateral lobe), and (3) upstaging of malignant pleural effusion from T4 to M1a.
References: AJCC Cancer Staging Manual, 7th edition, 2009.

13. What is the half-life of the most common radio-isotope instilled to treat cystic craniopharyngiomas?

(A) 7 days
(B) 14 days
(C) 60 days
(D) 90 days

Key: B
Rationale: 32P is most commonly instilled into cystic cavities from craniopharyngioma. The half-life of this beta emitter is approximately 14 days.

14. Which of the following is the MOST appropriate treatment after near total resection (>90%) of a large left temporal lobe ependymoma in a 30-year-old male if there is no evidence of drop metastasis on brain and spinal MRI?

(A) Observation
(B) Involved field radiotherapy alone
(C) Combined chemotherapy and involved field radiotherapy
(D) Craniospinal irradiation followed by involved field radiotherapy

Key: B
References: Merchant TE. Current management of childhood ependymoma. Oncology (Williston Park). 2002 May; 16(5):629-42, 644; discussion 645-6, 648. Review.
Paulino AC. Radiotherapeutic management of intracranial ependymoma. Pediatr Hematol Oncol. 2002 Jul-Aug; 19(5):295-308.
Paulino AC et al. Intracranial ependymomas: an analysis of prognostic factors and patterns of failure. Am J Clin Oncol. 2002 Apr; 25(2):117-22.

15. What molecular subtype of gene expression is more common in inflammatory breast cancer than non-inflammatory breast cancer?

(A) Luminal A
(B) Luminal B
(C) Basal-like
(D) Normal-like

Key: C
References: Van Laere et al Breast Cancer Research and Treatment (2006) 95: 243-255 and Bertucci et al Cancer (2010) 116: 2783-2793.

16. What is the MOST distinguishing characteristic of an inflammatory breast cancer from a locally advanced non-inflammatory breast cancer?

(A) Rapid onset
(B) Palpable mass
(C) Peau d'orange
(D) Dermal lymphatic invasion

Key: A
Rationale: Both inflammatory breast cancer and neglected locally advanced breast cancer can present with palpable mass, peau d'orange, eythema, or even dermal lymphatic invasion. A rapid onset is characteristic of inflammatory rather than a long-standing history of a mass that secondarily grows to involve overlying skin.
References: Robertson et al CA CANCER J CLIN 2010; 60:351-375.

17. According to the Early Breast Cancer Trialist Cooperative Group, a 20% decrease in local regional recurrence at 5 years will result in an improvement in 15 year overall survival by:

(A) <1%.
(B) 5%.
(C) 10%.
(D) 15%.

Key: B
References: Disease of the Breast, Jay Harris, et al. 4th edition. Lippincott, Williams and Wilkins, pp. 600. 2010.

18. What was the strongest predictor for local recurrence for DCIS treated by excision without radiation on the ECOG E5194 study at 5 years?

(A) Age
(B) Size
(C) Grade
(D) Margin

Key: C
References: Clin Oncol; Vol 27, pgs. 5319-5324. 2009.

19. Of the following types of radiation, which will cause the greatest amount of cell killing and DNA damage per unit dose?

(A) ^{60}Co gamma rays
(B) 6 MeV electrons
(C) 250 MeV protons
(D) 250 MeV/n carbon ions

Key: D
Rationale: 250 MeV/n carbon ions are considered a medium linear energy transfer (LET) radiation quality (the other three types are considered low LET radiation qualities) and will generate the greatest degree of DNA damage and cell killing per unit dose. The clinical relative biological effectiveness of carbon ions compared to 60Co gamma rays is approximately 3.
References: IAEA Technical Report 461, "Relative biological effectiveness in ion beam therapy", 2008.

20. The relative exposure rate of an x-ray generator is proportional to:

(A) kVp.
(B) $(kVp)^2$.
(C) $(mAs)^2$.
(D) $(mAs)^3$.

Key: B
Rationale: The exposure rate is proportional to the mAs and the square of kVp.
References: Khan FM, The physics of Radiotherapy, 3rd Edition, Chapter 3, Fig 3.10.

21. A relatively specific marker of Langerhans cell histiocytosis is:

(A) CD1a.
(B) Myogenin.
(C) CD99 *(MIC2).*
(D) Neuron specific enolase (NSE).

Key: A
References: Br J Haematol. 2012 Jan; 156(2):163-72. doi: 10.1111/j.1365-2141.2011.08915.x. Epub 2011 Oct 24. Recent advances in the understanding of Langerhans cell histiocytosis. Badalian-Very G, Vergilio JA, Degar BA, Rodriguez-Galindo C, Rollins BJ.

22. Which of the following is TRUE concerning the use of adjuvant radiation in colon cancer?

(A) It is routine, as colon cancer has significantly higher local recurrence rates than rectal cancer.

(B) The INT 0130 trial showed adjuvant chemoradiation significantly improved survival compared to chemotherapy alone.

(C) The INT 0130 trial showed adjuvant chemoradiation significantly improved disease-free survival compared to chemotherapy alone.

(D) There is no prospective evidence supporting the use of adjuvant radiation in colon cancer patients.

Key: D

Rationale: Adjuvant radiation is not typically used in resected colon cancer. Colon cancer has lower rates of local recurrence than rectal cancer (matched for stage) due to the location and anatomy of the rectum. The INT0130 randomized patients (any T4; or T3 Node positive patients of the ascending and descending colon) to 5FU+Levamisole with or without radiation. The trial was closed to low accrual and was underpowered but did not show any significant differences in OS or DFS. The only data that supports the use of radiation in colon cancer is from retrospective series.

References: INT 0130 (Martenson et al., JCO 22(16): 3277-3283).

23. Which statistical method should be applied when measuring the degree of reliability between two radiologists interpreting the same chest x-rays?

(A) Chi-square test

(B) McNemar test

(C) Kappa coefficient

(D) One way analysis of variance

Key: C

Rationale: The Kappa coefficient is a widely used statistic for measuring the degree of reliability between different and independent raters. It compares the agreement against that which might be expected by chance. The Kappa coefficient ranges from 1 (perfect agreement) to -1 (complete disagreement). Here is one possible interpretation of Kappa.

Poor agreement = Less than 0.20
Fair agreement = 0.20 to 0.40
Moderate agreement = 0.40 to 0.60
Good agreement = 0.60 to 0.80
Very good agreement = 0.80 to 1.00

24. Which of the following statements about patients who have breast cancer with a BRCA1 germline mutation is true?

(A) The risk of developing ovarian cancer is 20% to 40%.
(B) There is a higher frequency of papillary breast cancers.
(C) The majority are ER positive, PR positive, and HER 2/neu positive.
(D) These patients have a poorer prognosis compared to sporadic breast cancers.

Key: A
Rationale: A higher risk of ovarian cancer is found in patients with BRCA1 germline mutations. There is a higher proportion of medullary cancers than seen in any other group. The tumors tend to be ER-, PR-, and HER-2/neu-negative. Patients who are carriers have the same prognosis as do those of patients in the general population when all other prognostic factors are controlled.
References: Harris J, et al. Diseases of the Breast. 3rd ed. 2004; p. 15-345, p. 566.

25. Which of the following is a favorable prognostic factor for oligodendroglioma?

(A) Solitary 19q loss
(B) Higher radiation dose
(C) Seizures as a presenting symptom
(D) Presence of contrast enhancement

Key: C
References: Chaichana KL, McGirt MJ, Niranjan A, Olivi A, Burger PC, Quinones-Hinojosa A. Prognostic significance of contrast-enhancing low-grade gliomas in adults and a review of the literature.Neurol Res. 2009 Nov; 31(9):931-9. Epub 2009 Feb 12.
Scheie D, Meling TR, Cvancarova M, Skullerud K, Mørk S, Lote K, Eide TJ, Helseth E, Beiske K.Prognostic variables in oligodendroglial tumors: a single-institution study of 95 cases.Neuro Oncol. 2011 Nov; 13(11):1225-33. Epub 2011 Aug 19.
Karim AB, Maat B, Hatlevoll R, Menten J, Rutten EH, Thomas DG, Mascarenhas F, Horiot JC, Parvinen LM, van Reijn M, Jager JJ, Fabrini MG, van Alphen AM, Hamers HP, Gaspar L, Noordman E, Pierart M, van Glabbeke M. A randomized trial on dose-response in radiation therapy of low-grade cerebral glioma: European Organization for Research and Treatment of Cancer (EORTC) Study 22844. Int J Radiat Oncol Biol Phys. 1996 Oct 1; 36(3):549-56.
Shaw E, Arusell R, Scheithauer B, O'Fallon J, O'Neill B, Dinapoli R, Nelson D, Earle J, Jones C, Cascino T, Nichols D, Ivnik R, Hellman R, Curran W, Abrams R. Prospective randomized trial of low- versus high-dose radiation therapy in adults with supratentorial low-grade glioma: initial report of a North Central Cancer Treatment Group/Radiation Therapy Oncology Group/Eastern Cooperative Oncology Group study.J Clin Oncol. 2002 May 1; 20(9):2267-76.

26. What is the most common genetic aberration in rhabdoid tumors of the kidney?

(A) EGFR amplification
(B) 1p/19q co-deletion
(C) Deletion in Chromosome 10p
(D) Deletion in Chromosome 22q

Key: D

Rationale: Both AT/RT and the analogous tumor outside the brain, malignant rhabdoid tumor, share a polyphenotypic immunoprofile and frequent 22q deletions with inactivation of the IN11/hSNF5 gene.

27. Following radiosurgery or surgery for brain metastases, the EORTC trial reported by Kocher et al, showed that whole brain irradiation improved the rate of:

(A) overall survival.
(B) treatment of related adverse events.
(C) death due to intracranial progression.
(D) duration of functional independence (time to WHO PS>2).

Key: C

Rationale: The addition of WBRT, as compared to observation, following surgery or radiosurgery, did not improve overall survival, functionally independent survival or side effects. The neurologic death rate was improved (44% vs 28% crude rate on WBRT vs Observation arms, respectively).

References: Kocher JCO 29, 2011. PMID: 21041710.

28. What is the percentage of false negative clinical examination for groin metastases by palpation in vulvar cancer?

(A) 5%
(B) 10%
(C) 15%
(D) 20%

Key: D

Rationale: From 1977 to 1984 the Gynecologic Oncology Group (GOG) conducted a prospective clinical and surgical staging protocol of squamous cell carcinoma of the vulva (n = 637). The subject of this report was on factors that predict groin node metastasis based on all 588 evaluable patients. Groin node metastasis was 18.9% for the<or = 2-cm diameter tumors and 41.6% for the>2-cm diameter lesions. The inaccuracy of clinical palpation of the groin nodes (23.9% false negative) largely accounted for underestimation of extent of disease.

References: Prognostic factors for groin node metastasis in squamous cell carcinoma of the vulva (GOG study) Homesley HD, Bundy BN, Sedlis A, Yordan E, Berek JS, Jahshan A, Mortel R Gynecol Oncol. 1993; 49(3):279.

29. What is an established risk factor for fallopian tube cancer?

(A) Nulligravida
(B) Late menarche
(C) Early menopause
(D) BRCA gene mutation

Key: D

Rationale: A BRCA gene mutation is the most established risk factor for fallopian tube and primary peritoneal carcinoma. BRCA mutations, primarily BRCA1, have been identified in 16 to 43 percent of women with primary fallopian tube cancer. Therefore, BRCA mutation testing should be offered to women with these tumors and risk-reduction surgery for BRCA carriers includes salpingectomy.

References: Fallopian tube and primary peritoneal carcinomas associated with BRCA mutations. Levine DA, Argenta PA, Yee CJ, Marshall DS, Olvera N, Bogomolniy F, Rahaman JA, Robson ME, Offit K, Barakat RR, Soslow RA, Boyd J J Clin Oncol. 2003; 21(22):4222.
Genetic epidemiological study of carcinoma of the fallopian tube.

30. What was the radiation dose in Gy used in ECOG 1484 (Horning et. al. JCO, 2004) for patients with non-Hodgkin lymphoma in complete response following chemotherapy?

(A) 20
(B) 30
(C) 40
(D) 50

Key: B

Rationale: This trial randomized patients in CR after 8 cycles of CHOP (cyclophosphamide, doxorubicin, vincristine, and prednisone) to either 30 Gy involved field RT or no further therapy.

31. What is the MOST appropriate dose in Gy for PCI in a 10-year-old boy with high risk acute lymphoblastic leukemia (ALL) and no evidence of central nervous system involvement?

(A) 5.2
(B) 18
(C) 23.4
(D) 30.6

Key: B
Rationale: For prophylactic treatment, 18 Gy is sufficient. Recent protocols use even lower doses of 12 Gy.

32. At a depth of 5 cm in tissue, which of the following beams has the narrowest lateral penumbra?

(A) Co-60
(B) 6X photon
(C) 20 MeV electron
(D) 200 MeV proton

Key: D
Rationale: Proton beams have a very narrow lateral penumbra, but its sharpness decreases with increasing beam energy, hence, depth of penetration. The width of the penumbra (80-20 percent isodose levels) is narrower for proton than for photon beams for penetrations up to approximately 17 cm. The next largest penumbra at a depth of 5 cm is the 20 MeV electron beam, followed by a Co-60 beam.
References: ICRU Report # 78.

33. What parameter is currently used to quantify brachytherapy source strength?

(A) Air kerma
(B) Absorbed dose
(C) Specific activity
(D) Dose rate constant

Key: A
Rationale: Brachytherapy source strengths are defined in terms of air kerma strength (cGy cm^2/ hr) according to AAPM Task Group 43. The dose rate constant defines the dose per unit air karma strength at a distance of 1 cm along the transverse axis in water. Absorbed dose rate is no longer used. Specific activity is the activity per unit mass and is not used to describe encapsulated brachytherapy sources.
References: AAPM Task Group 43 Report.

34. What is the MOST appropriate therapy for persistent disease after definitive radiation therapy for a solitary extraosseous plasmacytomas?

(A) Surgery
(B) Cryotherapy
(C) Brachytherapy
(D) Radio-frequency ablation

Key: A
Rationale: Extraosseous plasmacytoma can be cured with multimodality treatment. Surgery may have a role in the treatment of extraosseous plasmacytoma.
References: NCCN MM Guidelines MS-4.

35. Which variant of well-differentiated thyroid cancer has the worst prognosis?

(A) Follicular carcinoma
(B) Hurthle cell carcinoma
(C) Papillary carcinoma
(D) Papillary carcinoma with euploid DNA

Key: B
References: Cady et al. Surgery. 1988 Dec; 104(6):947-53. Sherman SI, Cancer. 1998 Sep 1; 83(5):1012-21.

36. Which of the following effects of radiation is stochastic?

(A) Hematopoietic syndrome
(B) Cancer
(C) Cataracts
(D) Skin erythema

Key: B
Rationale: Of the options listed above, only cancer is a stochastic effect, while the others are deterministic effects. The latter show dose thresholds and can vary in severity, unlike stochastic effects.
References: Chapter 17 in Hall and Giaccia, Radiobiology for the Radiologist, Seventh Edition, 2012.

37. The skin reaction assay can be used to construct a radiation dose response curve by:

(A) removing skin cells from an irradiated animal and transferring them to an organ in an untreated animal where colony formation occurs.

(B) removing skin cells from an irradiated animal and plating them in a Petri dish for colony formation.

(C) measuring the severity of the skin reaction in the irradiated animal using an ordinal scoring system.

(D) monitoring the regrowth of nodules in irradiated areas of the animal's skin.

Key: C

Rationale: The skin reaction assay is an example of a "functional" assay whereby a dose response curve is constructed that measures changes in the severity of the effect following irradiation. In the case of the skin reaction assay, reactions such as erythema and desquamation are observed and given an arbitrary score as to their severity. Average scores can be plotted as a function of dose. These types of experiments were used routinely in early studies measuring the effects of fractionation.

References: Chapter 19 in Hall and Giaccia, Radiobiology for the Radiologist, Seventh Edition, 2012.

38. Long-term Hodgkin lymphoma survivors who received radiation therapy during childhood have approximately what chance of developing a treatment-induced cancer?

(A) 5%

(B) 15%

(C) 25%

(D) 35%

Key: C

Rationale: Long term survivors of childhood Hodgkin lymphoma have about a 25% risk of developing a second malignancy later in life.

References: Chapter 10 in Hall and Giaccia, Radiobiology for the Radiologist, Seventh Edition, 2012. Bhatia S et al. N Eng J Med 1996; 334:745-751.

39. Which tumor is associated with loss of INI1?
(A) Pineoblastoma
(B) Pineal germinoma
(C) Supratentorial ependymoma
(D) Atypical teratoid rhabdoid tumor
Key: D
Rationale: Atypical teratoid rhabdoid tumor is a embryonal posterior fossa tumor occurring almost exclusively in infants. Loss of INI1 is diagnostic and distinguishes this tumor from medulloblastoma.
References: Pediatric Radiation Oncology 5th edition, 2011.

40. Which of the following is a feature of radiation-induced necrosis?
(A) Generates a local inflammatory response
(B) Is an ATP-independent process
(C) Is associated with sequence-specific DNA cleavage
(D) Can be confused with the early phase of apoptosis
Key: A
Rationale: Over the last decade, it has been shown that necrosis is an ATP-dependent process. Pro-necrotic signaling through membrane-bound death receptors, kinases (RIP1, MAPK family members), and DNA repair proteins (PARP1) all deplete cellular ATP levels, and the balance between necrotic and apoptotic cell death pathways may be dependent on cellular ATP levels
References: Wilson PF and Bedford JS. In: Leibel and Philips, Textbook of Radiation Oncology, Third Edition, 2010, pp. 24.

41. What is the current standard dose for a gross tumor in Ewing's sarcoma not within the spinal column?

(A) 45 Gy
(B) 50.4 Gy
(C) 55.8 Gy
(D) 60 Gy
Key: C
Rationale: This is the recommended dose for gross Ewings sarcoma. One exception is the spine, which is classically 45 Gy. Though, modern treatment planning can allow for higher doses with sparing of the spinal cord.

42. According to the GEC ESTRO recommendations, when developing a 3D-based treatment plan for cervical brachytherapy, which of the following targets should receive the prescription dose?

(A) Point A
(B) Point B
(C) Low risk CTV (LR CTV)
(D) High risk CTV (HR CTV)

Key: D
Rationale: Per the GEC ESTRO recommendations, when generating a volume-based treatment plan, the HR CTV should receive the prescription dose. The LR CTV is typically treated by surgery and/or external beam radiotherapy versus brachytherapy. Traditionally, the prescription point for patient's receiving cervical brachytherapy has been Point A, and most centers in the U.S. continue to prescribe to this point. Point B has traditionally been recorded to monitor dose falls off with distance from the implant.
References: Potter et al., Radiotherapy and Oncology 78, 67-77 (2006).

43. Which of the following is a histological feature of ependymoma?

(A) Microcystic changes
(B) Homer-Wright rosettes
(C) Perivascular pseudorosettes
(D) Flexner-Wintersteiner rosettes

Key: C
Rationale: Perivascular pseudorosettes are a feature of ependymoma. Homer-Wright rosettes are a histological feature of medulloblastoma. Flexner-Wintersteiner rosettes are a feature of retinoblastoma. Microcystic changes are a feature of diffuse astrocytoma.
References: Wiestler et al. Ependymoma. In: Who Health Organisation Classification of Tumours. Pathology & Genetics. Tumours of the Nervous System. (Eds: Kleihues and Cavenee). P. 71-76. IARC 2000.

44. What is the inferior border of the parametria for cervical cancer treatment planning?

(A) Urogenital diaphragm
(B) Top of the broad ligament
(C) Posterior border of the external iliac vessel
(D) Medial edge of the internal obturator muscle

Key: A
Rationale: The boundaries are: Anterior-posterior wall of the bladder or posterior border of the external iliac vessel; Posterior- uterosacral ligaments and mesorectal fascia; Lateral-medial edge of internal obturator muscle/ischial ramus bilaterally ; Superior-Top of fallopian tube/broad ligament (Depending upon the degree of uterine flexion this may also be the anterior boundary); Inferior-urogenital diaphragm.
References: IJROBP Vol 79, No.2, pp 348-355, 2011

45. What is the T stage of a fallopian tube cancer that has pelvic extension with malignant cells in the peritoneal washings?

(A) T1b
(B) T2c
(C) T3b
(D) T3c

Key: B
Rationale: A T2c fallopian tube cancer involves one or both fallopian tubes with pelvic extension and has malignant cells in ascites or peritoneal washings.
References: Staging Guidelines.

46. Which of the following findings is MOST predictive of a chest wall recurrence after mastectomy for breast cancer?

(A) Extent of involvement of the axilla
(B) Size of the primary tumor in the breast
(C) Presence of lymph-vascular space invasion
(D) Presence of an extensive intraductal component

Key: A
Rationale: Multiple studies (including Recht, et al, and Katz, et al) have shown that the extent of metastatic involvement of the axilla is the single greatest predictor of local/regional recurrence of breast cancer following mastectomy.

47. What is the expected 5-year overall survival for a stage III carcinoma of the female urethra with treatment?

(A) 10-15%
(B) 20-40%
(C) 50-70%
(D) 75-90%

Key: B
Rationale: T2N1 and T3N0 and T3N1 patients have a reasonable life expectancy with treatment. The majority of patients will present with these stages.
References: ACOS ACS.

48. Japanese survivors of the atomic bombings who were irradiated *in utero* with 1 Sv between the 8th and 15th weeks of gestation have a probability of severe mental retardation of approximately:

(A) 0.05.
(B) 0.1.
(C) 0.2.
(D) 0.4.

Key: D
Rationale: Irradiation at 8 to 15 weeks of gestation is within the time frame for development of the cerebral cortex. Irradiation during this period can have a large negative effect on the survival of embryonic brain cells and their ability to migrate from proliferative zones into the cortex. This manifests itself after birth as severe mental retardation.
References: Chapter 12 in Hall and Giaccia, Radiobiology for the Radiologist, Seventh Edition, 2012.

49. What is the rate of clinical radiation pneumonitis in breast cancer patients from comprehensive regional node irradiation that includes the internal mammary lymph node chain?

(A) 1%
(B) 5%
(C) 10%
(D) 15%

Key: A
Rationale: The incidence of pneumonitis was reported in randomized trials of IMN irradiation by the European Organisation for Research and Treatment of Cancer and the National Cancer Institute of Canada.
References: Matzinger et al Acta Oncologica, 2010; 49: 24-34, and the National Cancer Institute of Canada (Whelan et al ASCO 2011).

50. Assuming that platelet counts follow a normal distribution, what is the range for 95% of individuals in a population with a mean of 220,000 and standard deviation of 35,000?

(A) 150,000 to 290,000
(B) 185,000 to 255,000
(C) 115,000 to 305,000
(D) 205,000 to 235,000

Key: A
Rationale: In a normally distributed population: 95% of values fall within ±2 standard deviations of the mean; 67% within ±1 standard deviation of the mean; 99% within ±3 standard deviations.

51. What is the sensitivity of a screening test used to determine the presence or absence of a disease?

(A) The percentage with a disease who are classified as having the disease
(B) The percentage with a disease who are classified as not having the disease
(C) The percentage without a disease who are classified as having the disease
(D) The percentage without a disease who are classified as not having the disease

Key: A
Rationale: Screening refers to the application of test to people who as yet have no symptoms of a particular disease. It is classified as having a positive (disease likely) or negative (disease unlikely) finding. Diagnostic tests tell whether or not a subject actually has the disease. The performance of a screen test is considered by the sensitivity and specificity. The sensitivity is the percentage of subjects with disease who are classified as having disease and the specificity is the percentage of subjects without disease who are classified as not having disease. Those subjects with the disease should all be classified as having disease, and those subjects without the disease should be classified as not having disease. Therefore a highly sensitive and specific test is preferred.

52. What is the 5-year survival rate for patients with inflammatory breast cancer?

(A) 20%
(B) 40%
(C) 60%
(D) 80%

Key: B
Rationale: The overall survival for patients with inflammatory breast cancer is approximately 40%. The survival may be higher in more favorable subgroups such as having a good response to chemotherapy or having hormone-sensitive breast cancer.
References: Anderson et al. Epidemiology of inflammatory breast cancer (IBC). Breast Dis. 2005-2006; 22:9-23 and Robertson et al CA CANCER J CLIN 2010; 60: 351-375.

53. What ratio of positive ipsilateral groin nodes to total resected predicts contralateral groin metastasis in vulvar cancer?

(A) 5%
(B) 10%
(C) 15%
(D) 20%

Key: D
Rationale: A Gynecologic Oncology Group protocol (37) enrolled 114 patients randomly allocated to postoperative pelvic and groin radiation (45-50 Gy, n=59) or to ipsilateral pelvic node resection (n=55) after radical vulvectomy and inguinal lymphadenectomy. Retrospective analyses for 114 enrolled patients included both risk of progression and death after treatment and assessment of toxicity. A ratio of more than 20% positive ipsilateral groin nodes (number positive/number resected) was significantly associated with contralateral lymph node metastasis, relapse, and cancer-related death.
References: Obstet Gynecol. 2009 Sep; 114(3):537-46.Radiation therapy compared with pelvic node resection for node-positive vulvar cancer: a randomized controlled trial. Kunos C, Simpkins F, Gibbons H, Tian C, Homesley H.

54. Which is NOT a structure of the supraglottic larynx?

(A) Infrahyoid epiglottis
(B) Suprahyoid epiglottis
(C) Pre-epiglottic space
(D) False vocal cords

Key: C

55. Which of the following BEST describes the role of autologous stem cell transplantation (ASCT) in patients with Hodgkin lymphoma?

(A) Toxicity risks outweigh the benefit with relapsed or refractory disease.
(B) It is an effective treatment for relapsed disease.
(C) It is used in patients who have achieved partial response to induction chemotherapy.
(D) It is used in patients over 70 years old.

Key: B
Rationale: ASCT is proven to be very important part of salvage regimen in patients with refractory and relapsed Hodgkin's lymphoma and is now the generally accepted standard of care for patients with primary refractory or first-relapsed HL. It gives them over 50% of progression-free survival and superior outcome compared to non-transplantation regimens.
References: Linch DC, Winfield D, Goldstone AH et al. Dose intensification with autologous bone-marrow transplantation in relapsed and resistant Hodgkin's disease: Results of a BNLI randomised trial. Lancet 1993; 341:1051-1054. Schmitz N, Pfistner B, SextroMet al. Aggressive conventional chemotherapy compared with high-dose chemotherapy with autologous haemopoietic stem-cell transplantation for relapsed chem.

56. Compared to a 3D conformal treatment, a conventional linac-based IMRT treatment:
(A) is forward planned.
(B) uses 1 segment per beam.
(C) uses less total monitor units.
(D) can conform better to the target volume.
Key: D
Rationale: An IMRT treatment is inverse planned and uses several segments per beam to create intensity modulation that can conform better to our target volume. Due to the large number of segments used, IMRT treatments typically uses more monitor units.
References: Khan FM, The physics of Radiotherapy, 3rd Edition, Chapter 20.

57. Which endpoint associated with radiation-induced γ-H2AX foci is thought to be of the greatest clinical utility for radiotherapy?

(A) Baseline number of γ-H2AX foci prior to irradiation
(B) Number of γ-H2AX foci 1 hour after irradiation
(C) Residual numbers of γ-H2AX foci 24 hours after irradiation
(D) Co-localization of γ-H2AX foci with other DNA double strand break markers
Key: C
Rationale: Among the options listed above, residual levels of γ-H2AX foci are most significantly correlated with cell killing and tumor radiosensitivity.
References: Belyaev IY, Mutation Research 704:132–141, 2010.

58. Compared to the mycotoxin aflatoxin B1, the neoplastic transformation frequency for an equitoxic dose of X-rays is:

(A) much higher.
(B) higher.
(C) lower.
(D) much lower.
Key: D
Rationale: Aflatoxin B1, a mycotoxin produced by Aspergillus fungi, is arguably the most potent carcinogens known. In neoplastic transformation assays in vitro, it produces a much higher (by up to two orders of magnitude depending on the experimental system) transformation frequency than an equitoxic dose of X-rays. This demonstrates that, contrary to popular belief, ionizing radiation is not a particularly potent carcinogen.
References: Chapter 3 in Tannock, Hill, Bristow and Harrington. The Basic Science of Oncology, Fourth Edition, 2005.

59. Nonsecretory myeloma is associated with:
(A) elevated UPEP levels.
(B) nonexistent urine protein levels only.
(C) nonexistent serum protein levels only.
(D) nonexistent serum and urine protein levels.
Key: D
Rationale: Understand that 3% of MM produces no protein products. Nonsecretory MM has nonexistent serum and urine proteins levels.
References: NCCN MM Guidelines MS-2.

60. In total photon body irradiation (TBI), the purpose of the beam spoiler is to:

(A) increase the dose at depth.
(B) decrease the dose at depth.
(C) increase the dose at the surface.
(D) decrease the dose at the surface.
Key: C
Rationale: A common dosimetric goal in total body irradiation is to achieve dose uniformity within 10%. Dose in the buildup region of a photon beam is typically much less than 10% of the maximum dose, requiring steps to increase the skin dose. A 1-2 cm thick acrylic beam spoiler, placed close to the patient surface, is generally sufficient to increase the skin dose to at least 90% of the prescription dose.
References: AAPM Task Group 29 report.

61. Absolute output calibrations for a medical linear accelerator are BEST performed using:

(A) an ion chamber.
(B) a diode detector.
(C) a piece of radiographic film.
(D) a Geiger counter.
Key: A
Rationale: AAPM Task Group 51 requires absolute dose calibration to be performed using a small ion chamber, approximating a Bragg-Gray cavity. Diode detectors and radiographic film are useful for relative measurements, but have dependencies on energy, exposure, and other factors making dose calibration less accurate. A Geiger counter is an ion chamber tuned to maximum sensitivity to allow the detection of very small signals, and would therefore be saturated and overwhelmed by the dose rate from a therapeutic beam.
References: AAPM Task Group 51 report.

62. Which prognostic factor is the MOST important predictor of clinical outcomes for patients with well-differentiated papillary carcinoma of the thyroid?

(A) Age at the diagnosis
(B) Extranodal extension
(C) Extrathyroidal extension
(D) Cervical lymph node >5 cm

Key: A
References: Cady et al. Surgery. 1988 Dec; 104(6):947-53.

63. Perianal skin cancer:

(A) should be treated the same as anal canal cancer.
(B) behaves like squamous cancers of the skin.
(C) is more common than anal canal cancers.
(D) has a similar biology to melanomas.

Key: B
Rationale: Perianal squamous cell carcinomas arise within the hair-bearing skin or distal to the squamous mucocutaneous junction. They are thought to behave biologically as squamous cell cancers of the skin and are treated as such. They are not biologically similar to melanomas and are much rarer (3-5x) than anal canal cancers.
References: Wiefeldt et al. Clin Colon Rectal Surg 22(2):127-35, 2009. Leonard D et al. Clin Colon Rectal Surg 24(1):54-63, 2011.

64. When developing a plan to treat a free breathing lung lesion based on CT imaging, which of the following ICRU volumes is defined solely by oncological considerations?

(A) CTV
(B) ITV
(C) PRV
(D) PTV

Key: A
Rationale: Per ICRU Report # 50 and 62, the CTV consists of the gross macroscopic disease and tumor infiltration. In contrast to the remaining volumes listed, the delineation of the CTV is solely dependent on oncological consideration. When defining the ITV, PTV and PRV, an adequate safety margin for organ motion and irradiation technique must also be considered.
References: ICRU Report #50 and 62.

65. Which high grade DCIS subtype is MOST strongly associated with both local recurrence and progression to invasive carcinoma?

(A) Solid
(B) Comedo
(C) Papillary
(D) Cribriform

Key: B

Rationale: The architectural pattern of "comedo-type" necrosis and high grade DCIS are both strongly associated with local recurrence and progression to invasive carcinoma. The finding of microinvasive carcinoma associated with DCIS is a predisposing risk factor for recurrence and dissemination. DCIS that is extensive in distribution, is large in size, or involves the surgical resection margin is associated with a high likelihood for local recurrences. Wider surgical margins are associated with a decreased risk of local recurrence, but controversy exists as to the optimal margin size.

References: Allegra, C.J. et al. National Institutes of Health State-of-the-Science Conference Statement; Diagnosis and Management of DCIS. Sept. 22-24, 2009. JNCI 2010; 102(3), 161-169.

66. Wortmannin functions as a potent radiosensitizer by:

(A) inhibiting DNA double-strand break repair.
(B) inhibiting p53 function.
(C) activating the cellular necrosis pathway.
(D) synchronizing cells in radiosensitive phases of the cell cycle.

Key: A

Rationale: Wortmannin is an inhibitor of PI3K and PI3K-related kinases. It is known to inhibit DNA-PK, which in turn impairs the repair of DNA double stranded breaks by the process of non-homologous end-joining.

References: Workman P, Clarke PA, Raynaud FI, van Montfort RL. Drugging the PI3 kinome: from chemical tools to drugs in the clinic. Cancer Res 2010; 70: 2146-57.

67. Which of the following proteins or protein complexes are common to both the NHEJ and HR DNA double-strand break repair pathways?

(A) DNA-PK complex
(B) Rad51
(C) Rad52
(D) Mre11-Rad50-Nbs1 complex

Key: D
Rationale: The Mre11-Rad50-Nbs1 (MRN) complex is responsible for damage recognition and end resection in both pathways. The DNA-PK complex is involved in the NHEJ process while Rad51 facilitates strand exchange and Rad52 provides protection against exonucleolytic degradation during HR.
References: Chapter 2 in Joiner and van der Kogel, Basic Clinical Radiobiology, Fourth Edition, 2009.

68. What is the FIGO stage for a 4.5 cm adenocarinoma of the uterus that invades 6/10 mm of myometrium and the endocervical glands but not the cervical stroma?

(A) IA
(B) IB
(C) IIA
(D) IIB

Key: B
Rationale: The most recent AJCC manual no longer considers endocervical glandular involvement in the staging of endometrial cancer. In the previous edition, this would be considered stage IIA disease. Since the tumor invades more than ½ of the myometrium and does not extend to cervical stroma, it should be staged IB. The tumor size is not one of the criteria used to stage endometrial carcinoma.
References: AJCC, 6th edition; 2002. AJCC, 7th edition; 2009.

69. According to the ACOSOG Z0011 trial, the study's design showed that stage II breast cancer patients with positive sentinel nodes have:

(A) benefit of radiation therapy to axillary nodes.
(B) no benefit of radiation therapy to the supraclavicular nodes.
(C) benefit of chemotherapy in the setting of multiple positive sentinel nodes.
(D) no benefit of axillary node dissection for finding of 1 - 2 positive sentinel nodes.

Key: D
Rationale: The study concluded there was no significant clinical benefit of further axillary node dissection in patients with positive sentinel nodes. Median follow-up at time of analysis was 6.2 years. All patients received radiation therapy to intact breast and the vast majority of patients received chemotherapy.
References: Giuliano, A.E. et. al., Axillary Dissection Vs. No Axillary Dissection in Women With Invasive Breast Cancer and Sentinel Node Metastases – A Randomized Clinical Trial, JAMA 2011: 305 (6): 569-575.

70. For patients with craniopharyngioma, which structure is MOST LIKELY to be dose-limiting for radiosurgery treatment?

(A) Retina
(B) Brainstem
(C) Optic chiasm
(D) Mesial temporal lobe

Key: C
Rationale: Craniopharyngiomas most often present as cystic and solid masses in the suprasellar region and often about the optic structures including compression of the optic chiasm. The dose limit to the optic chiasm is 8-10 Gy in a single fraction.
References: Pediatric Radiation Oncology 5th edition, 2011.

71. Which of the following patient positioning verification methods uses non-ionizing radiation?

(A) Port films
(B) Conebeam CT
(C) Ultrasound guidance
(D) Stereoscopic x-rays

Key: C
Rationale: Only ultrasound does not use ionizing radiation out of the options given. All other choices use x-rays which are ionizing.

72. In the recently published CROSS study for esophageal cancer, patients were randomized to surgery alone versus neoadjuvant chemoradiation with:

(A) cisplatin and 5-FU.
(B) cisplatin and capecitabine.
(C) carboplatin and paclitaxel.
(D) carboplatin and cetuximab.

Key: C
Rationale: The CROSS study randomized 368 patients to receive either surgery alone or weekly carboplatin and paclitaxel for 5 weeks with concurrent radiotherapy. Preoperative chemoradiation was found to improve overall survival among potentially curable esophageal or GE junction cancers.
References: Van Hagen et al. NEJM 366(22): 2074-84, 2012.

73. Which method is used for detection of the oncogenic EML4-ALK translocation in patients with lung adenocarcinoma?

(A) DNA sequencing
(B) Polymerase chain reaction
(C) Fluorescent *in situ* hybridization
(D) Immunofluorescence microscopy

Key: C
Rationale: Fluorescent in-situ hybridization (FISH) is used clinically to identify a chromosomal translocation resulting in an aberrant fusion gene that encodes a constitutively active ALK. It took only 3 years from discovery of this alteration in lung cancers to the report of dramatic clinical responses upon treatment with the small molecule inhibitor crizotinib, leading to FDA approval in 2011. Whether these alterations predominate in stage IV disease remains to be determined. This is an important example of molecular profiling of cancers impacting therapy.
References: Shaw et al. J Clin Oncol 2011; 27:4247-4253.

74. The Phoenix Definition is used to monitor for post-radiation recurrence following external beam radiation therapy with or without androgen deprivation therapy. According to this definition, biochemical failure occurs when the PSA increases how many ng/ml above the PSA nadir?

(A) 1 ng/ml
(B) 2 ng/ml
(C) 3 ng/ml
(D) 4 ng/ml

Key :B
Rationale: The Phoenix Definition for biochemical failure is the nadir PSA + 2.

75. What technology is used to create an intensity modulated radiotherapy (IMRT) beam in helical tomotherapy?

(A) Compensators
(B) Spot scanning
(C) Assymetric jaws
(D) Binary multileaf collimators

Key: D
Rationale: Binary multileaf collimators are used in helical tomotherapy to modulate the intensity as the beam and the patient passes thru the plane of the beam. Compensators are used for static IMRT. Spot scanning is a technique used in proton therapy to deliver the dose to different region in the target. While tomotherapy utilizes asymmetric jaws, they are not responsible for the IMRT beam.
References: Mackie et al., Tomotherapy: a new concept for the delivery of dynamic conformal radiotherapy. Med Phys 20 (6) 1993.

76. Which of the following statements concerning post-irradiation gene expression profiling of tissues is true?

(A) There is minimal inter-individual variation in post-irradiation gene expression profiles.
(B) Post-irradiation gene expression profiles show a high degree of correlation with post-irradiation proteomic profiles.
(C) The patterns of gene expression post-irradiation remain relatively constant over time.
(D) The patterns of gene expression change over time and vary between individuals.

Key: D
Rationale: The overarching conclusion from ionizing radiation gene expression studies in human cells and tissues is that gene expression profiles show significant time dependence, dependence upon the tissue being analyzed, significant inter-individual variation, and minimal correlation to post-irradiation proteomic profiles.
References: Begg AC. Predicting response to radiotherapy: evolutions and revolutions. Int J Radiat Bio 2009; 85(10):825-836.

77. If a low-energy electron beam is matched to a photon beam at a patient's surface, which of the following dosimetric phenomenon is observed between the two fields?

(A) Cold spot at depth in electron beam
(B) Cold spot at the surface of the electron beam
(C) Hot spot at depth in the photon beam
(D) Hot spot at the surface at field junction

Key: C
Rationale: For field junction on a flat surface, the hot spot in always in photon beam side due to the out-scatter of the electrons. These areas overlap with the matched photon beam at depth, resulting in regions between the matched fields that have excessively high doses (hot spots). Avoiding hot spots at depth would require separating beams at the surface (i.e. using non-matching beams), leading to a cold spot at the surface.
References: F. Khan, "The Physics of Radiation Therapy," Fourth Edition, Lippincott Williams & Williams, Baltimore, MD, Copyright 2010.

78. The contamination at the end of the electron range in electron beam radiotherapy is due to what interaction?

(A) Alpha decay
(B) Beta decay
(C) Pair production
(D) Bremmstrahlung production

Key: D
Rationale: Photons produced by bremsstrahlung interactions either in the treatment head or in the patient create an unwanted photon dose at the end of the electron range. Only these photons have enough energy to contribute to dose at depths beyond the electron range. Alpha and beta decay are modes radioactive decay. Pair production is a high energy photon interaction.
References: Khan, The Physics of Radiation Therapy, Ch. 14 Electron beam therapy.1994.

79. Which of the following options BEST describes NCCN's recommendations for the primary management of non-metastatic urothelial carcinoma of the ureter?

(A) Definitive chemoradiotherapy

(B) Neoadjuvant radiotherapy followed by surgery

(C) Surgery, with consideration of neoadjuvant or adjuvant chemotherapy based on pre- and post-surgery findings

(D) Definitive radiotherapy, with consideration of adjuvant or neoadjuvant chemotherapy based on pre- and post-surgery findings

Key: C

Rationale: Whenever feasible, the primary management of non-metastatic urothelial carcinoma of the ureter should be surgery. The NCCN recommends that neoadjuvant chemotherapy may be considered in patients with pre-surgical evidence of tumor invasion, and adjuvant chemotherapy may be considered in patients with pT2, pT3, pT4, and pN+ tumors. The NCCN does not include radiotherapy in the algorithm for the management of ureter tumors. However, retrospective studies suggest that adjuvant radiotherapy may diminish the likelihood of local recurrence, but it does not appear to have an impact on overall survival or reducing future distant metastases.

References: NCCN Clinical Practice Guidelines in Oncology. Bladder Cancer v2. 2012. Pages UTT-2 and UTT-3. www.NCCN.org, accessed 7/16/2012. Cozad, S.C., et al., Transitional cell carcinoma of the renal pelvis or ureter: patterns of failure. Urology, 1995. 46(6): p. 796-800. Cozad, S.C., et al., Adjuvant radiotherapy in high stage transitional cell carcinoma of the renal pelvis and ureter. Int J Radiat Oncol Biol Phys., 1992. 24(4): p. 743-5.

80. According to the CLASSIC trial, which of the following therapies improved disease-free survival among patients with gastric cancer?

(A) Perioperative chemotherapy with epirubicin, cisplatin, and 5-FU

(B) Postoperative chemoradiation with 5-FU

(C) Preoperative chemotherapy with epirubicin, cisplatin, and 5-FU and adjuvant chemoradiation

(D) Postoperative capecitabine and oxaliplatin

Key: D

Rationale: The capecitabine and oxaliplatin adjuvant study in stomach cancer (CLASSIC) study was a phase III randomized trial performed in Asia. Patients with stage II-IIIB gastric cancer who had had curative D2 gastrectomy were randomly assigned to receive adjuvant chemotherapy of eight 3-week cycles of oral capecitabine (1000 mg/m^2 twice daily on days 1 to 14 of each cycle) plus intravenous oxaliplatin (130 mg/m^2 on day 1 of each cycle) for 6 months or surgery only. The 3-year disease-free survival was significantly improved among patients treated with chemotherapy compared to surgery (74% vs. 59%, $p<0.0001$). Adjuvant capecitabine plus oxaliplatin treatment after curative D2 gastrectomy should be considered as a treatment option for patients with operable gastric cancer.

References: Bang et al.

81. What is the MOST appropriate next step for a patient with a localized adenocarcinoma at 8 cm from the anal verge?

(A) Chemoradiation
(B) Abdominoperineal resection
(C) Low anterior resection
(D) Endorectal ultrasound or pelvic MRI

Key: D
Rationale: As this patient has not yet been staged adequately, it is not yet clear what the proper management will be. Assessment of the T and N stage can be performed via either endorectal ultrasound or MRI of the pelvis. For patients with T3/4 or N+ disease, pre-operative chemoradiation is recommended.

82. The randomized trial by EORTC and RTOG comparing standard PCI dose to higher-dose in patients with limited-stage SCLC showed the higher dose of PCI:

(A) improved CNS disease-free survival.
(B) reduced overall mortality rates.
(C) did not reduce brain metastases.
(D) increased the rate of CNS toxicity.

Key: C
Rationale: No significant reduction in the total incidence of brain metastases was observed after higher radiotherapy dose for PCI when compared with standard radiotherapy dose for PCI, but there was a significant increase in mortality. PCI at 25 Gy should remain the standard of care in limited-stage SCLC.
References: LePechoux C, Dunant A, Senan S, et al. Standard-dose versus higher-dose prophylactic cranial irradiation (PCI) in patients with limited-stage small-cell lung cancer in complete remission after chemotherapy and thoracic radiotherapy (PCI 99-01, EORTC 22003-08004, RTOG 0212, and IFCT 99-01): a randomized clinical trial. The Lancet 2009; 10(5):467-474.

83. Which of the following is the MOST accurate description of early-stage nodular lymphocyte predominant Hodgkin lymphoma in adults?

(A) It most commonly affects extranodal sites.
(B) It is CD20+ and Rituximab alone will achieve a high cure rate.
(C) Multi-agent chemotherapy is the treatment of choice.
(D) Involved-field radiotherapy is the treatment of choice.

Key: A, D
Rationale: Disease commonly presents in supradiaphragmatic sites and spares mediastinum. In most studies, radiotherapy (RT) as a single-modality therapy was used primarily in limited stage disease, whereas chemotherapy was reserved mostly for advanced stage disease; few patients were treated with chemotherapy alone.
References: GP, Mauch P: What is the appropriate systemic chemotherapy for lymphocyte-predominant Hodgkin's lymphoma? J Clin Oncol (2010) ; Regula DP Jr., Hoppe RT, Weiss LM. Nodular and diffuse types of lymphocyte predominance Hodgkin's disease. N Engl J Med1988;318:214-219; Sextro M, Diehl V, Franklin J, et al. Lymphocyte predominant Hodgkin's disease - a workshop report. European Task Force on Lymphoma.

84. What is the standard treatment for a stage IAE marginal zone lymphoma of the orbit?

(A) 30 Gy only
(B) R-CHOP x 6 only
(C) R-CHOP x 6 and 30 Gy
(D) R-CHOP x 3 and 40 Gy

Key: A
Rationale: 30 Gy involved field RT has a local control of > 90% and is the standard of care.

85. What accessory is used to lower the beam energy in total skin electron therapy?

(A) Bolus
(B) Wedge
(C) Lucite blocks
(D) Custom cerrobend cutout

Key: C
Rationale: Lucite blocks are used to decrease beam energy and improve beam flatness.
References: Khan, The Physics of Radiation Therapy, Ch. 14 Electron beam therapy. 1994.

86. When performing LDR brachytherapy for carcinoma of the cervix, the ABS recommends limiting the vaginal surface dose to what percent of the dose at Point A?

(A) <100%
(B) <150%
(C) >150%
(D) >200%

Key: B
Rationale: The ABS suggests limiting Vs dose to less than 150% of point A dose.
References: IJROBP Vol 52 No. 1, pp33-48, 2002.

87. Gantries for proton therapy accelerators are much larger than for electron linacs because:

(A) protons have a smaller charge then electrons.
(B) protons have a larger magnetic moment than electrons.
(C) protons are much more massive than electrons.
(D) protons interact more readily with residual gas in the beam line than electrons.

Key: C
Rationale: The magnitude of the deflecting force exerted on a charged particle traveling perpendicular to a magnetic field is qvB, where q is the charge, v is the speed and B is the strength of the magnetic field. These quantities are all roughly the same for protons and electrons in treatment machine gantries (except that the charge is the opposite sign). The mass of a proton however is 2000 times larger than an electron and therefore it follows a curved trajectory that is much larger. Options B and D are irrelevant.
References: P.N. McDermott and C.G. Orton, "The Physics and Technology of Radiation Therapy," Medical Physics Publishing, Madison, WI, Copyright 2010.

88. For patients with non-Hodgkin lymphoma, what report demonstrated an overall survival advantage of adding involved-field RT to chemotherapy compared to chemotherapy alone?

(A) ECOG (Horning et. al. JCO, 2004)
(B) GELA (Bonnett et. al. JCO, 2007)
(C) SWOG (Miller et. al. NEJM, 1998)
(D) EORTC (Aleman, NEJM 2003)

Key: C
Rationale: Only the initial report from the SWOG study showed an overall survival advantage for the addition of involved field RT to chemotherapy. The ECOG study demonstrated only a disease free survival advantage. The GELA study included patients older than 60 years with good IPI and showed no advantage to RT. EORTC 20884 referred to Hodgkin lymphoma.

89. There are several normal tissues that, in order to carry out their functions or in response to certain disease states, display one or more malignant phenotypes, yet are not considered cancer. Which of the following pairs of normal tissue type and malignant phenotype is correct?

(A) bone marrow : angiogenic
(B) placenta : limitless replicative potential
(C) endometriosis : metastatic
(D) psoriasis : apoptosis resistant

Key: C
Rationale: Endometriosis is a consequence of the abnormal growth of endometrial cells outside of the uterus. Akin to a metastatic process, these cells spread around the pelvis and seed structures called "endometriosis implants" that can continue to grow and spread further. Implants are most commonly found on the Fallopian tubes, outer surfaces of the uterus or intestines, and on the surface lining of the pelvic cavity. Normal bone marrow is not angiogenic *per se*, and only shows an increase in vascular density secondary to hematopoietic malignancies or myelodysplastic syndromes. Placental cells can be invasive, but are not characterized by replicative immortality. Psoriasis is a disorder of keratinocyte hyperproliferation in the epidermis, but not apoptosis-resistance.

90. The fraction of the original nuclide remaining after 5 half-lives is:

(A) 1/5.
(B) 1/10.
(C) 1/24.
(D) 1/32.

Key: D
Rationale: After 5 half-lives, the remaining amount of a radioactive nuclide is N*(1/2)^5 = N/32.
References: Khan FM, The physics of Radiotherapy, 3rd Edition, Chapter 2.

91. Which of the following are indications for whole-abdominal radiation for a favorable histology Wilms tumor?

(A) Malignant ascites
(B) Involvement of the renal hilum
(C) Involvement of regional lymph nodes
(D) Microscopic positive surgical margins

Key: A
Rationale: The "SPAR" pneumonic for indications for whole-abdominal radiation include: Spillage during surgery, Peritoneal seeding, Ascites and preoperative Rupture.

92. In which interaction does the number of neutrons increase?

(A) Alpha decay
(B) Compton effect
(C) Electron capture
(D) Photoelectric effect

Key: C
Rationale: Photoelectric effect and Compton scatter are atomic interactions that do not alter the nucleus. Alpha decay is a nuclear interaction where a helium nucleus is ejected from the nucleus. In electron capture, an orbital electron is captured by the nucleus and it combines with proton to from a neutron.
References: Attix, Introduction to Radiological Physics and Radiation Dosimetry, Ch. 5 Absorbed dose in radioactive material. Khan. The Physics of Radiation Therapy, Ch. 2 Nuclear Transformations, 1994.

93. A phase III randomized study of preoperative chemotherapy versus chemoradiation for locally advanced GE junction cancers (German Esophageal Cancer Group) demonstrated that:

(A) the chemoradiation arm had a pathologic complete response rate of 25%.
(B) the chemotherapy arm had a pathologic complete response rate of 10%.
(C) there was a trend towards improved overall survival with chemotherapy alone.
(D) there was no significant difference in postoperative mortality.

Key: D
Rationale: This study randomized patients to receive induction chemotherapy followed by surgery or induction chemotherapy, followed by chemoradiation, then surgery. Patients treated with chemoradiation had a higher pathologic complete response rate (15.6% vs. 2%) and a trend towards improved overall survival (3 year survival 28% vs. 47%, p=0.07). There was a non-significant increase in postoperative mortality (10% vs. 3.8%, p=0.26) among patients treated with chemoradiation.
References: Stahl et al. JCO 27(6): 851-6, 2009.

94. Which structures should be included in the initial pelvic radiation field of a male patient receiving radiation therapy for bladder preservation?

(A) Bladder, external iliac, internal iliac lymph nodes
(B) Bladder, prostate, external iliac, internal iliac lymph nodes
(C) Bladder, prostate, external, internal, and common iliac lymph nodes
(D) Bladder, prostate, external, internal, common iliac, and lower para-aortic lymph nodes

Key: B
Rationale: The initial pelvic radiation field should encompass the bladder, prostate (and the prostatic urethra), internal and external iliac lymph nodes.
References: Perez and Brady et al, Principles and Practice of Radiation Oncology, 5th Edition.

95. What study design allows for a double-blind analysis of patients with metastatic colorectal cancer treated with either a novel biologic therapy or placebo followed by treatment with the other agent?

(A) Cohort study
(B) Crossover study
(C) Case control study
(D) Randomized control study

Key: B

Rationale: A cross-over study is a paired study design in which treatments are switched between the groups half way through the study. Each group of subjects receives the same treatments but in a different sequence. A case control study is an observational study that begins with patients who have the outcome or disease being investigated and control subjects who do not have the outcome or disease. It then looks backward to identify possible precursors or risk factors. A cohort study is an observational study, which follows a group of people (with similar characteristics) and analyzes risk factors to determine any correlations. These studies can be performed retrospectively, prospectively and/or in a randomized fashion. A randomized controlled study randomly assigns a patient pool to an intervention, or to a nonintervention (or alternative intervention).

96. What isotope is commonly utilized to treat pterygium?

(A) ^{90}Sr
(B) ^{89}Sr
(C) ^{32}P
(D) ^{192}Ir

Key: A

Rationale: 90Sr is commonly utilized to treat pterygium with contact therapy. This beta emitter should be distinguished from 89Sr, which is utilized as an intravenous radiopharmaceutical for bone metastases.

97. What is the TNM clinical stage of a squamous cell carcinoma of the proximal female urethra invading the bladder neck and with a 3 cm obturator lymph node?

(A) T3N1
(B) T3N2
(C) T4N1
(D) T4N2

Key: B

Rationale: A T3 lesion extends to involve the bladder neck or vagina. Since the LN is > 2 cm it is a N2. The size and number of nodes is important in nodal staging.

References: AJCC Staging Manual 2010.

98. Which of the following regulatory bodies oversees the medical use of byproduct materials (e.g., brachytherapy sources) in an agreement state?

(A) American Brachytherapy Society (ABS)
(B) Nuclear Regulatory Commission (NRC)
(C) U.S. Food and Drug Administration (FDA)
(D) Individual state agencies (e.g. department of human health)

Key: D
Rationale: According to the NRC, an agreement state is a state that has signed an agreement with the NRC authorizing the state to regulate certain uses of radioactive materials within the state. In an agreement state, a specific state agency such as the department of human health or the radiation regulatory agency is responsible for regulating and overseeing the medical use of byproduct materials. In a non-agreement state, this responsibility is under the purview of the NRC.
References: http://www.nrc.gov/reading-rm/basic-ref/glossary/agreement-state.html.

99. Compared to normal vasculature, tumor vasculature is:

(A) porous and leaky.
(B) less tortuous.
(C) spaced at regular intervals.
(D) resistant to ionizing radiation.

Key: A
Rationale: Tumor vasculature has many unique characteristics when compared to normal vasculature, including, among others, large pores and poorly organized, leaky structures. It is also more tortuous and spaced irregularly through the tumor.
References: Jain RK. Normalization of tumor vasculature: an emerging concept in antiangiogenic therapy. Science 2005; 307:58-62.

100. What is the estimated risk of fracture at 5 years for a vulvar cancer patient if the femoral neck received 50 Gy when treating the inguinal nodes?

(A) 5%
(B) 10%
(C) 20%
(D) 25%

Key: A**,** B
Rationale: 50 Gy to the femoral neck is associated with an 11% risk of fracture at 5 years.
References: Grisby et al., Med Dos 2004.

101. Which of the following trials of concurrent chemoradiation and brachytherapy permitted the use of a High-Dose Rate (HDR) in the treatment of cervical cancer?

(A) NCIC
(B) GOG 120
(C) GOG 123
(D) RTOG 90-01

Key: A
Rationale: NCIC: WP 45 Gy + LDR 35 Gy x 1 or HDR 8 Gy x 3; weekly cisplatin during external beam.
References: JCO 2002; 20; 966-972 JCO 2004;22:872-880 JCO 2007 25 2804-2810 NEJM 1999; 340: 1137-1161.

102. Which of the following statements is CORRECT concerning the management of retroperitoneal sarcomas?

(A) Post-operative irradiation is preferred to pre-operative irradiation.
(B) A pre-radiation differential renal scan is beneficial to confirm total renal function.
(C) Tumor extension into the peritoneal cavity will increase risk for local recurrence.
(D) Post-operative radiation field design will include residual tumor plus a planning volume.

Key: B
Rationale: Radiation for retroperitoneal sarcomas will commonly include at least one kidney that will be treated beyond renal tolerance. A differential renal scan will confirm activity of both kidneys and assure the treated kidney is not a dominant organ. Tumor extension into the peritoneal cavity does not increase the risk for local recurrence. It is extension into the soft tissues of the retroperitonium that creates the risk for local recurrence. Pre-operative irradiation is preferred because there is less risk of late effects when compared with post-operative irradiation. Post-operative field design should include the preoperative tumor volume with appropriate compartment delineation as well.
References: Chao, K.S. Clifford, et al. Radiation Oncology Management Decisions. 3rd edition. Lippincott, Williams and Wilkins. 2011. Pages 703-718.

103. In the recently published CROSS study for esophageal cancer, the pathologic complete response rate among patients treated with preoperative therapy is:

(A) 8%.
(B) 15%.
(C) 29%.
(D) 40%.

Key: C
Rationale: Among patients randomized to receive preoperative chemoradiation, a pathologic complete response was achieved in 29% (47 of 161) who underwent resection.
References: Van Hagen et al. NEJM 366(22): 2074-84, 2012.

104. According to the Early Breast Cancer Trialist Cooperative Group, radiation therapy after mastectomy in the setting of node positive disease reduces the risk of local recurrence by:

(A) 30%.
(B) 50%.
(C) 70%.
(D) 90%.

Key: C
Rationale: 70%
References: Disease of the Breast, Jay Harris, et al., 4th edition. Lippincott, Williams and Wilkins, pp. 600-601. 2010.

105. What would be the cure rate for patients with stage III NSCLC treated with either surgery or radiation therapy alone?

(A)
(B) 20%
(C) 30%
(D) 50%

Key: A
Rationale: About 150,000 new cases of NSCLC are diagnosed every year in the United States. At least 40% will present with Stage III NSCLC. Surgical resection or radiotherapy alone will result in cure in less than 10% of patients (Mountain CF. Revisions in the international staging system for staging lung cancer. Chest 111:1710-1717, 1997).

106. For the treatment of prostate carcinoma with low-dose rate brachytherapy, the American Brachytherapy Society recommends slightly different prescription doses depending on whether I-125 sources or Pd-103 sources are used. The reason for a slightly higher recommended prescription dose for I-125 sources is the fact that I-125 has a:

(A) longer half-life.
(B) smaller seed size.
(C) lower anisotropy constant.
(D) larger average photon energy.

Key: A
Rationale: A longer half-life Dose is delivered over a longer period of time for a source with a longer half-life, necessitating a higher total dose.
References: Perez and Brady's Principles and Practice of Radiation Oncology, 5th Edition, Lippincott Williams & Wilkins, Copyright 2008.

107. A patient with stage IIA pure seminoma is treated with radiation therapy. Where is the inferior edge of the AP/PA fields placed?

(A) Bottom of L5
(B) Bottom of the SI joints
(C) Top of the acetabulum
(D) 2–3 cm below the ischial tuberosity

Key: C
Rationale: Para-aortic and ipsilateral pelvic radiation is recommended for stage IIA pure seminoma. The inferior border should be placed at the top of the acetabulum.

108. What is the MOST appropriate hormone ablation therapy duration to be given with external beam radiation therapy for a 58-year-old patient in good health with stage T3b, Gleason 9 (4+5), PSA 25.0 prostate cancer?

(A) None
(B) 6 months
(C) 12 months
(D) 28 months

Key: D
Rationale: RTOG 92-02 showed superior outcomes for patients with high-risk prostate cancer with long-term hormone ablation therapy (28 months).
References: Horwitz, et al, JCO 2008, 26: 2497.

109. A therapeutic neutron beam deposits doses most efficiently in which of the following materials?

(A) Fat
(B) Bone
(C) Lung
(D) Muscle

Key: A
Rationale: Neutron beams transfer energy most efficiently in collisions with particles of similar mass (protons), and will therefore deposit dose most efficiently in hydrogen-rich materials. Fat is among the most hydrogen-rich tissues. Neutron doses in fat can be 20% higher than in muscle. Bone is among the least hydrogen-rich tissues in the body, so neutron beams are often described as “bone-sparing”.
References: F. Khan, “The Physics of Radiation Therapy,” Fourth Edition, Lippincott Williams & Williams, Baltimore, MD, Copyright 2010.

110. What is the MOST appropriate treatment for a patient who is diagnosed with pT1bN0M0 Grade 2 squamous cell carcinoma on the prepuce of the penis with lymphovascular space invasion present?

(A) Wide local excision only
(B) Total penectomy only
(C) Wide local excision and inguinal lymph node dissection
(D) Total penectomy, inguinal lymph node dissection, and adjuvant chemoradiation

Key: C
Rationale: Given the tumor's lymphovascular space invasion, NCCN guidelines recommend an inguinal lymph node dissection. Total penectomy and adjuvant chemoradiation are not recommended in this setting.

111. Images produced with megavoltage (MV) x-rays show lower contrast between bone and soft tissue than kilovoltage (kV) x-ray images because:

(A) MV x-rays are more penetrating.
(B) the physical penumbra is smaller for MV x-rays.
(C) MV photons scatter through smaller angles.
(D) Compton scattering dominates at MV energies.

Key: D
Rationale: One of the primary reasons for poor contrast in MV x-ray images is due to the fact that Compton scattering is the dominant interaction in tissue at these energies. Compton scattering is almost independent of atomic number for all elements except hydrogen. It is true that MV x-rays are more penetrating but it is differential penetration that is crucial for contrast. The penumbra is generally larger for MV x-rays. MV x-rays do tend to scatter through smaller angles than kV x-rays but they cannot be eliminated.
References: P.N. McDermott and C.G. Orton, "The Physics and Technology of Radiation Therapy," Medical Physics Publishing, Madison, WI, Copyright 2010.

112. Which of the following is TRUE regarding a logrank test?

(A) It cannot account for censored data.
(B) It requires that all enrolled subjects have follow-up data.
(C) It tests the null hypothesis that the survival curves are the same for both groups.
(D) It is designed to test that the survival rate at a time point is the same for both groups.

Key: C
Rationale: The correct answer is C since a logrank test is designed to compare survival curves. Because that comparison involves the entire curve, the test does not address hypotheses about specific time points.

113. Which of the following is a contraindication for larynx-preservation with chemoradiation?

(A) Paraglottic space invasion
(B) Invasion through the thyroid cartilage
(C) Involvement of vallecula
(D) Impaired vocal cord mobility

Key: B
Rationale: Refer to the Intergroup trial eligibility. Forastiere AA et al. N Engl J Med. 2003 Nov 27; 349(22):2091-8.

114. Which of the following is correct regarding Masaoka staging for thymomas?

(A) Stage I: Microscopic capsular involvement
(B) Stage IIA: Invasion into surrounding fat or invasion into mediastinal pleura
(C) Stage III: Extension to surrounding organs or great vessels
(D) Stage IVA: Lymph node involvement

Key: C
Rationale: Stage I is encapsulated tumors without microscopic capsular invasion. Stage IIA is microscopic capsular involvement. Invasion into surrounding fat is stage IIB. Stage IVA is pleural or pericardial involvement, but any lymph node involvement (including distant metastasis) is considered stage IVB.

115. Which of the following is TRUE about phase II cancer trials?

(A) They should be non-randomized.
(B) They should include a control group.
(C) They are expected to provide definitive results about a treatment.
(D) They should be conducted after the maximum tolerated dose is determined.

Key: D
Rationale: The correct answer is D since phase II studies are designed to follow dose ranging phase I studies that determine the maximum tolerated dose.

116. The dose response curve shape for exchange-type chromosome aberrations following acute doses of low LET radiation is linear-quadratic. Lowering the dose rate will:

(A) have no effect on the linear (αD) or quadratic (βD^2) components.
(B) have no effect on the linear (αD) component, but decrease the quadratic (βD^2) component.
(C) decrease the linear (αD) component, but have no effect on the quadratic (βD^2) component.
(D) decrease both the linear (αD) and quadratic (βD^2) components.

Key: B

Rationale: A chromosome exchange results when a cells misrepairs two or more chromosome breaks that are spatially and temporally proximate by joining the break ends to inappropriate partners. Two biophysical processes can produce these conditions, the first where both breaks are produced by the same energy absorption event (single track, linear kinetics, "α") and the second where each break is produced by a separate and independent electron track (multi-track, curvilinear kinetics, "β"). Reducing the dose rate spaces out in time the formation of these tracks allowing the cell to restitute a chromosome break before a second spatially proximate break can be formed. By lowering the dose rate the production of single track exchanges (α) is unaffected while the production of multi-track exchanges (β) is curtailed.

117. What is the MOST appropriate radiation therapy dose for WHO grade II classical oligodendroglioma?

(A) 50.4 Gy in 28 fractions
(B) 57.6 Gy in 31 fractions
(C) 59.4 Gy in 33 fractions
(D) 63 Gy in 35 fractions

Key: A

Rationale: Karim AB, Maat B, Hatlevoll R, Menten J, Rutten EH, Thomas DG, Mascarenhas F, Horiot JC, Parvinen LM, van Reijn M, Jager JJ, Fabrini MG, van Alphen AM, Hamers HP, Gaspar L, Noordman E, Pierart M, van Glabbeke M. A randomized trial on dose-response in radiation therapy of low-grade cerebral glioma: European Organization for Research and Treatment of Cancer (EORTC) Study 22844. Int J Radiat Oncol Biol Phys. 1996 Oct 1; 36(3):549-56.

Shaw E, Arusell R, Scheithauer B, O'Fallon J, O'Neill B, Dinapoli R, Nelson D, Earle J, Jones C, Cascino T, Nichols D, Ivnik R, Hellman R, Curran W, Abrams R. Prospective randomized trial of low- versus high-dose radiation therapy in adults with supratentorial low-grade glioma: initial report of a North Central Cancer Treatment Group/Radiation Therapy Oncology Group/Eastern Cooperative Oncology Group study.J Clin Oncol. 2002 May 1; 20(9):2267-76.

118. Which of the following is TRUE regarding the INT 0139, a trial comparing neoadjuvant chemoradiation and surgical resection to definitive chemoradiation for locally advanced NSCLC?

(A) The majority of the treatment-related deaths occurred in patients undergoing pneumonectomy.

(B) The majority of the treatment-related deaths in both groups occurred during chemoradiation.

(C) Both the lobectomy and pneumonectomy after the chemoradiation provided identical overall survival.

(D) Chemotherapy for both groups consisted of carboplatin and taxol.

Key: A

Rationale: In this pivotal trial, only patients with stage IIIA (N2) NSCLC were eligible. Progression-free survival was superior for neoadjuvant chemoradiotherapy (median 12.8 vs. 10.5 mo, p=0.017), though overall survival was not. In an unplanned analysis, overall survival was improved for neoadjuvant chemoradiotherapy for patients who underwent lobectomy but not pneumonectomy. High rates of treatment related deaths occurred in patients undergoing pneumonectomy.

References: Albain et al, Lancet 2009.

119. Which of the following is NOT an adverse prognostic factor for patients with SCLC?

(A) Continuation of smoking

(B) Lower performance score

(C) Elevated alkaline phosphatase level

(D) Female gender

Key: D

Rationale: Patient factors influencing outcome are performance status and sex". "Continuation of smoking will adversely affect the outcome". "Other prognostic factors are elevated lactic dehydrogenase and alkaline phosphatase".

References: Perez and Brady's Principles and Practice of Radiation Oncology Fifth Edition, 2009 Wolters Kluwer/ Lippincott Williams & Wilkins; page 1100.

120. What is the recommended dose in Gy for an 8-year-old boy with testicular relapse of acute lymphoblastic lymphoma (ALL)?

(A) 12

(B) 24

(C) 36

(D) 45

Key: B

Rationale: 24 Gy is the preferred dose.

121. A 55-year-old male with long standing history of metastatic renal cell carcinoma presents with chest pain and is found to have a 3 cm rib-based metastasis involving the posteriolateral 6th right rib evidenced on CT and bone scan. His pain is an 8/10 on the Wong-Baker FACES pain rating scale. Which of the following is MOST LIKELY to offer effective, timely pain relief?

(A) 18 Gy in 3 fractions (BED = 33, α / β of 7) with SBRT
(B) 24 Gy in 3 fractions (BED = 51, α / β of 7) with SBRT
(C) 30 Gy in 5 fractions (BED = 56, α / β of 7) with SBRT
(D) 40 Gy in 5 fractions (BED = 86, α / β of 7) with SBRT

Key: D
Rationale: The data suggest a dose-response with regards to time to symptom resolution, with a benefit seen at a BED of >85 Gy (assuming an α / β of 7). The only option with a BED > 85 is D.
References: Jhaveri PM, Teh BS, Paulino AC, Blanco AI, Lo SS, Butler EB, Amato RJ. A dose-response relationship for time to bone pain resolution after stereotactic body radiotherapy (SBRT) for renal cell carcinoma (RCC) bony metastases. Acta Oncol. 2012 May; 51(5):584-8. Epub 2012 Jan 17.

122. Regarding extrahepatic cholangiocarcinoma,:

(A) papillary subtype carries the worst prognosis.
(B) Klatskin tumors arise near the Ampulla of Vater.
(C) primary sclerosing cholangitis is a risk factor.
(D) gemcitabine alone is the optimal chemotherapy.

Key: C
Rationale: In the randomized ABC trial, gemcitabine/cisplatin was shown to have superior survival over gemcitabine alone. The papillary subtype carries the best prognosis. Klatskin tumors arise at the bifurcation of the right and left hepatic ducts. PSC carries a 10-15% risk of developing cholangiocarcinomas.
References: Valle et al., N Engl J Med. 2010 Apr 8; 362(14):1273-81. Jarnagin Ann Surg. 2005 May; 241(5):703-12. Bergquist et al, J Hepatol. 2002 Mar; 36(3):321-7.

123. A woman with a history of a TAH has a FIGO stage II squamous cell carcinoma involving the upper vagina. She has a complete response on clinical exam and vaginal ultrasound after 45 Gy of pelvic radiation. Which is the MOST appropriate next treatment option?

(A) No further therapy
(B) Vaginal cylinder brachytherapy
(C) Interstitial brachytherapy
(D) Boost field with IMRT

Key: B, D
Rationale: Although the patient has had an excellent response to external radiation, 45Gy is not an adequate dose to control a Stage II vaginal cancer. Although external beam radiation could be used to treat the microscopic residual disease, this technique would lead to substantially more dose to the bladder and rectum compared with brachytherapy. Since any residual disease is <0.5cm, the optimal treatment is brachytherapy using a vaginal cylinder.
References: Gay H et al. Vaginal Cancer in Radiation Oncology: An Evidence-Based Approach. Springer 2009.

124. Which of the following conditions is NOT associated with Wilms tumor?

(A) WAGR syndrome
(B) Denys-Drash syndrome
(C) Beckwith-Wiedemann syndrome
(D) von Hippel-Lindau syndrome

Key: D
Rationale: Halperin E, Constine L, Tarbell N, Kun L. (eds). Pediatric Radiation Oncology. 4th edition. 2004; Lippincott, Williams & Wilkins.

125. Platinum chemotherapeutics function by:

(A) crosslinking DNA strands.
(B) intercalating between DNA bases.
(C) disrupting microtubule function.
(D) inhibiting thymidylate synthase.

Key: A
Rationale: Platinum chemotherapeutics (including cisplatin, carboplatin and oxaliplatin) are among the most commonly used classes of cancer drugs clinically. The platinum compounds function by crossing linking DNA through covalent bonds between Pt complexes and the DNA bases, with preference for guanine residues.
References: Chapter 27 in Hall and Giaccia, Radiobiology for the Radiologist, Seventh Edition, 2012.

126. Which of the following is TRUE of pancreatic cancer?

(A) Most arise in the body/tail.
(B) It is associated with BRCA1.
(C) CEA is the most useful serum tumor marker.
(D) It is the tenth most common cancer diagnosed in the United States.

Key: D
Rationale: The 2011 cancer statistics show that pancreas cancer is the 10 most common cancer diagnosed and 4th deadliest cancer in the United States. Most pancreatic cancers arise in the pancreatic head. CA 19-9 is the most useful tumor marker of diagnosis and surveillance.
References: Siegel et al., CA Cancer J Clin. 2012 Jan-Feb; 62(1):10-29. Lillis-Hearne et al., Cancer of the Pancreas. In: Hoppe RT, Roach M, Phillips T, eds. Textbook of Radiation Oncology, 3rd edition, Elsevier, Philadelphia, PA; 2010: 801-819.

127. Which of the following medulloblastoma subtypes confers the most favorable outcome in non-infant patients with this disease?

(A) WNT group, CTNNB1 mutation
(B) SHH group, PTCH1/SMO/SUFU mutation, GLI2 amplification, or MYCN amplification
(C) Group 3, MYC amplification, photoreceptor/GABAergic gene expression
(D) Group 4, gene expression of neuronal/glutamatergic, CDK6 amplification, MYCN amplification

Key: A
Rationale: Transcriptional profiling show the existence of four main subgroups (Wnt, Shh, Group 3, and Group 4). • Very good prognosis: WNT group, CTNNB1 mutation • Infants good prognosis, others intermediate: SHH group, PTCH1/SMO/SUFU mutation, GLI2 amplification, or MYCN amplification • Poor prognosis: Group 3, MYC amplification, photoreceptor/ GABAergic gene expression • Intermediate prognois: Group 4, gene expression of neuronal/ glutamatergic, CDK6 amplification, MYCN amplification.
References: Acta Neuropathol. 2012 April; 123(4):473-484.

128. As opposed to forward based 3D treatment planning, which of the following is typically needed for an inverse treatment plan?

(A) OAR dose limits
(B) Delineation of a ring structure
(C) Delineation of target and OARs
(D) Selection of incident beam angle

Key: B
Rationale: Inverse plans rely heavily on the user defined cost functions and dose objectives; as such they tend to ignore regions that are not specifically defined in the objectives. As a result, high-dose regions are typically found immediately outside of the defined target. One technique implemented to avoid this issue is to create a ring structure around the target and define the dose constraints for this structure in the objectives. The remaining options must be defined for both forward and inverse based plans.
References: Van Dyk, J. The Modern Technology of Radiation Oncology, Volume 2, Medical Physics Publishing, Copyright 2005.

129. After completion of chemoradiation for anal canal cancer:

(A) an assessment at 4 weeks by MRI is performed.
(B) biopsies are performed even in clinical complete responses to rule out occult disease.
(C) persistent disease at 4 weeks is followed to document regression.
(D) for progressive local disease, chemotherapy is preferred over salvage surgery.

Key: C
Rationale: Typically post-treatment monitoring would begin at 8-12 weeks of therapy by clinical exam (DRE, anoscopy and clinical nodal evaluation). Imaging at 4 weeks would likely be misleading and wouldn't be considered. A clinical complete response wouldn't be biopsied – it would continue to be followed (NCCN guidelines). The regression can indeed take quite some time with some studies showing continued regression >20 weeks after completion of chemoradiation. Most would agree that in the setting of histological documented local progression that a local therapy (such as APR) would be preferred over systemic therapy.
References: NCCN Guidelines.

130. What is the biological effective dose (BED) when 48 Gy of SBRT is given in 3 fractions for stage I NSCLC?

(A) 72 Gy
(B) 84 Gy
(C) 100 Gy
(D) 132 Gy

Key: D

Rationale: The linear quadratic (LQ) equation has been the generally accepted method for comparing different RT fractionation schemes. Use of this equation yields a biologically effective dose (BED) for a given schedule against which the potency another can be compared. BED=nd(1+d/αβ radio) where dose, d, represents individual fraction size in Gy, n the number of individual doses of radiation, and α and β are intrinsic properties of the tumor cells. For comparison purposes, an α/β ratio of 10 is assumed for tumor killing effects and was used for calculations by the RTOG trials. 60 Gy in 30 fractions would have BED of 74 Gy, 70 Gy in 35 fractions equal BED of 84 Gy. 48 Gy in 3 fractions would equal BED of 132 Gy.

131. Ewing's sarcoma predominantly occurs in:

(A) African American males and arises within the diaphysis of long bones.
(B) Caucasian males and arises within the diaphysis of long bones.
(C) African American males and arises within the metaphysis of long bones.
(D) Caucasian males and arises within the metaphysis of long bones.

Key: B

Rationale: Other characteristics for Ewing's sarcoma include a greater percentage of cases presenting in the axial skeleton, the t11;22 translocation. Osteosarcomas occur in greater frequency in African American males, at the growth plate of long bones.

132. How would a stage IIB classical nodular sclerosing Hodgkin lymphoma in a 30-year-old female with a 14 cm mediastinal mass be characterized?

(A) Early stage favorable
(B) Early stage unfavorable
(C) Advanced stage favorable
(D) Advanced stage unfavorable

Key: B

Rationale: Stage I and II are early stage, while stage III and IV belong to advanced stage groups. Patients with bulky disease, especially when coupled with "B" symptoms are known to have less favorable outcome and stage IIB bulky patients do belong to" advanced early stage" group.

133. What is the recommended management of the axilla in inflammatory breast cancer?

(A) Excisional biopsy
(B) Level I/II dissection
(C) Axillary boost radiation
(D) Sentinel lymphadenectomy

Key: B
Rationale: A level I/II dissection remains standard of care for inflammatory breast cancer. National Comprehensive Cancer Center guidelines recommend level I/II dissection and radiation to the chest wall and supraclavicular nodes. Sentinel node biopsy is not recommended in inflammatory breast cancer cancer (National Comprehensive Cancer Center Guidelines for Breast Cancer and Stearns et al. Sentinel lymphadenectomy after neoadjuvant chemotherapy for breast cancer may reliably represent the axilla except for inflammatory breast cancer.
References: Annals of Surgical Oncology, 9(3):235-242; 2002.)

134. What is the most common radiation dose for Graves ophthalmopathy?

(A) 10 Gy
(B) 20 Gy
(C) 30 Gy
(D) 40 Gy

Key: B
Rationale: Although utilized for many years, there is considerable debate regarding the timing of orbital RT in the management of Graves opthalmopathy. The most common regimen is 20 Gy in 10 fractions but lower doses may be efficacious.
References: Int. J. Radiation Oncology Biol. Phys., Vol. 82, No. 1, pp. 117–123, 2012.

135. Which of the following is a characteristic of homologous recombination repair (HRR)? HRR:

(A) occurs predominantly in the S and G2 phases of the cell cycle.
(B) is an error-prone process.
(C) does not require physical contact with an undamaged chromosome or chromatid.
(D) signaling pathways include ATM as an effector protein.

Key: A
Rationale: HRR occurs predominantly in the S and G2 phases of the cell cycle. HRR is a high-fidelity process that requires physical contact with an undamaged chromosome or chromatid. ATM is a sensor protein in the HRR signaling pathway.

136. Which of the following factors correctly matches the hereditary and sporadic characteristics associated with patients who have retinoblastoma?

	Hereditary	Sporadic
(A) Age at occurrence	Older	Younger
(B) Risk of secondary malignancies	Lower	Higher
(C) Bilateral disease	Less common	More common
(D) Incidence	Lower	Higher

Key: D

137. What tumor is MOST LIKELY to change size during radiation therapy?

(A) Meningioma
(B) Oligodendroglioma
(C) Craniopharyngioma
(D) Brain metastasis from breast cancer

Key: C
Rationale: Craniopharyngiomas associated cysts can increase in size during radiation therapy. The other tumors listed are less likely to shrink or grow during fractionated treatment.
References: Pediatric Radiation Oncology 5th edition, 2011.

138. What is the Ann Arbor stage of Hodgkin disease limited to the right supraclavicular and right cervical regions?

(A) IA
(B) IIA
(C) IIIA
(D) IVA

Key: A
Rationale: The supraclavicular and cervical anatomic regions are considered a single region in the Ann Arbor staging system.

139. According to the Common Terminology Criteria for Adverse Events (CTCAE) Version 4.0, a Grade 3 radiation dermatitis consists of:

(A) moist desquamation in skin folds.
(B) moist desquamation with bleeding induced by minor trauma.
(C) brisk erythema with extensive dry desquamation.
(D) skin necrosis.

Key: B
Rationale: Residents need to be familiar with CTCAE v4 and the characterization and scoring of typical adverse effects caused by radiation. CTCAE is increasingly replacing the more classical radiation injury scoring systems, such as RTOG, LENT and SOMA.

140. Which of the following accurately describes a patient with FIGO stage III vaginal cancer?

(A) Mass in the lower vagina extending to the clitoris
(B) Mass in the upper vagina extending to the exocervix, paravaginal tissues, and pelvic sidewall
(C) Mass in the mid vagina involving the paravaginal tissues that are fixed to the left pelvic sidewall
(D) Mass in the mid vagina involving the paravaginal tissues without extension to the pelvic sidewall

Key: C
Rationale: Vaginal cancers that extend to the pelvic sidewall are considered stage III disease. If the cancer is confined to the vagina and para-vaginal tissues then it is stage II. Vaginal tumors that involve the cervix or vulva are staged as arising from those structures, not as vaginal cancer.
References: RAJCC, 7th edition; 2009.

141. What is the T stage of a squamous cell carcinoma of the penile urethra involving the corpus spongiosum?

(A) T1
(B) T2
(C) T3
(D) T4

Key: B
References: AJCC Staging (7th Edition, 2009).

142. In a photon-producing linear accelerator, replacing a higher-Z target with a lower-Z target results in which of the following?

(A) Increased photon production and higher average beam energy
(B) Increased photon production and lower average beam energy
(C) Reduced photon production and higher average beam energy
(D) Reduced photon production and lower average beam energy

Key: D
Rationale: X-rays are produced through a process called bremsstrahlung, which is more efficient for higher-Z materials. High-Z materials are also efficient at filtering out low-energy photons from the beam, leading to higher beam average beam energies. Therefore, replacing a high-Z target (typically tungsten, Z=74) with a lower-Z target (e.g. copper, Z=29) will result in less-efficient photon production and lower average beam energy.
References: F. Khan, "The Physics of Radiation Therapy," Fourth Edition, Lippincott Williams & Williams, Baltimore, MD, Copyright 2010.

143. What test should be used when comparing the grading of dermatitis between two groups in a randomized trial comparing the effects of a novel skin cream on radiation dermatitis?

(A) Cox regression analysis
(B) Wilcoxon rank sum analysis
(C) Analysis of Covariance (ANCOVA)
(D) Chi-square goodness of fit test

Key: B
Rationale: The Wilcoxon rank sum test is used to compare 2 groups in independent samples, ordering observations from low to high, and then assigning a rank to each observation. The Cox regression analysis is a multivariate survival method of assessing several predictor variables on a categorical outcome when the outcome is censored. Chi-square goodness of fit tests a null hypothesis that the frequency distribution of certain events observed in a sample is consistent with a particular theoretical distribution.

144. Active multiple myeloma is BEST imaged by a:

(A) PET scan.
(B) bone scan.
(C) gallium scan.
(D) lymphangiogram.

Key: A
Rationale: Recognize that PET scan has a role in evaluating MM. PET scan is superior to these other imaging studies in active MM.
References: NCCN MM Guidelines MS-3.

145. Which of the following is TRUE regarding the use of radiotherapy for a squamous cell carcinoma of the upper lip?

(A) Involvement of the commissure is a relative contraindication.
(B) The submental nodes would not be at risk.
(C) Brachytherapy is typically combined with external beam for early lesions.
(D) A lead shield should be placed behind the lip when electron beam is used.

Key: D

Rationale: Lymphatic vessels from both the upper and lower lip primarily drain to the submandibular and submental nodes which in turn drain to the deep cervical chain [1]. On occasion, the upper lip may also drain to the preauricular and infraparotid nodes. While the majority of early lesions of the lip can be treated with a simple, surgical excision, it is generally thought that involvement of the commissure yield poorer cosmesis with surgery should be treated with radiotherapy [2,3]. Brachytherapy alone yields excellent local control results in the range of 85-90% for T1 and T2 lesions [4,5]. For T3 and T4 lesions, it is necessary to treat the draining lymph nodes [6,7]. This can be done with lateral fields encompassing the primary and nodes with the primary lesion being boosted either with brachytherapy or with an enface electron or othovoltage beam with appropriate shielding.

References: Renner GJ, Zitsch RP. Cancer of the lip. In: Cancer of the Head and Neck, 3rd Ed., Eds. Myers EN, Suen JY. WB Saunders, Philadelphia, 1996, pp.294-320.
Harrison LB: Applications of brachytherapy in head and neck cancer. Semin Surg Oncol 13: 177-184, 1997.
Sranc MF, Fogel M, Dische S. Comparison of lip function: Surgery vs. radiotherapy. Br J Plat Surg 40: 598-604, 1987.
Oreccia R, Rampino M, Gribudo S, et al. Interstitial brachytherapy for carcinomas of the lower lip. Results of treatment. Tumori 77: 336-338, 1991.

146. The entire course of external beam and brachytherapy for cervical cancer should be completed within:

(A) 8 weeks.
(B) 9 weeks.
(C) 10 weeks.
(D) 11 weeks.

Key: A

Rationale: Several retrospective analyses have suggested an adverse effect of prolonged duration on outcome overall. Extension of treatment time beyond 6-8 weeks can result in 0.5% to 1% decrease in pelvic control and cause specific survival for each day of extended treatment time. Although no prospective randomized trials have been done, it is generally accepted that the entire course should be completed within 8 weeks. Delays and splits should be avoided when possible.

References: IJROBP 1995 32: 1275-1288IJROBP 1995 32:1301-1307 IJROBP 1993 27:1051-1056 IJROBP 1993 25: 391-397 Radiother Oncol 1992 25:273-279.

147. Progressive multifocal leukoencephalopathy is MOST often associated with the use of:
(A) ABVD.
(B) CHOP.
(C) Rituximab.
(D) Cetuximab.
Key: C
Rationale: Rituximab carries potentially serious side-effects. Rituximab, an anti CD20 monoclonal antibody, is associated with PML, a fatal infection by the JC virus.
References: NCCN NHL Guidelines MS-14.

148. According to the SHARP trial, what is the response rate to sorafanib among patients treated with hepatocellular carcinoma?

(A) 2%
(B) 5%
(C) 12%
(D) 20%
Key: A
Rationale: In this multicenter, phase 3, double-blind, placebo-controlled trial, 602 patients with advanced hepatocellular carcinoma who had not received previous systemic treatment were randomized to receive either sorafenib (at a dose of 400 mg twice daily) or placebo. Primary outcomes were overall survival and the time to symptomatic progression. Median overall survival was 10.7 months in the sorafenib group and 7.9 months in the placebo group (hazard ratio in the sorafenib group, 0.69; 95% confidence interval, 0.5.
References: Llovet et al. "Sorafenib in Advanced Hepatocellular Carcinoma." NEJM 359(4):378-90, 2008.

149. Which of the following statements about trilateral retinoblastoma is FALSE?

(A) It is associated with an intracranial neuroblastic tumor.
(B) It has a favorable prognosis with approximately 80% overall survival.
(C) It has a higher incidence in patients with germline Rb mutations.
(D) It requires heightened surveillance with MRI until the age of 5 years.
Key: B
Rationale: Paulino AC. Trilateral retinoblastoma: is the location of the intracranial tumor important? Cancer 1999; 86(1):135-41. Kivelä T. Trilateral retinoblastoma: a meta-analysis of hereditary retinoblastoma associated with primary ectopic intracranial retinoblastoma. Journal of Clinical Oncology 1999; 17(6):1829-37.

150. For a 12-year-old boy with a paratesticular embryonal rhabdomyosarcoma, work-up should include all of the following EXCEPT:

(A) a brain MRI.
(B) a bone scan.
(C) a bilateral bone marrow aspiration/biopsy.
(D) an ipsilateral retroperitoneal lymph node dissection.

Key: A
Rationale: The standard work up for a child over 10 years of age with a paratesticular embryonal rhabdomyosarcoma is delineated in the Children's Oncology Group Protocols, including ARST0531, and include ipsilateral retroperitoneal lymph node dissection, bilateral bone marrow aspiration/biopsy, and bone scan, but not brain MRI.

151. What is the equivalent square for a 10 cm x 4 cm field?

(A) 2.8 cm
(B) 4 cm
(C) 5.7 cm
(D) 8.3 cm

Key: C
Rationale: According to Day's rule, the area to perimeter ratio (A/P) of the square and rectangle are equal to each other. For a square of side a, (A/P) = a/4. For a rectangle with sides b and c, (A/P) = bc/(2(b+c)). Thus, a = 2bc/(b+c) = (80/14)=5.7 cm.
References: Khan FM, The physics of Radiotherapy, 3rd Edition, Chapter 9, pp 164-165.

152. Which of the following is an advantage of using thermoluminescent dosimeters (TLDs) for *in-vivo* measurements?

(A) Their response is independent of energy.
(B) Their small size makes them convenient for use.
(C) They create a permanent record of the dose delivered.
(D) One dosimeter provides a 2D representation of the dose distribution.

Key: B
Rationale: The small size of TLDs makes then very convenient to position accurately and they do not alter the dose distribution in any significant manner. They are energy dependent, with the response being much larger in the kV range than in the MV range. Once read, they lose most of their information and therefore do not create a permanent record of dose. Finally, one TLD also give a single reading, not a 2D distribution like film would.
References: Khan FM, The physics of Radiotherapy, 3rd Edition, Chapter 8, pp 144-148.

153. A 69-year-old male presents with T1C, Gleason 4+3 and PSA of 9 ng/mL adenocarcinoma of the prostate. He has no hematuria or dysuria and no rectal pain. He reports rectal bleeding, sometimes associated with firm bowel movements, but more recent regular bleeding over the last month. He has attributed this to hemorrhoids. His last colonoscopy was several years ago. What is the MOST appropriate next step in the management of this patient?

(A) Colonoscopy because this patient has acute lower gastrointestinal bleeding

(B) Prostate brachytherapy because he is healthy with good urologic function and clinically organ confined disease

(C) Watchful waiting because he has early stage, low grade disease and results of the PIVOT trials suggest no survival advantage with local therapy

(D) External beam radiotherapy and androgen deprivation therapy because the Dana Farber and RTOG 9408 have demonstrated a survival benefit with combination therapy

Key: A

Rationale: This patient has acute lower gastrointestinal bleeding. A colonoscopy is needed to exclude the diagnosis of colorectal cancer. Furthermore, the origin of his bleeding should be established prior to treatment and remedied if possible. It is important not to mistake rectal bleeding during or after radiotherapy for radiation proctopathy, which generally managed conservatively, for more dangerous causes of bleeding such as cancer.

References: Trade knowledge.

154. According to the latest AJCC staging manual for lung cancer, which of the following would be classified as a T3 tumor?

(A) A tumor >5 cm but ≤7 cm in greatest dimension

(B) Separate tumor nodule(s) in the same lobe

(C) Involvement of the main bronchus, ≥ 2 cm distal to the carina

(D) Visceral pleura invasion

Key: B

Rationale: Pertinent changes to the lung staging system from the 6th to 7th edition include (1) more discrete stratification of tumors by size and partitioning of larger (>7 cm) tumors into T3, (2) downstaging of multiple nodules to T3 (same lobe), T4 (same lung), and M1a (contralateral lobe), and (3) upstaging of malignant pleural effusion from T4 to M1a.

References: AJCC Cancer Staging Manual, 7th edition, 2009.

155. What is the MOST appropriate management for a mid-rectal T3N1M0 cancer?

(A) Pelvic radiation alone
(B) Low anterior resection followed by chemoradiation
(C) Abdomino-perineal resection
(D) Chemoradiation followed by low anterior resection

Key: D

Rationale: For locally advanced rectal cancer, the most appropriate choice is chemoradiation followed by surgical resection, in this case low anterior resection with total mesorectal excision. The superiority of pre-operative vs. post-operative chemoradiation was demonstrated in the study by Sauer and colleagues with improved local control (6 vs. 13 percent) and decreased toxicity (27 vs. 40 percent grade 3-4) as compared to postoperative treatment. The treatment of locally advanced rectal cancer with surgery alone will result in higher rates of local recurrence. Radiation alone is not a standard definitive approach.

References: Sauer R, et al. New England Journal of Medicine. Oct 21, 2004; 351(17) pp: 1731-40. Kapiteijn E, et al. New England Journal of Medicine. Aug 30 2001; 345(9) pp: 638-46.

156. Which lymph nodes have the lowest likelihood of involvement for tumors in the distal stomach?

(A) Periduodenal
(B) Splenic hilar
(C) Peripancreatic
(D) Hepatoduodenal

Key: B

Rationale: Tumors in the distal stomach have the highest likelihood of travelling to the periduodenal, peripancreatic, and hepatoduodenal stations. They have the lowest likelihood of involving the periesophageal, mediastinal and splenic hilar lymph nodes.

References: Tepper et al. Seminars in Radiation Oncology 12(2): 187-195, 2002.

157. What is the MOST appropriate management for a 52-year-old male with a T4N2M0 nasopharyngeal carcinoma?

(A) Definitive radiation therapy alone
(B) Induction chemotherapy followed by radiotherapy
(C) Craniofacial resection followed by chemoradiation
(D) Concurrent chemoradiation with adjuvant chemotherapy

Key: D

Rationale: The standard of care for this patient would be concurrent chemoradiation with Cisplatin-based chemotherapy with or without adjuvant chemotherapy. This was established by the landmark Intergroup Study 0099, which randomized patients with locally advanced disease to radiotherapy alone versus chemoradiation [1]. The role of concurrent chemoradiation was also confirmed by a number of studies conducted in endemic populations of nasopharyngeal carcinoma [2,3]. Intergroup 0099 demonstrated an improvement in survival with the addition of 3 cycles of Cisplatin 100 mg/m2 on days 1, 22, and 43 concurrent with radiation followed by adjuvant chemotherapy with CDDP/5-FU. Compliance with adjuvant chemotherapy was poor with only about 55% of patients able to complete all 3 cycles, so it is controversial whether adjuvant chemotherapy is necessary. A recently reported Chinese multicenter study randomized patients with locally advanced nasopharyngeal carcinoma to chemoradiation alone versus chemoradiation plus adjuvant chemotherapy. In early follow-up, 2-year failure-free survival is not significantly different between the arms. Longer follow up will be needed to confirm the lack of benefit for the addition of adjuvant chemotherapy. Even with locally advanced disease and T4 primary tumors, many patients fare well with concurrent chemoradiation. Modern chemoradiation series with IMRT demonstrate very high rates of locoregional control. Lee et al reviewed the UCSF experience and reported 4-year estimated OS of 88% and 4-year locoregional progression free rate of 98% [4]. Meta-analyses of chemotherapy trials have demonstrated that the greatest improvement in survival is associated with concomitant chemotherapy with radiation, with no significant improvement associated with neoadjuvant or adjuvant chemotherapy [5,6].

References: Al-Sarraf, M., et al., *Chemoradiotherapy versus radiotherapy in patients with advanced nasopharyngeal cancer: phase III randomized Intergroup study 0099.* Journal of clinical oncology: official journal of the American Society of Clinical Oncology, 1998. 16(4): p. 1310-7. Lin, J.C., et al., *Phase III study of concurrent chemoradiotherapy versus radiotherapy alone for advanced nasopharyngeal carcinoma: positive effect on overall and progression-free survival.* Journal of clinical oncology: official journal of the American Society of Clinical Oncology, 2003. 21(4): p. 631-7. Wee, J., et al., *Randomized trial of radiotherapy versus concurrent chemoradiotherapy followed by adjuvant chemotherapy in patients with American Joint Committee on Cancer/International Union against cancer stage III and IV nasopharyngeal cancer of the endemic variety.* Journal of clinical oncology: official journal of the American Society of Clinical Oncology, 2005. 23(27): p. 6730-8. Lee, N., et al., *Intensity-modulated radiotherapy in the treatment of nasopharyngeal carcinoma: an update of the UCSF experience.* International journal of radiation oncology, biology, physics, 2002. 53(1): p. 12-22.
Baujat, B., et al., *Chemotherapy in locally advanced nasopharyngeal carcinoma: an individual patient data meta-analysis of eight randomized trials and 1753 patients.* International journal of radiation oncology, biology, physics, 2006. 64(1): p. 47-56.
Langendijk, J.A., et al., *The additional value of chemotherapy to radiotherapy in locally advanced nasopharyngeal carcinoma: a meta-analysis of the published literature.* Journal of clinical oncology: official journal of the American Society of Clinical Oncology, 2004. 22(22): p. 4604-12.

158. Which of the following statements is CORRECT regarding the treatment for a patient with a T2 verrucous carcinoma of the buccal mucosa?

(A) A surgical resection is generally the preferred treatment.

(B) Radiotherapy should be avoided because of the high risk of dedifferentiation.

(C) The local failure rate with either surgery or radiotherapy is approximately 50%.

(D) Higher dose radiation is required compared to more conventional squamous cell carcinoma.

Key: A

Rationale: With early stage tumors of the buccal mucosa, surgery is generally the preferred form of therapy. However, if the patient is medically inoperable or if the morbidity associated with a surgical resection is too great, then radiotherapy may be offered. Many recurrent tumors appear to be more biologically aggressive than the original tumor but this holds for all forms of treatment [1]. There is little evidence that radiotherapy presents a higher degree of risk [2,3]. The doses used are the same as for other forms of squamous cell carcinomas and the results of treatment are comparable with the expected local control rate being in the range of 70-75% [4,5].

References: Koch BB, Trask DK, Hoffman, et al. National survey of head and neck verrucous carcinoma: Patterns of presentation, care, and outcome. Cancer 92: 110-120, 2001. Jyothirmni R, Sankananarayanan R, Varghese C, et al. Radiotherapy in the treatment of verrucous carcinoma of the oral cavity. Oral Oncol 33: 124-128, 1997. Nair MK, Sankaranarayanan R, Madhu CS. Oral verrucous carcinoma. Treatment with radiotherapy. Cancer 61: 458-461, 1988. Wang CC. Radiation Therapy for Head and Neck Neoplasms, 3rd Ed, John Wiley, 1996, Ch 6. Nair MK, Sankaranerayanan R, Padmanabhan Tk. Evaluation of the role of radiotherapy in the management of carcinoma of the buccal mucosa. Cancer 61: 1326-1331, 1988.

159. In testing the null hypothesis, a Type II (β) error occurs if one:

(A) fails to reject the null hypothesis when it is false.

(B) rejects the null hypothesis when it is really true.

(C) concludes there is a difference when no difference exists.

(D) detects a difference when a difference exists.

Key: A

Rationale: A type I (α) error results if a true null hypothesis is rejected or if a difference is concluded when no difference exists. A type II (β) error results if a false null hypothesis is not rejected or if a difference is not detected when a difference exists.

References: Dawson B and Trapp RG. Basic and Clinical Biostatistics. 4th edition, pp 108-109 and 414.

160. Approximately what percent of pediatric patients with Hodgkin lymphoma present with stage IV disease?

(A) 5%
(B) 20%
(C) 35%
(D) 50%

Key: B
Rationale: Handbook of Evidence-Based Radiation Oncology. Hansen and Roach editors.

161. What is the most appropriate treatment for a 20-year-old male with a biopsy suggestive of suprasellar germinoma with no evidence of neuroaxis dissemination but with markedly elevated βhCG and α-fetoprotein levels?

(A) Chemotherapy alone
(B) Craniospinal irradiation followed by involved field radiation therapy
(C) Whole ventricular irradiation followed by involved field radiation therapy
(D) Combined chemotherapy and craniospinal irradiation followed by involved field radiation therapy

Key: D
Rationale: With markedly elevated markers, even with a germinoma histology, the patient should be managed like non-germinomatous germ cell tumor. Among the 4 options, option B (combined radiotherapy and chemotherapy) is the most appropriate option.
References: Kretschmar C, Kleinberg L, Greenberg M, Burger P, Holmes E, Wharam M. Pre-radiation chemotherapy with response-based radiation therapy in children with central nervous system germ cell tumors: a report from the Children's Oncology Group. Pediatr Blood Cancer 2007 Mar; 48(3):285-91.

162. What dose in Gy is used to treat solitary plasmacytomas?

(A) 10-30
(B) 31-35
(C) 36-44
(D) >45

Key: D
Rationale: General idea of the dose to treat Solitary plasmacytoma as it differs from MM. Solitary plasmacytoma should be treated >45 Gy.
References: NCCN MM Guidelines MS-4.

163. Which of the following statements is true about the dose rate effect for X-rays?

(A) The dose rate effect is a manifestation of the repair of potentially lethal damage.

(B) The biological effectiveness of 30 Gy delivered as 5 daily doses of 5 Gy is less than for 30 Gy delivered as a single dose.

(C) Survival curves for low dose rate or highly fractionated irradiation are roughly exponential.

(D) For repair-competent cells, as the dose rate increases, survival curves become progressively shallower.

Key: C

Rationale: As dose rates drop, survival curves for low LET types of radiation become shallower and increasingly exponential. The dose rate effect is a consequence of the repair of sublethal damage, not potentially lethal damage. Typically, biological effectiveness decreases as the dose rate decreases (or amount of fractionation increases). For repair competent cells, survival curves become shallower as the dose rate decreases, not increases.

References: Chapter 5 in Hall and Giaccia, Radiobiology for the Radiologist, Seventh Edition, 2012.

164. Which of the following lymph nodes is considered an N1 lymph node in gastric cancer?

(A) Subpyloric

(B) Common hepatic

(C) Celiac

(D) Splenic

Key: A

Rationale: The first eschelon of lymph nodes (N1) are the perigastric lymph nodes including the R and L paracardial LN, greater and lesser curvature LN, and the suprapyloric and subpyloric LNs. The second eschelon of lymph node drainage (N2) includes the celiac artery and its branches.

References: Hartgrink et al. JCO 22(11): 2069-2077, 2004.

165. Chronic lymphocytic leukemia (CLL) differs from small lymphocytic lymphoma (SLL) in that a large number of abnormal lymphocytes are found in the:

(A) CNS.
(B) skin.
(C) lymph nodes.
(D) bone marrow and blood.

Key: D
Rationale: To be able to distinguish CLL from SLL. CLL is confined mainly to blood and bone marrow where SLL in marked by lymphadenopathy.
References: NCCN NHL Guidelines MS-17.

166. The radiotherapeutic treatment of head and neck cancer of unknown origin should:

(A) include the entire pharyngeal axis in all cases.
(B) exclude the nasopharynx in non-Asian patients.
(C) always involve concurrent chemotherapy.
(D) use a dose of >50 Gy to mucosal sites at risk.

Key: D

167. Which of the following is an example of a parallel organ?

(A) Lung
(B) Esophagus
(C) Spinal cord
(D) Optic chiasm

Key: A
Rationale: To model the response of OARs to radiation, tissues are assumed to be made up of functional subunits (FSUs). The response of these FSUs is dependent on whether the tissue is organized in a serial, parallel, or serial-parallel manner. For parallel tissues (e.g. lung), complication rates are proportional to the volume of tissue exposed to doses in excess to the tissue tolerance. In contrast, for serial tissues (e.g. spinal cord, esophagus, and optic chiasm), it is assumed that irradiation of even a small volume of tissue to a dose above tolerance, could be detrimental. Of the options presented, the only parallel organ listed is the lung.
References: ICRU Report 62.

168. In which clinical setting is the risk of internal mammary node breast cancer involvement the highest?

(A) Upper outer quadrant, negative axillary nodes
(B) Upper outer quadrant, positive axillary nodes
(C) Upper inner quadrant, negative axillary nodes
(D) Upper inner quadrant, positive axillary nodes

Key: D
Rationale: The risk of internal mammary involvement increases with medial tumors in the setting of positive axillary nodes.
References: Disease of the Breast, Jay Harris, et. al., 4th Edition. Lippincott, Williams and Wilkins. pp 4-5. 2010.

169. Which of the following is CORRECT regarding a patient with a non-keratinizing undifferentiated nasopharyngeal carcinoma extending into the posterior nasal cavity along with bilateral level II lymphadenopathy (< 5cm)?

(A) The stage is IVA.
(B) The T classification is T1.
(C) The N classification is N3.
(D) The tumor histology is WHO Type I.

Key: B
Rationale: The correct T classification is T1, which includes tumors confined to the nasopharynx or tumors with extension into the oropharynx and/or nasal cavity without parapharyngeal extension. Note that in the most recent AJCC staging system (7^{th} edition 2010), parapharyngeal extension alone distinguishes T1 from T2 primaries [1]. Tumors with extension into the oropharynx and/or nasal cavity without parapharyngeal extension, previously classified as T2a, are now classified as T1 reflecting their more favorable prognosis and the negative prognostic impact of parapharyngeal extension. The distribution and prognostic impact of regional nodal involvement in nasopharyngeal cancer is different from other head and neck cancers, hence the unique N classification system. This patient has N2 disease due to bilateral cervical metastases, 6 cm or less in dimension, above the supraclavicular fossa. The correct Stage grouping is III, T1N2M0. There are three WHO histologic classifications: Type I – keratinizing squamous cell carcinoma, Type II non-keratinizing differentiated carcinoma, and Type III – non-keratinizing undifferentiated carcinoma. Type III is the most common type in both North American (about 63% of patients) and endemic Asian populations (about 95% of patients). There is a greater proportion of Type I disease in North America (about 25% of patients) compared to endemic areas (about 2% of patients) [2].
References: Edge, S.B. and American Joint Committee on Cancer. AJCC cancer staging manual. 7th ed2010, New York: Springer. xiv, 648 p. Wei, W.I. and J.S. Sham, Nasopharyngeal carcinoma. Lancet, 2005. 365(9476): p. 2041-54.

170. The rate of laryngeal preservation at 2-years after non-surgical treatment in the Department of Veterans Affairs Laryngeal Cancer Study Group trial (NEJM 1991) was approximately:

(A) 20%.
(B) 40%.
(C) 60%.
(D) 80%.

Key: C
References: N Engl J Med. 1991 Jun 13; 324(24):1685-90.

171. What is the BEST indication for postmastectomy radiation in a patient with clinical stage II breast cancer treated by neoadjuvant chemotherapy?

(A) Pathologic N1
(B) HER-2 positive
(C) Clinical T2 tumor size
(D) Lymphovascular invasion

Key: A
Rationale: Data from National Surgical Adjuvant Breast and Bowel Project studies B-18 and B27, and MD Anderson Cancer Center, show that pathologic node positivity after neoadjuvant chemotherapy is most associated with subsequent risk of local-regional recurrence.
References: Buchholz et al (J Clin Oncol 26:791-797).

172. Which of the following represents a consensus definition by the RTOG when contouring for treatment planning of carcinoma of the cervix?

(A) The cervix and uterus contoured as separate structures.
(B) The sigmoid begins at the anal verge and stops at the ascending colon laterally.
(C) The bladder from the base to the dome including the adjacent 5 cm of ureters.
(D) The femoral heads from the lowest level of the ischial tuberosities to the top of the ball of the femur, including the trochanters.

Key: D
Rationale: The sigmoid contour begins where the anorectum ends and stops prior to connecting to the ascending colon laterally. The bladder contour begins inferiorly at the base and extends superiorly to the dome but does not include the ureters. The cervix and uterus should be contoured as one structure. The femoral heads from the lowest level of the ischial tuberosities to the top of the ball of the femur including the trochanters.
References: RTOG Consensus Contouring Guidelines found at the RTOG website.

173. Following 50-54Gy fractionated radiotherapy for an optic nerve sheath meningioma, the rate of blindness in the irradiated eye is approximately:

(A) <5%.
(B) 20%.
(C) 50%.
(D) >95%.

Key: A
Rationale: Despite affecting the optic nerve, fractionated irradiation has less than 5% risk of radiation-associated vision loss. It can improve vision in 75% of patients and obtains local control in over 95%. Surgery should not be performed for ONSMs. RT is the standard of care.
References: Gondi, J Neurooncol 99, 2010.

174. What is an appropriate radiation dose for a 15-year-old boy with stage IIB Hodgkin lymphoma of the neck and mediastinum without bulky disease is to be treated with involved-field radiation therapy after a complete response to four cycles of chemotherapy?

(A) 15 Gy
(B) 21 Gy
(C) 36 Gy
(D) 45 Gy

Key: B
Rationale: Based on COG AHOD 0031.

175. A sentinel lymph node biopsy is positive in what proportion of patients with Ductal Carcinoma In Situ (DCIS)?

(A) 1%
(B) 3%
(C) 5%
(D) 7%

Key: C
Rationale: The incidence of sentinel lymph node metastasis in patients with an excisional diagnosis of DCIS is approximately 5%.
References: Allegra, C. J. et al. National Institutes of Health State-of-the-Science Conference Statement: Diagnosis and Management of DCIS. Sept. 22-24, 2009. JNCI 2010; 102(3) 161-169.

176. A patient with a 6 cm rhabdomyosarcoma of the liver with no clinically involved regional lymph nodes and no evidence of metastases has what stage disease?

(A) 1
(B) 2
(C) 3
(D) 4

Key: A
Rationale: Based on the TNM pre-treatment staging classification.

177. Which of the following statements about CNS-related atypical teratoid/rhabdoid tumors (AT/RT) is true?

(A) It has the same prognosis as medulloblastoma.
(B) The median age of diagnosis is less than 1 year.
(C) Standard treatment involves postoperative involved-field radiation therapy alone.
(D) Leptomeningeal spread rarely occurs in patients with AT/RT.

Key: B

178. What is the predominant mode of energy transfer for fast neutrons in tissue?

(A) Nuclear reactions
(B) Compton scatter with electrons
(C) Recoil collisions with protons
(D) Bremsstrahlung production

Key: C
Rationale: Fast neutrons interact with tissue primarily by setting protons in motion. Nuclear reactions are of lesser importance especially for fast neutrons. Bremsstrahlung production only occurs for electrons.
References: P.N. McDermott and C.G. Orton, "The Physics and Technology of Radiation Therapy," Medical Physics Publishing, Madison, WI, Copyright 2010.

179. The 5-year, cause-specific survival for patients with medically inoperable FIGO stage I endometrial carcinomas treated with definitive radiation is approximately:

(A) 10-20%.
(B) 40-50%.
(C) 65-75%.
(D) 80-90%.

Key: D
Rationale: Several retrospective studies have shown that radiation therapy, using brachytherapy alone or in combination with external beam radiation, are very effective in treating Stage I-II endometrial carcinoma. The cause-specific survival at 5 years has ranged between 80-87% with most patients dying of intercurrent disease and not endometrial cancer.
References: Coon D et al. Int J Radiat Oncol Biol Phys. 2008; 71:779-783. Niazi TM et al. Int J Radiat Oncol Biol Phys. 2005; 63:1108-1113. Kupelian PA et al. Int J Radiat Oncol Biol Phys. 1993; 27:817-24.

180. Which of the following statistical methods provides information about the hazard ratio associated with one treatment as compared to another?

(A) Cox regression
(B) Linear regression
(C) Logistic regression
(D) Polynomial regression

Key: A
Rationale: The correct answer is a since Cox regression is a form of survival analysis that yields a central result about hazard ratios in one group as compared to another group. The other regression techniques do not yield information about hazard rates.

181. The 5-year overall survival for patients with pyriform sinus cancer treated by either surgical or non-surgical treatment on EORTC phase 3 trial (24891) was approximately:

(A) <10%.
(B) 30%.
(C) 50%.
(D) 70%.

Key: B
References: Lefebvre JL, et al. J Natl Cancer Inst. 1996 Jul 3; 88(13):890-9.

182. What occurs if a true null hypothesis is rejected or if a difference is concluded when no difference exists?

(A) Type I error
(B) Type II error
(C) Standard error
(D) Standard deviation

Key: A
Rationale: A Type I error results if a true null hypothesis is rejected or if a difference is concluded when no difference exists.
References: Dawson B and Trapp RG. Basic and Clinical Biostatistics. 4th edition, 2004; pp. 414.

183. Appropriate radiotherapy management of supra-tentorial primitive neuroectodermal tumor (PNET) in a 6-year-old patient after complete resection would include:

(A) 18 Gy to the craniospinal axis followed by a 36 Gy boost to the tumor bed plus margin.
(B) 23.4 Gy to the craniospinal axis followed by a 30.6 Gy boost to the tumor bed plus margin.
(C) 36 Gy to the craniospinal axis followed by an 18 Gy boost to the tumor bed plus margin.
(D) 54 Gy to the tumor bed plus margin.

Key: C
Rationale: All PNETs of the central nervous system require craniospinal irradiaiton (CSI) due to their propensity for drop metastases and include: medulloblastoma, supratentorial PNET, atypical teratoid/rhabdoid tumor, and pineoblastoma. The recommended dose is 36 Gy. The one exception is children >3 years old with standard risk medulloblastoma, in which the dose is lowered to 23.4 Gy and concurrent vincrisitne is administered. Dose reduction for CSI in patients under 3 years-old is currently under investigation.

184. What is the next step in the management of a pilocytic astrocytoma located within the cerebellum that has been completely resected?

(A) Continued observation
(B) 45-50.4 Gy with close margins
(C) Adjuvant temozolomide chemotherapy
(D) Platinum-based adjuvant chemotherapy

Key: A
Rationale: For completely resected, grade I tumors, especially in children, the next step would be to observe and avoid any cytotoxic therapies.

185. Which of the following is a type of programmed cell death characterized by the cell degrading its own components using the lysosomal machinery?

(A) Apoptosis
(B) Autophagy
(C) Mitotic catastrophe
(D) Necrosis

Key: B
Rationale: Both apoptosis and autophagy are types of programmed cell death. Autophagy is associated with the appearance of autophagosomes and degradation of the cell's own components.
References: White, E. Deconvoluting the context-dependent role for autophagy in cancer. Nat Rev Cancer 2012; 12(6):401-410.

186. What is the MOST appropriate treatment for a healthy 55-year-old with a stage IAE marginal zone lymphoma of the stomach?

(A) Total gastrectomy
(B) Radiation therapy to 30 Gy
(C) R-CHOP x 6
(D) R-CHOP x 3 with involved field RT

Key: B
Rationale: RT alone to 30 Gy yields freedom from relapse rates of > 90% and is the standard of care.

187. What is the strongest predictor of survival for patients with IIIA NSCLC treated with neoadjuvant chemoradiation and resection?

(A) Total dose of radiation
(B) Intensity of chemotherapy
(C) Primary tumor response
(D) Pathologic nodal clearance

Key: D
Rationale: The strongest predictor of long- term survival was mediastinal nodal clearance, which had a hazard ratio of 0.22, (p=.0003) (Betticher et al., J Clin Oncol. 21(9): 1752-1759, 2003). Most importantly, in the phase III trial, INT 0139, nodal clearance predicted outcome. Patients with N0 resection specimens demonstrated a 41% 5-year survival versus 24% for those with pN1-3 in the surgical specimen (Albain et al. J Clin Onc. 23:16S: 7014, 2005). Clearly, studies of induction therapy (chemotherapy or chemoradiotherapy) followed by surgical resection have consistently demonstrated that mediastinal nodal sterilization is a powerful predictor of outcome and can serve as a surrogate marker.

188. How does the OER change with changing LET?

(A) Increase in OER with increase in LET
(B) Decrease in OER with increase in LET
(C) No change in OER with increase in LET
(D) No change in OER with decrease in LET

Key: B

Rationale: OER, the oxygen enhancement ratio, equals the ratio of radiation doses with and without oxygen to yield the same biological endpoint. Since high LET radiation causes more direct, irreparable DNA damage, it is less reliant on the oxygen "fixing" additional free radicals. Therefore, the OER decreases with increasing LET.

References: Chapter 6 in Hall and Giaccia, Radiobiology for the Radiologist, 7th Edition, 2012.

189. What is the MOST appropriate treatment for a 23-year-old male with a suprasellar germinoma with no evidence of neuroaxis dissemination and normal βhCG and α-fetoprotein levels?

(A) Chemotherapy alone
(B) Involved field radiation therapy
(C) Whole ventricular irradiation followed by involved field radiation therapy
(D) Combined chemotherapy and craniospinal irradiation followed by involved field radiation therapy

Key: C

Rationale: Among the 4 options, option C is most appropriate for localized CNS germinoma, which is radiosensitive.

References: Rogers SJ, Mosleh-Shirazi MA, Saran FH. Radiotherapy of localised intracranial germinoma: time to sever historical ties? Lancet Oncol. 2005 Jul; 6(7):509-19 Review.

190. What is the MOST appropriate treatment for a patient with a p16 (-) T4N2M0 squamous cell carcinoma of the base of tongue?

(A) Conventionally fractionated radiotherapy
(B) Concurrent chemotherapy and radiotherapy
(C) Transoral laser microsurgery followed by radiotherapy
(D) Induction chemotherapy followed by transoral laser microsurgery

Key: B

Rationale: This patient has a locally advanced oropharyngeal squamous carcinoma. The standard of care is concurrent chemotherapy and radiotherapy, which is superior to radiotherapy alone [1]. Surgery is generally reserved for salvage of treatment failures. Transoral laser microsurgery is contraindicated in tongue base tumors that extend ventrally into the floor of mouth [2]. There is no data to support induction chemotherapy followed by surgery in this situation.

References: Denis F, Garaud P, Bardet E, et al. Final Results of the 94-01 French Head and Neck Oncology and Radiotherapy Group Randomized Trial Comparing Radiotherapy Alone With Concomitant Radiochemotherapy in Advanced-Stage Oropharynx Carcinoma. J Clin Oncol 22:69-76. 2004. Haughey BH, Hinni ML, Salassa JR, et al.Transoral Laser Microsurgery as Primary Treatment for Advanced-stage Oropharyngeal cancer: A United States multicenter study. Head & Neck—DOI 10.1002/hed December 2011.

191. What was the approximate 5-year pelvic control rate FIGO stage II vaginal cancers treated with definitive radiation, as reported by Frank et. al

(A) 55%
(B) 65%
(C) 75%
(D) 85%

Key: D

Rationale: The 5 year pelvic control rates were 86%, 84% and 71% for stages I, II and III-IV, respectively.

References: Frank SJ et al. Int J Radiat Oncol Biol Phys; 62:138-47.

192. A nucleus undergoing β^- decay will experience which of the following changes in atomic and mass number?

(A) ${}^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y$

(B) ${}^{A}_{Z}X \rightarrow {}^{A}_{Z-1}X$

(C) ${}^{A}_{Z}X \rightarrow {}^{A}_{Z-1}Y$

(D) ${}^{A}_{Z}X \rightarrow {}^{A}_{Z+1}X$

Key: A

Rationale: Beta decay is a fundamental process in many therapeutically useful brachytherapy seeds. Beta decay, whether electron or positron decay, maintains the total number of nucleons, so the atomic mass (A) remains constant. The emission of a negatively charged electron in beta-minus decay must be compensated for by increasing the positive charge in the nucleus, increasing the atomic number (Z) by 1.

References: F. Khan, "The Physics of Radiation Therapy," Fourth Edition, Lippincott Williams & Williams, Baltimore, MD, Copyright 2010.

193. The most common site of metastatic disease for retroperitoneal soft tissue sarcoma is in the:

(A) brain.
(B) liver.
(C) lung.
(D) mediastinum.

Key: B

Rationale: Soft tissue sarcomas of the extremities tend to metastasize to the lungs, whereas retroperitoneal sarcomas will metastasize to the liver.

References: Hansen, Eric K. et. al. Handbook of Evidence-Based Radiation Oncology. 2nd edition Springer Scientific. 2010. Page 616.

194. Which of the following sites of a squamous cell carcinoma of the skin has the highest risk for lymph node metastasis?

(A) Tip of nose
(B) Eyelid
(C) Scalp
(D) Preauricular

Key: D
Rationale: Preauricular squamous cell skin cancer has a high incidence of intraparotid lymph node metastasis.

195. Which of the following is appropriate coverage for subclinical disease in a patient undergoing radiotherapy for nasopharyngeal carcinoma?

(A) The posterior cervical nodes should not be covered.
(B) The bilateral retropharyngeal nodes should be covered.
(C) The cavernous sinus should be covered with disease involving the maxillary sinus.
(D) The posterior one-third to one-half of the nasal cavity should be covered only in patients with nasal obstruction.

Key: B
Rationale: Nasopharyngeal carcinoma is associated with a high risk of retropharyngeal nodal involvement, which should be electively covered in all patients [1]. Posterior cervical chain involvement is also commonly seen and must be included in the neck target volumes. The cavernous sinus is at risk in patients with higher T-stage primaries (T3 to T4 tumors). Elective coverage of the cavernous sinus should be considered with tumor extent involving these anatomic sites: foramen ovale, foramen lacerum, foramen rotundum, sphenoid sinus, and clivus [2]. In particular, foramen ovale is the most common pathway of spread to the skull base in patients with cavernous sinus invasion. The posterior one-third to one-half of the nasal cavity and maxillary sinuses should be electively covered in all patients [3].
References: Wang, X.S., et al., Patterns of retropharyngeal node metastasis in nasopharyngeal carcinoma. International journal of radiation oncology, biology, physics, 2009. 73(1): p. 194-201. Liang, S.B., et al., Extension of local disease in nasopharyngeal carcinoma detected by magnetic resonance imaging: improvement of clinical target volume delineation. International journal of radiation oncology, biology, physics, 2009. 75(3): p. 742-50. Ang, K.K. and A.S. Garden, Radiotherapy for head and neck cancers: indications and techniques. 3rd ed2006, Philadelphia, PA: Lippincott Williams & Wilkins, xi, p. 212.

196. Which of the following lymph nodes should be electively irradiated for a locally advanced middle to high rectal cancer?

(A) Internal iliac and peri-rectal
(B) Internal iliac, pre-sacral, and peri-rectal
(C) internal iliac, external iliac, pre-sacral, and peri-rectal
(D) Internal iliac, external iliac, inguinal, pre-sacral, and peri-rectal

Key: B
Rationale: For a middle-to-high rectal cancer, the most appropriate choice is B. Pre-sacral lymph nodes are a site at high risk of failure, whereas external iliac and inguinal lymph nodes are not likely to be involved with a cancer at this level.
References: Myerson R, Int J Radiat Oncol Biol Phys. 2009 July 1; 74(3) pp. 824-30.

197. What was the involved field radiation therapy dose in Gy used for nodal sites in complete response in EORTC trial 20884 (Aleman et. al. New England Journal of Medicine, 2003) in patients with stage III or IV Hodgkin lymphoma after MOPP-ABV.

(A) 20
(B) 24
(C) 30
(D) 36

Key: B
Rationale: For patients in CR after chemotherapy, 24 Gy was used for nodal sites.

198. Which of these patients is BEST suited for active surveillance as an acceptable treatment option?

(A) 55-year-old male with stage T2b, Gleason 7 (3+4), PSA 11.0, 6/12 cores
(B) 65-year-old male with stage T1c, Gleason 8 (4+4), PSA 9.0, 3/12 cores
(C) 70-year-old male with stage T3a, Gleason 9 (4+5), PSA 21.0, 9/12 cores
(D) 75-year-old male with stage T1c, Gleason 6 (3+3), PSA 3.5, 1/12 cores positive

Key: D
Rationale: According to the NCCN guidelines, patients with low-volume, low-risk prostate cancer (also known as very low risk) are good candidates for active surveillance. Patients with intermediate-risk prostate cancer can be considered for active surveillance; however, the patient in this question is 55 and likely has a greater than 10-year life expectancy.
References: 2011 NCCN Guidelines for Prostate Cancer.

199. Which of the following immunostains is NOT commonly associated with Merkel cell cancer?

(A) Chromogranin
(B) Synaptophysin
(C) p63
(D) Neuron-specific enolase

Key: C

200. Which of the following proteins is an apical kinase in the cellular response to ionizing radiation?

(A) Hypoxia-inducible factor 1 (HIF-1)
(B) Ataxia telangiectasia mutated (ATM)
(C) p53
(D) Retinoblastoma (Rb)

Key: B
Rationale: Ataxia telangiectasia mutated (ATM) is a key apical kinase that orchestrates the cellular DNA damage response to ionizing radiation, including the initial sensing of DNA damage, mobilization of DNA repair proteins, and the stopping of cell cycle progression while repair is occurring.
References: Chapter 2 in Hall and Giaccia, Radiobiology for the Radiologist, Seventh Edition, 2012.

201. Clinical photodynamic therapy (PDT) shares which characteristic with clinical radiotherapy?

(A) Generation of immediate DNA double-strand breaks
(B) Generation of reactive oxygen species
(C) Requirement for drug sensitization
(D) Ability to reach deep-seated tumors

Key: B
Rationale: Of the options listed above, PDT shares only the ability to generate reactive oxygen species (in photodynamic drug-sensitized cells) with clinical radiotherapy. PDT does not directly induce DNA DSBs, require drug photosensitization, and has restricted body penetration due to the physics of light absorption in human tissue (these are not features associated with clinical radiotherapy).
References: Dolmans D, Fukumura D, Jain RK. Nat Rev Cancer 2003; 3:380-387.

202. What is the approximate effective dose to a patient receiving a 4D CT of the chest on a multi-slice CT scanner?

(A) 0.02 mSv
(B) 2 mSv
(C) 20 mSv
(D) 200 mSv

Key: D
Rationale: The effective dose to a patient receiving a 4D CT of the chest on a multi-slice CT is approximately 200 mSv. During a 4D CT acquisition, a patient is scanned multiple times at each couch position; as such their exposure to radiation can be up to an order of magnitude higher than a standard multi-slice protocol (~ 20 mSv). The effective dose to patient receiving a standard chest x-ray is approximately 0.02 mSv.
References: J. Valentin, Annals of the ICRP 30 (4), 19-24 (2000). T. Li et al., Med. Phys. 32 (12), 3650-60 (2005).

203. Which of the following statements regarding perineural invasion associated with a squamous cell carcinoma of the skin is TRUE?

(A) The extent of radiographic perineural involvement is not predictive of outcomes.
(B) Microscopic perineural invasion requires treating the nerve back to the base of skull.
(C) Clinical perineural involvement has a worse prognosis compared to microscopic involvement.
(D) Radiotherapy has > 50% chance to reverse symptomatic cranial nerve involvement.

Key: C
References: Garica-Serra A, et al. Head Neck. 2003 Dec; 25(12):1027-33 Galloway Cancer Volume 103, Issue 6, pages 1254-1257, 15 March 2005.

204. An upper tract urothelial carcinoma with invasion into the muscularis is associated with what T stage?

(A) T1
(B) T2
(C) T3
(D) T4

Key: B
Rationale: AJCC T staging for renal pelvic and upper tract urothelial cancers is based on depth of invasion. Invasion into the muscularis is considered T2 disease.

205. To generate an x-ray survival curve for a new cell line, 4 Petri dishes were seeded with 10^2, 10^3, 10^4 and 10^5 cells, and irradiated with 0, 3, 6 and 9 Gy, respectively. At the end of a 2 week incubation period, a total of 40 colonies was counted on each dish. This cell line's survival curve:

(A) has a D_0 of 3 Gy.
(B) is exponential.
(C) has a broad shoulder.
(D) has an n of 15.

Key: B

Rationale: The finding that each subsequent dose produces one log's difference in cell survival suggests that the survival curve for this cell line is exponential. Exponential survival curves are characterized by having no shoulders and extrapolation numbers of 1.0. The D0 for this cell line is 1.3 Gy. (D10 = 3 Gy = 2.3 * D0).

206. Which of the following is a CONTRAINDICATION to unilateral, rather than bilateral, groin dissection for stage IB vulvar cancer?

(A) Unifocal lesion
(B) No palpable nodes in either groin
(C) Lateral location > 1 cm from midline
(D) Cancer located in the anterior portion of the labia minora

Key: D

Rationale: Unilateral LND was associated with <1% risk of contralateral groin node metastases in multiple for Stage IB disease that meets all of the following requirements: Unifocal; lateral > 1 cm from the midline; NOT located in the anterior portion of the labia minora defined anatomically as the area just posterior to the clitoris as this area may have contralteral lymph flow; no palpable lymphadenopathy in either groin; no lymph node metastases found at the time of unilateral LND.

References: Lymph drainage from the vulva. Iversen T, Aas M Gynecol Oncol. 1983;16(2):179 And Early stage I carcinoma of the vulva treated with ipsilateral superficial inguinal lymphadenectomy and modified radical hemivulvectomy: a prospective study of the Gynecologic Oncology Group.Stehman FB, Bundy BN, Dvoretsky PM, Creasman WT Obstet Gynecol. 1992;79(4):490.

207. What is the typical peak energy of protons used to treat prostate tumors?

(A) 250 keV
(B) 6 MeV
(C) 70 MeV
(D) 250 MeV

Key: D
Rationale: Proton facilities typically accelerate protons to approximately 250 MeV. A series range modulators are then used to degrade the energy and create a Spread Out Bragg Peak to treat at range of depths within the tumor. Ocular tumors are treated with lower energy protons beam with maximum energies around 70 MeV. Typical photon IMRT beams used in prostate cancer are 6 MV.
References: Dyk, Jacob, Van (1999). The modern technology of radiation oncology: a compendium for medical physicists and radiation oncologists, Ch. 20 Medical Physics Publishing Corporation.

208. Which statement about apoptotic cell death is true?

(A) It is a cell-type independent process.
(B) Bax is an oncogenic protein that suppresses apoptosis.
(C) DNA double stranded breaks produced during apoptosis cause the characteristic ladders seen on electrophoretic gels.
(D) During the apoptosis process, cells flatten and spread out in order to maintain physical contact with neighboring cells.

Key: C
Rationale: Apoptosis is cell-type dependent; different types of cells are more or less prone to undergo apoptosis in response to an injury or stressor. Bcl-2 is an oncogenic protein that suppresses apoptosis, whereas Bax is a tumor suppressor protein that facilitates the apoptosis process. Cells undergoing apoptosis typically round up and detach from their neighbors.
References: Chapter 3 in Hall and Giaccia, Radiobiology for the Radiologist, Seventh Edition, 2012.

209. A 65-year-old male with a stage IIA (T2AN0M0) with Gleason score 3+4 adenocarcinoma and pretreatment PSA of 9 ng/mL is undergoing intensity modulated radiotherapy (IMRT) with gold seed fiducial markers and electronic portal imaging for daily prostate localization. At his first on-treatment visit, having received 8 Gy of a planned 80 Gy, he is complaining of increased daytime urinary frequency, urgency, and dysuria. He is getting up 1-2 times at night, which is new for him. What is the MOST appropriate next step in the management of this patient?

(A) Obtain a urinalysis and culture for a possible infection
(B) Prescribe Tamsulosin once or twice a day for his urinary symptoms
(C) Reassure the patient that his side effects are expected and continue treatment as planned
(D) Change his prescription from 2 Gy fractions to 1.8 Gy fractions to reduce his urinary side effects

Key: A
Rationale: It is unusual for patients to experience this degree of side effects so early in the course of radiotherapy. His symptoms are most likely associated with an infection secondary to fiducial marker placement for IGRT. A urinalysis is important for this patient to exclude an infection that may require antibiotics.

210. A tumor in which of the following salivary glands is MOST LIKELY to be malignant?

(A) Minor
(B) Parotid
(C) Sublingual
(D) Submandibular

Key: C
References: Devita text book.

211. Which of the following factors MOST accurately predict the outcome of patients with diffuse large B-cell lymphoma?

(A) "B" symptoms, age, sex, extranodal sites, and number of nodal sites

(B) "B" symptoms, age, erythrocyte sedimentation rate, mediastinal bulk, and number of involved sites

(C) "B" symptoms, sex, erythrocyte sedimentation rate, mediastinal bulk, and number of nodal sites

(D) ECOG performance status, age greater than 60 years, LDH, extranodal sites, and stage

Key: D

Rationale: The International Non-Hodgkin's Lymphoma Prognostic Factors Project had outlined the following factors as the most predictive of outcome in patients diagnosed with aggressive non-Hodgkin lymphoma: Age, stage, performance status, extranodal involvement, serum LDH.

References: Project TIN-HsLPF. A predictive model for aggressive non-Hodgkin's lymphoma. The International Non-Hodgkin's Lymphoma Prognostic Factors Project. N Engl J Med. 1993; 329:987-994.

212. Which soft tissue sarcoma has the lowest incidence of lymph node metastases?

(A) Epithelial sarcoma

(B) Clear cell sarcoma

(C) Synovial cell sarcoma

(D) Malignant fibrous histiocytoma

Key: D

Rationale: Malignant fibrous histiocytoma ~10%; synovial sarcoma ~14%; clear cell sarcoma 28% and epithelial sarcoma 20%.

References: Hansen, Eric K. et al. Handbook of Evidence-Based Radiation Oncology. 2nd edition. Springer Scientific, 2010. p 616.

213. Which of the following cell types of ovarian cancer may include adjuvant radiation as a treatment option for stage I cancers?

(A) Serous
(B) Clear cell
(C) Dysgerminoma
(D) Sertoli-Leydig cell

Key: C
Rationale: Standard treatment options for Stage I Dysgerminomas include: USO with or without lymphangiography or CT; USO followed by observation; USO with adjuvant radiation or chemotherapy. Incompletely staged patients or those with higher stage tumors should probably receive adjuvant treatment. Options include radiation or chemotherapy.
References: Ovarian Germ Cell Tumors PDQ-NCI.

214. What is the correct clinical stage for a squamous cell cancer of the penis invading into the penile urethra with a single mobile palpable enlarged lymph node?

(A) T2N1
(B) T2N2
(C) T3N1
(D) T3N2

Key: C
Rationale: Penile cancer invading into the urethra is T3. A single enlarged lymph node that is mobile and palpable is N1.
References: AJCC 7th edition.

215. What is the mechanism of action of Sunitinib, approved for the treatment of patients with metastatic clear cell renal cell cancer?

(A) An inhibitor of the mammalian target of Ramaycin (mTOR) protein
(B) A multi-kinase inhibitor targeting a number of receptor tyrosine kinases
(C) A monoclonal antibody directed against the epidermal growth factor receptor
(D) A monoclonal antibody that binds and neutralizes circulating vascular endothelial growth factor

Key: B
Rationale: Sunitinib is a multi-kinase inhibitor targeting a number of receptor tyrosine kinases. Bevacizumab is a recombinant humanized monoclonal antibody that binds and neutralizes circulating vascular endothelial growth factor. Temsirolimus is an inhibitor of the mammalian target of Ramaycin (mTOR) protein. Cetuximab is a monoclonal antibody directed against the epidermal growth factor receptor.
References: Trade knowledge.

216. What is the annual whole body effective dose limit (in milli-Sievert) for a radiation worker?

(A) 0.5 mSv
(B) 5 mSv
(C) 50 mSv
(D) 500 mSv

Key: C
Rationale: The annual whole body limit is 50 milli-Sievert (5 rem) for a radiation worker.
References:, Reference, () -NRC Title 10 of the Code of Federal Regulations (CFR) 20.1201

217. Which statistical measure is MOST commonly used to assess differences in survival between two populations?

(A) Student *t*-test
(B) Chi-square test
(C) Fisher exact test
(D) Kaplan-Meier estimate

Key: D
Rationale: The Kaplan-Meier estimator is used to estimate the survival function from lifetime data. In medical research, the Kaplan-Meier estimate and the log rank tests are most commonly used to measure the fraction of patients alive or without disease following treatment.

218. Using the linear-quadratic model, what mathematical expression corresponds to the slope of the survival curve?

(A) α
(B) β
(C) (α+β)
(D) (α+βD)

Key: D
Rationale: The linear quadratic survival expression is $S = e^{-(\alpha D + \beta D^2)}$, where S is the cell surviving fraction, D is the dose delivered and the terms α and β are constants particular to the cell type. Taking the natural log of both sides of the equation "linearizes" it into the general form of "y = mx + b", with a slope corresponding to $\alpha + \beta D$.

219. The BC2001 (James et. al., NEJM 2012) study was a phase III trial that randomized patients with muscle invasive bladder cancer between chemoradiotherapy versus radiotherapy alone. What is the locoregional disease free survival at 2 years in patients who underwent chemoradiotherapy?

(A) 38%
(B) 53%
(C) 67%
(D) 81%

Key: C
Rationale: This is an important study and percentage to remember because it reveals that patients with muscle invasive bladder cancer, who undergo chemoradiation have a cure rate that is comparable to some of the best reported cystectomy series.
References: James ND, Hussain SA, Hall E, et al. Radiotherapy with or without chemotherapy in muscle-invasive bladder cancer. N Engl J Med 2012;366:1477-1488. Shipley, William U., Zietman, Anthony L., (2012) Old Drugs, New Purpose - Bladder Cancer Turning a Corner. New England Journal of Medicine 366:16, 1540-1541.

220. A patient with a 6 cm rhabdomyosarcoma of the bladder with no clinically involved regional lymph nodes and no evidence of metastases has what stage disease?

(A) 1
(B) 2
(C) 3
(D) 4

Key: C
Rationale: Based on the TNM pre-treatment staging classification.

221. What standard protocol is used to facilitate the transfer of medical image data between different manufacturers?

(A) JPEG
(B) RTOG
(C) DICOM
(D) ALARA

Key: C
Rationale: Developed by the ACR and National Electrical Manufacturers Association (NEMA), the DICOM (Digital Imaging and Communications in Medicine) standard was created to aid in the creation and transmission of medical imaging data.
References: Http://medical.nema.org.

222. Linear energy transfer (LET) is defined as the average:

(A) amount of energy imparted to a medium by a charged particle per unit track length.
(B) length of a charged particle track per unit amount of energy imparted to a medium.
(C) amount of energy imparted to a medium per charged particle track independent of length.
(D) number of charged particle tracks imparting a unit amount of energy to a medium.

Key: A
Rationale: LET is defined as the average amount of energy imparted to a medium by a charged particle per unit track length. This is usually expressed in terms of keV/μm. It is important to remember that this is an average quantity and the amount of energy imparted along microscopic segments of the track of equal length is highly variable.
References: Chapter 7 in Hall and Giaccia, Radiobiology for the Radiologist, Seventh Edition, 2012.

223. What was the concurrent chemotherapy regimen used in RTOG 91-11 for laryngeal preservation?

(A) Cisplatin, weekly for 6 cycles
(B) Cisplatin, every three weeks for 3 cycles
(C) Cisplatin and 5-FU, for 3 cycles
(D) Carboplatinum and paclitaxel, weekly for 6 cycles

Key: B
References: Forastiere AA et al. N Engl J Med. 2003 Nov 27; 349(22):2091-8.

224. When Langerhans cell histiocytosis involves only a single organ, the most common single organ involved is the:

(A) bone.
(B) liver.
(C) lung.
(D) pituitary.

Key: A
References: Cancer Treat Rev. 2010 Jun; 36(4):354-9. Epub 2010 Feb 25. Langerhans cell histiocytosis: Current concepts and treatments. Abla O, Egeler RM, Weitzman S.

225. Which muscle invasion by a breast cancer is excluded from the TNM staging?

(A) Pectoralis
(B) Serratus
(C) Latissimus
(D) Intercostal

Key: A
Rationale: Refer to AJCC Staging Manual.

226. Which of the following statements is TRUE regarding INT 0160 trial exploring chemoradiation followed by resection for patients with superior sulcus NSCLC?

(A) Most patients were unable to complete neo-adjuvant chemoradiation.
(B) Local failure was the most common site of disease progression.
(C) Pathologic complete response or minimal microscopic disease occurred in > 50% of patients undergoing resection.
(D) Patients with T3 tumors had double the overall survival of those with T4 tumors.

Key: C
Rationale: In this trial, a very select group of patients with superior sulcus NSCLC (T3-4, N0-1) underwent induction chemoradiation with cisplatin and etoposide concurrent with 45 Gy radiation. Five-year overall survival for the entire group was 44% and 54% for those who underwent a complete resection, which is nearly double that reported for those with N2 disease treated with definitive chemoradiotherapy or neoadjuvant chemoradiotherapy.
References: Rush et al, JCO 2007.

227. Which of the following statements BEST reflects the management of early stage non-small cell lung cancer (NSCLC)?

(A) The 2-year local control rate after 60 Gy of conventional radiotherapy is around 80%.
(B) The 3-year local control rate after SBRT to 54 Gy in 3 fractions is >95%.
(C) The 5-year survival rate after SBRT for medically inoperable stage I disease is around 70%.
(D) Adjuvant chemotherapy is indicated after completion of SBRT for larger tumors.

Key: B
Rationale: A is incorrect because conventionally fractionated RT to 60 Gy is around 30%. The 5 year survival after SABRBRT in inoperable patients is around 30-50%. Giving adjuvant chemotherapy after SABRBRT is not a standard, regardless of tumor size. The correct choice is B, which was demonstrated to be 98% after 3 years based on RTOG 0236 (Timmerman JAMA 2010).

228. What is the MOST appropriate management strategy for thymomas?

(A) Postoperative radiotherapy is indicated for fully resected, well-encapsulated thymomas.
(B) Postoperative radiotherapy may not be needed for fully resected stage II thymomas.
(C) There is currently no established role for adjuvant chemotherapy.
(D) At least 60 Gy is recommended after R0 resection.

Key: B

Rationale: Choice A is incorrect since fully resected stage I thymomas do not need postoperative RT. Choice C is incorrect since chemotherapy is an important component in the management of thymomas. Choice D is incorrect since the recommended postoperative dose for R0 resected thymomas is 45-50 Gy. Choice B is correct because the most recent surgical series suggest that postoperative radiotherapy may be omitted for fully resected stage II thymomas.

229. The 10-year rate of local tumor failure for a WHO grade I meningioma following a Simpson grade I gross total surgical resection is approximately:

(A) 10%.
(B) 20%.
(C) 30%.
(D) 40%.

Key: A

Rationale: The 10 year rates of local failure following a Simpson grade I, II, III, IV resection are approximately 10, 20, 30 and 40%, respectively. High rates of local failure are seen with a 'gross total resection' in Simpson grade I-III resections. Patients need to be followed long term with imaging.

References: Simpson J Neurol Neurosurg Psychiat 20, 1957.

230. What percentage of anaplastic astrocytomas exhibits contrast enhancement on MRI with gadolinium?

(A) 65%
(B) 80%
(C) 85%
(D) 95%

Key: A

Rationale: Approximately 50-70% of anaplastic astrocytomas exhibits contrast enhancement on MRI.

References: Chaichana KL, Kosztowski T, Niranjan A, Olivi A, Weingart JD, Laterra J, Brem H, Quiñones-Hinojosa A.Prognostic significance of contrast-enhancing anaplastic astrocytomas in adults. J Neurosurg. 2010 Aug; 113(2):286-92.
Keles GE, Chang EF, Lamborn KR, Tihan T, Chang CJ, Chang SM, et al.: Volumetric extent of resection and residual contrast enhancement on initial surgery as predictors of outcome.

231. Which action increases the steepness of the tumor control probability curve for a patient population included in a dose escalation clinical trial?

(A) Inclusion of patients with very small tumors
(B) Removal of patients with uncommon radiosensitive tumors
(C) Inclusion of patients with very large tumors
(D) Removal of patients with the most common tumor stage

Key: B
Rationale: Clinically defined groups of tumors are usually characterized by shallow dose-response curves, resulting from heterogeneity among individual dose-response curves. This means that the more heterogeneous a study population is, the flatter the dose-response curve becomes and the more difficult it is to detect an improvement in treatment outcome as a result of an increase in the radiation dose. Factors that cause a flattening of the curve are not limited to different radiosensitivities of the tumors but also include differences in the initial number of clonogens (ie, tumor size), differing hypoxic fractions, or inhomogeneities of dose distribution.
References: Willers and Held. Hematol Oncol Clin N Am 2006; 20:1-24.

232. Which of the following is TRUE regarding surgery for pancreatic cancer?

(A) A biopsy is required before a Whipple procedure.
(B) A Whipple procedure is performed for pancreatic tail and body lesions.
(C) Tumors involving the superior mesenteric vein may still be resectable.
(D) Tumor involvement of the portal vein is an absolute contraindication to surgery.

Key: C
Rationale: A biopsy is not required prior to performing a Whipple to remove a suspicious pancreatic tumor. Tumors with less than 180 degrees of involvement of the superior mesenteric artery may still be resectable. A Whipple procedure is performed primarily for tumors that arise in the pancreatic head. Portal vein resection with reconstruction may be performed for portal vein involvement by tumor.
References: Katz et al., J Am Coll Surg. 2008 May; 206(5):833-46.

233. Which of the following statistical terms is a measure of spread?

(A) Median
(B) Variance
(C) p value
(D) Mean

Key: B
Rationale: Mean and median are both measures of location. Variance is a measure of spread.

234. Which of the following is the MOST important prognostic factor for thymic malignancies?

(A) Presence of myasthenia gravis
(B) Extent of surgical resection
(C) Addition of postoperative radiotherapy
(D) Addition of postoperative chemotherapy

Key: B

Rationale: Choice A is incorrect because myasthenia gravis is not a prognostic factor but an associated paraneoplastic disorder. The additional of radiotherapy improves local control but no convincing evidence that it may improve overall survival. The addition of chemotherapy is an important component in the management of thymic malignancies, but it is less important as compared to the extent of surgical resection. Outcomes are fully dependent on the extent and completeness of resection, regardless of stage or histology.

235. Which of the following features of pleural mesothelioma would indicate unresectable disease?

(A) Involvement of the endothoracic fascia
(B) Direct transdiaphragmatic extension to the peritoneum
(C) Extension into the mediastinal fat
(D) Nontransmural involvement of the pericardium

Key: B

Rationale: Only B is considered as T4 disease, which is locally advanced technically unresectable tumor. The rest features are T3 tumors and potentially resectable.

236. The radiation target volumes used in the randomized clinical trial (Turrisi, et. al.) comparing thoracic radiation of 45 Gy given in once-daily to twice-daily in addition to current chemotherapy for limited-stage SCLC included the gross tumor, bilateral mediastinal and:

(A) ipsilateral hilar lymph nodes.
(B) bilateral hilar lymph nodes.
(C) ipsilateral hilar and supraclavicular lymph nodes.
(D) bilateral hilar and supraclavicular lymph nodes.

Key: A
Rationale: The target volumes for thoracic radiotherapy (45 Gy, given either once or twice daily) beginning with cycle 1 of the chemotherapy (a total of four cycles of ciplatin plus etoposide was delivered) for limited-stage small-cell lung cancer included the gross tumor (as defined by chest CT scan), and the bilateral mediastinal and ipsilateral hilar lymph nodes. Irradiation of the uninvolved supraclavicular fossae was forbidden.
References: Turrisi AT, Kim K, Blum R, et al. Twice-daily compared with once-daily thoracic radiotherapy in limited small-cell lung cancer treated concurrently with cisplatin and etoposide. N Engl J Med 1999; 340:265-271.

237. Which characteristic of a clinical T3 breast cancer is MOST associated with the need for a mastectomy after neoadjuvant chemotherapy?

(A) Lobular histology
(B) Diffuse calcifications
(C) HER-2 over-expression
(D) Estrogen receptor negative

Key: B
Rationale: Diffuse calcifications would not be expected to respond to neoadjuvant chemotherapy and are therefore not good candidates for breast-conserving surgery.
References: Buchholz et al (J Clin Oncol 26:791-797).

238. Which of the following is the MOST aggressive non-Hodgkin lymphoma?

(A) Mycosis fungoides
(B) Mantle cell lymphoma
(C) Grade I follicular lymphoma
(D) Extranodal marginal zone B-cell lymphoma

Key: B
Rationale: Mantle cell lymphoma is mostly diagnosed as stage IV disease and is known to have moderately aggressive course with median survival around 3 years. Follicular, extranodal marginal zone and mycosis fungoides all have indolent disease course.

239. The EORTC randomized clinical study comparing PCI with observation in patients with extensive stage SCLC with any response to systemic chemotherapy showed PCI did all the following, EXCEPT:

(A) higher rate of CNS toxicity.
(B) the one-year cumulative risk of brain metastases was reduced from 40% to 15%.
(C) prolonged the disease-free and overall survival.
(D) reduced the risk of symptomatic brain metastases.

Key: A
Rationale: The cumulative risk of brain metastases within 1 year was 15% in the irradiation group and 40% in the control arm. The 1-year survival rate was 27% in the irradiation group and 13% in the control group. Prophylactic cranial irradiation reduced the incidence of symptomatic brain metastases and prolongs disease-free and overall survival.
References: Slotman B, Faivre-Finn C, Kramer G, et al. Prophylactic cranial irradiation in extensive small-cell lung cancer. N Engl J Med 2007; 357:664-672.

240. As the dose per fraction is reduced and number of fractions increased, the RBE for neutrons:

(A) remains unchanged.
(B) increases.
(C) increases but then plateaus.
(D) decreases.

Key: B
Rationale: As the dose per fraction is reduced and number of fractions increased, the RBE for neutrons increases. This occurs because the amount of sublethal damage recovery, and therefore the size of the shoulder on the cell survival, is less for high LET radiations than for X-rays. This difference is magnified the more highly fractionated (or the lower the dose rate) the treatment is.
References: Chapter 7 in Hall and Giaccia, Radiobiology for the Radiologist, 7th Edition, 2012.

241. Which of the following risk factors is most commonly associated with the development of gastric lymphoma?

(A) Epstein-Barr virus
(B) Human papilloma virus (HPV 16)
(C) Helicobacter pylori
(D) Borrelia burgdorferi

Key: C
Rationale: Helicobacter is well recognized as an associated risk factor in gastric lymphoma. Eradication of Helicobacter pylori with antibiotics often results in resolution of the lymphoma.

242. Which of the following statements is correct concerning proton versus photon beam therapy?

(A) When defining the PTV, an additional margin in depth is required for proton versus photon beams.
(B) Skin sparing effects are more pronounced with proton versus high energy photon beam therapy.
(C) Tissue heterogeneities have a less significant impact on proton versus photon dose distributions.
(D) Tissue dose beyond the distal edge of the target is equivalent for a 200 MeV proton and a 20 MV photon beam.

Key: A
Rationale: In contrast to photon radiotherapy, during proton beam therapy a margin in depth must be used to allow for uncertainties in the geometric relationship of the distal edge of the target relative to the 90% isodose line.
References: ICRU Report # 78.

243. A 70-year-old male with newly diagnosed low risk prostate cancer elects to undergo permanent low-dose rate brachytherapy as monotherapy. Which of the following is an appropriate prescribed monotherapy dose if the patient is treated with 125-Iodine or 103-Palladium?

(A) 110 Gy for 125-Iodine and 90 Gy for 103-Palladium
(B) 130 Gy for 125-Iodine and 115 Gy for 103-Palladium
(C) 145 Gy for 125-Iodine and 125 Gy for 103-Palladium
(D) 150 Gy for 125-Iodine and 100 Gy for 103-Palladium

Key: C
Rationale: An appropriate prescribed dose for low dose rate brachytherapy as monotherapy is 145 Gy for 125-Iodine and 125 Gy for 103-Palladium, according to the American Brachytherapy Society and NCCN guidelines.
References: Davis BJ, Horwitz EM, Lee WR, et al. American Brachytherapy Society consensus guidelines for transrectal ultrasound-guided permanent prostate brachytherapy. Brachytherapy. 2012 Jan-Feb; 11(1):6-19. NCCN Practice Guidelines in Oncology. 2012.

244. Which statement BEST characterizes absorbed dose and exposure?

(A) Absorbed dose and exposure are different measures of ionization in matter.
(B) The definition of both exposure and dose require charged particle equilibrium.
(C) Ionization chambers that are used to measure absorbed dose can also be used to measure exposure.
(D) Exposure is only defined in air for photon beams whereas dose is defined in all media and for all types of ionizing radiation (photons, electrons, protons, etc.).

Key: D
Rationale: B is not true, as absorbed dose is not only a measure of ionization in matter, but generally of imparted energy that includes energy transfers that are below the ionization threshold. A is only true for photon radiation and if you have both corresponding calibration factors. C is wrong, because dose does not require charged particle equilibrium.

245. A 3 cm squamous cell cancer of the anal canal with a 2 cm left inguinal node is staged as:

(A) T2N2 – stage IIB.
(B) T2N2 – stage IIIB.
(C) T3N1 – stage IIB.
(D) T3N1 – stage IIIB.

Key: B
Rationale: A 3 cm tumor would be T2 (2-5cm) and a unilateral inguinal node would be N2. The correct stage for a T2N2 is IIIB.
References: AJCC 7th Edition (2009).

246. Which of the following statements is TRUE about pleural mesothelioma?

(A) Only about 30% of all cases are associated with asbestos exposure.
(B) Sarcomatoid histology is the most common subtype.
(C) They rarely metastasize to lymph nodes.
(D) Epithelioid subtype has better prognosis than biphasic subtype.

Key: D

Rationale: The majority of pleural mesothelioma patients have history of asbestos exposure. There are three main histologic subtypes of mesothelioma: epithelioid, biphasic, and sarcomatoid. Epithelioid tumors are most common and have a better prognosis than biphasic and sarcomatoid tumors. Nodal metastasis is not uncommon.

247. What is the specificity of the x-ray if pathologic results are considered definitive diagnosis?

Normal x-ray and normal pathology	70 patients
Normal x-ray and abnormal pathology	20 patients
Abnormal x-ray and normal pathology	30 patients
Abnormal x-ray and abnormal pathology	180 patients

(A) 70%
(B) 77.8%
(C) 85.7%
(D) 90%

Key: A

Rationale: The sensitivity and specificity are also used in investigating the performance of simpler diagnostic tests. Suppose “gold standard” tests provide whether or not a subject actually has the disease. The number of subjects without disease based on the pathological result is 30+70. Among those 70 subjects are classified as not having disease by X-ray examination: Specificity=70/ (70+30) =70%.

248. The risk of vaginal recurrence at 5 years for patients randomized to vaginal brachytherapy in PORTEC-2 (Nout) was:

(A) 0.6%.
(B) 1.5%.
(C) 1.9%.
(D) 3.3%.

Key: B
Rationale: In PORTEC-2 patients with high-intermediate risk endometrial carcinoma were randomized to receive to pelvic radiation or vaginal brachytherapy after surgery. The vaginal recurrence risk was 1.9% and 1.5%, for pelvic radiation and brachytherapy, respectively.
References: Nout RA, et al. Lancet. 2010; 375: 816-23.

249. Approximately what total dose, delivered in daily 2 Gy fractions 5 days per week, is needed to locally control 90% of tumors containing an average of 10^9 clonogens each? (Assume $\alpha = 0.3$ Gy^{-1}, $\beta = 0.015$ Gy^{-2}, and $T_{pot} = 18$ days.)

(A) 70 Gy over 48 days
(B) 74 Gy over 50 days
(C) 80 Gy over 55 days
(D) 84 Gy over 57 days

Key: B
Rationale: This can be solved using D10 = 2.3/(□ + □d), with D10 corresponding to the dose that decrements cell survival by one log. D10 is then 2.3 * 3 = 6.9 Gy. In this example, ten D10's are needed to reduce cell survival by 10 logs, so therefore 10 * 6.9 = 69 Gy. Taking into account the Tpot, this would add about 3 more doubling times (18 days x 3 = 54 days) or 23 = 8 or 0.8 * D10 (6.9) = 5.5 Gy. Therefore, 69 + 5.5 = 74.5 Gy.

250. Which of the following molecules is the target for hyperthermia-induced cell killing?

(A) DNA
(B) RNA
(C) Lipid
(D) Protein

Key: D
Rationale: Even at mild hyperthermic temperatures, proteins are prone to unfolding and losing their function, whereas DNA, RNA and lipids are more resistant to heat effects.
References: Chapter 28 in Hall and Giaccia, Radiobiology for the Radiologist, Seventh Edition, 2012.

251. Which of the following statements is TRUE regarding lung cancer screening?

(A) Screening annual CXR with sputum cytology improves lung cancer detection.

(B) The Cochrane Meta-analysis (2004) reports an improvement in all-cause mortality with lung cancer screening.

(C) The International Early Lung Cancer Action Project (I-ELCAP) is a randomized trial to validate screening CT.

(D) Screening with low dose CT improves overall survival as compared to CXR.

Key: D

Rationale: All the statements are false except for D, which is the summary of the NLST Research Group published in the NEJM in 2011. Low dose CT improves all cause mortality by 6.7% compared to CXR alone in high risk patients. A is incorrect because CXR + sputum cytology did not improve cancer specific survival. The meta-analysis demonstrated no benefit of screening. The I-ELCAP is an observational study of 31,567 pts with screening CTs.

252. Which of the following provides the best operational definition of PLD repair?

(A) An increase in survival following the delayed plating post-irradiation of density-inhibited cells relative to immediate plating.

(B) An increase in survival following the delayed delivery of a second dose to density-inhibited cells relative to their receiving a second dose immediately after the first.

(C) A decrease in survival following the delayed plating post-irradiation of density-inhibited cells relative to their immediate plating.

(D) A decrease in survival following the addition of oxygen to hypoxic cells within 3 μsec post-irradiation relative to hypoxic cells that receive no oxygen.

Key: A

Rationale: Potentially lethal damage (PLD) is an operational definition that describes changes in survival with altered post-irradiation conditions. If survival is increased PLD is said to be repaired while if there is a decrease in survival PLD is said to be fixed as "fixed in place". The classic example of PLDR repair occurs when survival increases after the delayed post-irradiation subculture of plateau phase cells. The delayed application of a second dose of radiation (split dose experiment) is an example of sublethal damage repair. The addition of oxygen to hypoxic cells very shortly after irradiation is likely to decrease survival.

References: Chapter 5 in Hall and Giaccia, Radiobiology for the Radiologist, 7th Edition, 2012.

253. The largest source of scatter in a photon beam from a conventional linear accelerator treatment head is the:

(A) target.
(B) collimators.
(C) flattening filter.
(D) monitor chamber.

Key: C
Rationale: The flatting filter (FF) is the largest source of scatter. The primary photon beam passes directly through the high density material of the flattening filter creating unwanted photon scatter. Understanding the effects of FF is important as new FF-free machines are becoming an option for IMRT.
References: Liu HH, Mackie TR and McCullough EC "A dual source photon beam model used in convolution/superposition dose calculations for clinical megavoltage x-ray beams. " Med Phys. 24; 1960 (1997).

254. Which of the following T stage groups is appropriate for a 5.5 cm endometrial stromal sarcoma that invades through the myometrium into the serosa?

(A) T1a
(B) T1b
(C) T2a
(D) T3a

Key: B
Rationale: Uterine sarcomas now have a separate staging from uterine carcinomas. The tumor described in this example is confined to the uterus and is greater than 5cm. Therefore the T stage should be T1b.
References: AJCC, 7th edition; 2009.

255. Which of the following is the MOST important prognostic factor predicting survival for patients with ependymoma?

(A) Age
(B) Location
(C) Extent of resection
(D) Clinical target volume

Key: C
Rationale: Extent of resection is the most important prognostic factor. Presence of gross residual disease is associated with worse outcomes.
References: Merchant TE. Current management of childhood ependymoma. Oncology (Williston Park). 2002 May; 16(5):629-42, 644; discussion 645-6, 648, Review.

256. In the absence of stem cell transplantation, approximately how long would it take for half of a group of individuals exposed to 4 Sv whole-body irradiation to die of the hematopoietic syndrome?

(A) 1 week
(B) 2 weeks
(C) 1 month
(D) 2 months

Key: D
Rationale: The hematopoetic syndrome is elicited by acute, whole body radiation doses of more than about 2 Sv. The human LD50/60 in the absence of stem cell support is in the range of 3-4 Sv.
References: Chapter 11 in Shrieve and Loeffler (eds.), Human Radiation Injury, 2011.

257. A 65-year-old male with an 80 pack-year smoking history presents to his urologist with painless hematuria. A cystoscopy identifies a 2.5 cm mass that is biopsied in the office and demonstrates urothelial carcinoma. A staging workup including a CXR, CT of the abdomen and pelvis, and bone scan show no definite evidence of regional or distant metastasis. There is no hydronephrosis. The patient wishes to preserve his bladder and does not want a cystectomy. What is the MOST appropriate next step in the management of this patient?

(A) Begin cispatin-based chemoradiotherapy
(B) Perform a maximal transurethral resection of the tumor
(C) Begin cispatin-based chemoradiotherapy followed by adjuvant chemotherapy
(D) Begin neoadjuvant cispatin-based chemotherapy followed by concurrent chemoradiotherapy

Key: B
Rationale: Maximally safe resection of bladder tumor is essential prior to initiation of bladder preservation therapy with chemoradiation.

258. What structures comprise the CTV for Stage IIIA cervical cancer when using definitive IMRT?

(A) GTV, cervix, uterus, and parametria, including the ovaries

(B) GTV, cervix, uterus, and parametria, excluding the ovaries

(C) GTV, cervix, uterus, parametria including the ovaries and entire vagina

(D) GTV, cervix, uterus, parametria excluding the ovaries and entire vagina

Key: C

Rationale: The CTV components include the entire GTV as noted on intermediate/high signal seen in T2 weighted MR images; the entire cervix if not already included within the GTV contour; the entire uterus; entire parametrium including ovaries and the entire mesorectum if the uterosacral ligament is involved; for the vagina: minimal or no vaginal extension include the upper half, if upper vaginal involvement include the upper two thirds and if extensive vaginal involvement then include the entire vagina.

References: Consensus Guidelines For Delineation of Clinical Target Volume for Intensity-Modulated Pelvic Radiotherapy for the Definitive Treatment of Cervix Cancer. IJROBP Vol 79, No.2, pp 348-355, 2011.

259. What is the main physical mechanism by which photons are produced in a Gammaknife?

(A) The photons are produced by the annihiliation of a positron and an electron within the circular collimators.

(B) The photons are produced during the de-excitation of a Ni-60 nucleus that is the result of radioactive beta decay of a Co-60 nucleus.

(C) The photons are produced by bremsstrahlungs generation in the circular collimators by a beam of high-energetic electrons accelerated in a waveguide.

(D) The photons are produced during the de-excitation of a Co-60 atom that has been stripped of one of its inner-shell electrons by an internal photoeffect.

Key: B

Rationale: The Gammaknife contains Co-60 radioactive sources, therefore A and C are wrong. D is wrong because there is no internal photoeffect process.

260. Which of the following compounds requires hypoxia for its anti-cancer activity?

(A) Paclitaxel
(B) Pemetrexed
(C) Temozolomide
(D) Tirapazamine

Key: D
Rationale: Tirapazamine exhibits selective cytotoxicity for hypoxic cells. In the presence of hypoxia, tirapazamine is metabolized to form a highly reactive radical species capable of inducing single- and double-strand breaks. Under aerobic conditions the radical is back oxidized to the parent compound. It is this futile cycling that provides hypoxic selectivity.
References: Gandara DR et al., Semin Oncol 2002;29:102-109.

261. For a healthy 45-year-old non-smoker with a cT1N1M0 squamous cell carcinoma of the right palatine tonsil with a level 2A node, what is the MOST appropriate treatment?

(A) Induction chemotherapy followed by concurrent chemoradiotherapy
(B) Radiotherapy to the right tonsil and bilateral cervical lymph nodes
(C) Radiotherapy to the right tonsil and ipsilateral cervical lymph nodes
(D) Tonsillectomy and neck dissection followed by postoperative radiation

Key: C
Rationale: This patient has an excellent prognosis. With radiotherapy alone, the 5-year rate of locoregional control for T1N1 oropharyngeal squamous cancers is 95% [1]. The 5-year rate of distant metastases for patients with N1/2a disease treated without systemic therapy is 11% [1]. The risk of occult contralateral nodal metastases is < 5% in cases of well lateralized tonsillar cancers. With ipsilateral techniques, only 2-3% of patients develop contralateral neck failures [2,3]. The morbidity of treating bilateral cervical nodal regions or the addition of chemotherapy is not justifiable in these cases. Chemotherapy by itself is not a curative treatment for head and neck squamous cell carcinomas.
References: Garden AS, Asper JA, Morrison WH, et al. Is concurrent chemoradiation the treatment of choice for all patients with Stage III or IV head and neck carcinoma? Cancer 2004; 100:1171e1178.
Chronowski GM, Garden AS, Morrison WH, et al. Unilateral Radiotherapy for the Treatment of Tonsil Cancer. Int J Radiation Oncol Biol Phys, Vol. 83, No. 1, pp. 204e209, 2012.
O'Sullivan B, Warde P, Grice B, et al. The benefits and pitfalls of ipsilateral radiotherapy in carcinoma of the tonsillar region. Int J Radiat Oncol Biol Phys 2001; 51:332e343.

262. What subgroup of patients with inflammatory breast cancer may have a local control benefit with dose escalated postmastectomy radiation?

(A) High grade
(B) Age greater than 50
(C) Dermal lymphatic invasion
(D) Poor chemotherapy response

Key: D
Rationale: Dose escalation and/or hyperfractionated radiation are not routinely needed for all patients with inflammatory breast cancer (Damast et al. Int. J. Radiation Oncology Biol. Phys., Vol. 77, No. 4, pp. 1105-1112, 2010 and Bristol et al Int. J. Radiation Oncology Biol. Phys., Vol. 72, No. 2, pp. 474-484, 2008.). However, Bristol et al observed that for patients whose disease did not have at least a PR to chemotherapy, a higher dose was associated with a significant benefit in LRC (70% who received 66 Gy had LRC at 5 years versus 32% of those who received only 60 Gy had LRC at 5 years ($p = 0.04$)).
References: Damast et al. Int. J. Radiation Oncology Biol. Phys., Vol. 77, No. 4, pp. 1105-1112, 2010 and Bristol et al Int. J. Radiation Oncology Biol. Phys., Vol. 72, No. 2, pp. 474-484, 2008.).

263. The randomized clinical trial comparing thoracic radiation of 45 Gy given in once-daily to twice-daily in addition to current chemotherapy for limited-stage SCLC demonstrated that twice daily had significantly increased:

(A) Grade 4 esophagitis.
(B) Grade 4 myelotoxicity.
(C) Grade 3 esophagitis.
(D) Grade 3 pneumonitis.

Key: C
Rationale: Grade 3 esophagitis was significantly more frequent with twice-daily thoracic radiotherapy, occurring in 27% of patients, as compared with 11% in once-daily group. There was no difference between groups in the incidence of grade 4 esophagitis.
References: Turrisi AT, Kim K, Blum R, et al. Twice-daily compared with once-daily thoracic radiotherapy in limited small-cell lung cancer treated concurrently with cisplatin and etoposide. N Engl J Med 1999; 340:265-271.

264. What is the recommended tolerance for daily output constancy of a linear accelerator beam?

(A) 1%
(B) 3%
(C) 5%
(D) 10%

Key: B
Rationale: AAPM Task Group 142 recommends 3% tolerance for x-ray and electron beam constancy.
References: AAPM Task Group 142(2009) (an update to Task Group 40 in 1994).

265. The estimated genetic doubling dose for humans is based on mouse data. However recent human data from Japanese a-bomb survivors suggest that these mouse-derived estimates may be:

(A) too high.
(B) too low.
(C) approximately correct.
(D) meaningless.

Key: B
Rationale: The genetic doubling dose is the dose of radiation that produces an induced mutation frequency equal to the spontaneous frequency, hence doubling the overall mutation rate. These estimates have been based on mouse studies historically, and while comparisons with the available human data require judicious use of correction factors to take into account various differences between the systems, the general consensus is that the mouse estimates are too low.

266. The standard diagnostic evaluation of neuroblastoma includes all of the following EXCEPT:

(A) bone scan.
(B) MIBG scan.
(C) lumbar puncture.
(D) urinary catecholamines.

Key: C
References: Matthay KK, Haas-Kogan DA, Constine LS. Neuroblastoma. Halperin E, Constine L, Tarbell N, Kun L. (eds). Pediatric Radiation Oncology. 4th edition. 2004; Lippincott, Williams & Wilkins.

267. Which of the following tissues is hypointense on a T2 weighted MR image?

(A) Edema
(B) White matter
(C) Compact bone
(D) Cranospinal fluid

Key: C
Rationale: Compact bone has the shortest T2 signal of the tissues listed, which will appear hypointense (dark) in a T2 weighted MR image. Unlike the others, compact bone is a solid. In a solid, molecules are closely packed, thus more protons interact (the greater the spin-spin interactions compared to a liquid) and the quicker the T2 signal decays. The T2 relaxation times for the remaining tissues increase in the following order: white matter (77 msec, 1.5 T), edema (125 msec, 1.5 T), and CSF (180 msec, 1.5 T).
References: Hashemi, R.H et al., MRI the basics, 2nd Edition, Lippencott, Williams & Wilkins, Copyright 2004.

268. What study evaluates if a new drug is safe for human use at various dose levels without considering its therapeutic effectiveness?

(A) Phase I
(B) Phase II
(C) Phase III
(D) Phase IV

Key: A
Rationale: A Phase I investigation is devoted to discovering if a treatment is safe and gaining enough understanding of the treatment to design formal studies.
References: Riffenburgh RH. Stattistics in Medicine. 2nd edition.2006; page 5.

269. For which of the following parotid tumors can the post-operative radiotherapy be withheld based on the histologic subtype alone?

(A) Adenocarcinoma
(B) Acinic cell carcinoma
(C) Adenoid cystic carcinoma
(D) Squamous cell carcinoma

Key: B
References: North Int J Radiat Oncol Biol Phys 1990 Jun; 18(6):1319-26.

270. According to the ASTRO Consensus Statement, which of the following is a "cautionary" criterion for accelerated partial breast irradiation?

(A) LCIS present
(B) BRCA 1/2 mutation
(C) Pure DCIS greater than 3 cm
(D) Invasive carcinoma with extensive DCIS

Key: D
Rationale: The ASTRO Consensus Statement advises cautionary patients are those with pure DCIS less than or equal to 3 cm, have extensive intraductal carconima less than or equal to 3 cm or who have invasive lobular carcinoma. LCIS is not treated with breast irradiation. BRCA 1/2 mutation carrier patients are considered unsuitable for APBI.
References: ASTRO Consensus Paper – Accelerated Partial Breast Irradiation. IJROBP 74(4): 987-1001. 2009.

271. Which of the following statements best reflects postoperative management and outcomes for NSCLC?

(A) Chemotherapy is recommended for after a complete resection for a T1bN0M0 disease.
(B) Adjuvant chemotherapy is recommended for a patient with T1bN0 NSCLC after complete resection.
(C) A randomized trial (CALGB) has demonstrated the need for adjuvant chemotherapyradiation for resected T2N01 disease.
(D) Local failure rate after wedge resection is less than 10 percent.

Key: C
Rationale: Choice A is incorrect because adjuvant chemotherapy is only recommended for T2N0 (stage IB) patient with >4 cm tumors, and stage II-III tumors. The CALGB randomized trial for T2N0 NSCLC failed to demonstrate the benefit of adjuvant chemotherapy, except for larger tumors >4cm in an unplanned subset analysis. The local failure rate after wedge resection is 18 percent. The local failure rate of 6% is after a lobectomy.

272. The recommended planning volume around gross tumor for treatment of retroperitoneal sarcomas is a minimum of:

(A) 1.0 cm.
(B) 1.5 cm.
(C) 2.0 cm.
(D) 3.0 cm.

Key: D
Rationale: The recommended margin around gross tumor in the retroperitoneum is 3-5 cm.
References: Chao, K.S. Clifford, et al. Radiation Oncology Management Decisions. 3rd edition. Wippincott, Williams and Wilkins. 2011, page 708.

273. Irradiation of cells under which of the following experimental conditions would cause an inhibition of sublethal damage recovery?

(A) Maintaining cells at a partial pressure of oxygen of 2 mm Hg for 24 hours before and during irradiation
(B) Irradiating cells at 24º C rather than 37º C
(C) Irradiating cells at 40º C rather than 37º C
(D) Maintaining cells in exponential growth during irradiation

Key: A
Rationale: Maintaining cells under conditions of severe hypoxia before and during irradiation inhibits sublethal damage recovery. Recovery does occur for cells irradiated over a range of temperatures between about 5º and 40º C. Recovery also occurs for both exponentially growing and quiescent cells.
References: Chapter 5 in Hall and Giaccia, Radiobiology for the Radiologist, 7th Edition, 2012.

274. A 69-year-old male is diagnosed with a left-sided kidney tumor and five lung metastases, one in each lobe of the right and left lung. The patient undergoes a nephrectomy and stereotactic body radiosurgery (15 Gy x 2) of two of the largest lesions in the lungs. Three months later, the three untreated lesions show a partial response. This may be an example of:

(A) radiation fibrosis.
(B) an abscopal effect.
(C) a radiation recall reaction.
(D) the inverse dose-rate effect.

Key: B

Rationale: This is a potential example of an abscopal effect. An abscopal effect is when a local therapy, such as radiosurgery, has a systemic effect, i.e., a distant bystander effect. This phenomenon that has been rarely described in renal cell carcinoma primarily after hypofractionated radiotherapy.1,2 The mechanism is not well understood, but appears to be dose dependent and may be immune mediated or mediated by anti-tumoral or anti-angiogenic substances locally produced in the irradiated volume.

References: Wersäll PJ, Blomgren H, Pisa P, Lax I, Kälkner KM, Svedman C. Regression of non-irradiated metastases after extracranial stereotactic radiotherapy in metastatic renal cell carcinoma. Acta Oncol. 2006; 45(4):493-7. PubMed PMID: 16760190.
Ishiyama H, Teh BS, Ren H, Chiang S, Tann A, Blanco AI, Paulino AC, Amato R. Spontaneous Regression of Thoracic Metastases While Progression of Brain Metastases After Stereotactic Radiosurgery and Stereotactic Body Radiotherapy for Metastatic Renal Cell Carcinoma: Abscopal Effect Prevented by the Blood-Brain Barrier? Clin Genitourin Cancer. 2012 Mar 10. PubMed PMID: 22409865.
Camphausen K, Moses MA, Menard C, Sproull M, Beecken WD, Folkman J, et al. Radiation abscopal antitumor effect is mediated through p53. Cancer Res 2003; 63: 1990-1993
Demaria S, Ng B, Devitt ML, Babb JS, Kawashima N, Liebes L, Formenti SC. Ionizing radiation inhibition of distant untreated tumors (abscopal effect) is immune mediated. Int J Radiat Oncol Biol Phys 2004; 58: 862-70.

275. Base transversion mutations, identified by next-generation sequencing in cells from a small cell lung carcinoma, are caused by which of the following?

(A) Radon
(B) Tobacco
(C) Mutant EGFR
(D) Asbestos

Key: B

Rationale: Base transversion mutations, such as G>T or C>A, are associated with tobacco smoke carcinogens, a risk factor for the development of small cell lung carcinoma. Several recent articles have highlighted the power of next-generation sequencing methods to analyze the genomic profile of cancer cells.

References: Pleasance et al., Nature 2011; 463:184-90; Cassidy and Venkitaraman, Curr Op Genet Dev 2012; 22:10-13.

276. Common presentations of neuroblastoma include all of the following EXCEPT:
(A) hematuria.
(B) a neck mass.
(C) a palpable abdominal mass.
(D) respiratory compromise.
Key: A
Rationale: Choices B, C, and D are common presenting signs and symptoms of neuroblastoma.
References: Matthay KK, Haas-Kogan DA, Constine LS. Neuroblastoma. Halperin E, Constine L, Tarbell N, Kun L (eds). Pediatric Radiation Oncology. 4th edition. 2004; Lippincott, Williams & Wilkins.

277. Radiation therapy alone is the standard treatment for which of the following subtypes of Hodgkin lymphoma?

(A) Lymphocyte depleted
(B) Mixed cellularity
(C) Nodular sclerosis
(D) Nodular lymphocyte predominant
Key: D
Rationale: Nodular lymphocyte predominant Hodgkin's lymphoma is distinct from the 4 types of Classical Hodgkin's Lymphoma (nodular sclerosis, mixed cellularity, lymphocyte depleted, and lymphocyte-rich Hodgkin's lymphoma). It has an indolent course and is effectively treated with involved-field RT alone.

278. How often are mutations caused by ionizing radiation passed on to the next generation?

(A) Frequently
(B) Sometimes
(C) Rarely
(D) Never
Key: C
Rationale: Mutations caused by ionizing radiation are rarely passed on to the next generation, because first, these mutations must occur in germ cells; second, the particular germ cell (or its less mature precursor) affected must be the one selected to be fertilized; and finally, the mutation must not be of the type that causes embryonic/fetal lethality.
References: Chapter 11 in Hall and Giaccia, Radiobiology for the Radiologist, Seventh Edition, 2012.

279. What is considered to be a close surgical margin in fixed tissue for carcinoma of the vulva?

(A) 8 mm
(B) 10 mm
(C) 15 mm
(D) 18 mm

Key: A

Rationale: One hundred and thirty-five patients with squamous carcinoma of the vulva were treated at UCLA and City of Hope Medical Centers between 1957 and 1985. Sixty-two cases were stage I, 48 stage II, 18 stage III, and 7 stage IV. Twenty-one patients developed a local vulvar recurrence after primary radical resection. Ninety-one patients had a surgical tumor-free margin greater than or equal to 8 mm on tissue section and none had a local vulvar recurrence. Forty-four patients had a margin less than 8 mm; 21 had a local recurrence and 23 did not (P less than 0.0001). Of the 23 patients with a margin less than 8 mm who did not recur locally, 14 remained free of disease, and 9 had either advanced disease, declining health, or short follow-up. Surgical margin is the most powerful predictor of local vulvar recurrence. Combining factors in a stepwise logistical regression does not significantly improve this predictive value. Accounting for specimen preparation and fixation, a 1-cm tumor-free surgical margin on the vulva results in a high rate of local control, whereas a margin less than 8 mm is associated with a 50% chance of recurrence.

References: Surgical-pathologic variables predictive of local recurrence in squamous cell carcinoma of the vulva. Heaps, et al. Gynecol Oncol 1990; 38:309.

280. According to ACOSOG Z4031, which of the following is TRUE regarding staging FDG-PET for NSCLC?

(A) The accuracy is less than 30% in lesions <20 mm.
(B) The accuracy is greater than 90% in lesions >30 mm.
(C) The sensitivity is about 50%.
(D) The specificity is about 30%.

Key: D

Rationale: A prospective trial (ACOSOG Z4031) was reported at 2012 ASCO. This study evaluated the accuracy of FDG-PET in diagnosing NSCLC in 969 patients with clinical stage I (cT1-2N0M0) known or suspected NSCLC were enrolled in the study between 2004 and 2006. In this study, the accuracy of FDG-PET was less than 50% in lesions less than 20 mm, but greater than 80% in lesions greater than 30 mm. However, above 30 mm, the accuracy did not improve. The malignancy rate in patients with FDG-PET scans was 83%. The accuracy of FDG-PET to diagnose lung cancer was 73%, the sensitivity was 82%, and the specificity was only 31%. The positive predictive value was 85%, and negative predictive value was only 26%.

281. Which of the following is true regarding RTOG 9410, a phase III trial comparing sequential to concurrent chemoradiation for patients with locally advanced NSCLC?

(A) Sequential therapy arm consisted of cisplatin and etoposide followed by radiation to 63 Gy.
(B) Concurrent therapy arm consisted of chemotherapy and hyperfractionated radiation.
(C) Five-year overall survival was significantly improved with concurrent chemoradiation.
(D) The rate of acute toxicity was the same between all arms.

Key: C
Rationale: Sequential chemotherapy was delivered using cisplatin and vinblastine, which concurrent chemoradiation used either cisplatin and vinblastine (for QD radiation) or cisplatin and etoposide (for BID radiation). OS was superior for concurrent versus sequential treatment. Acute toxicity was worse with concurrent treatment, though late effects were similar.
References: Curran, J Natl Cancer Inst 2011.

282. What is the incidence of a given disease in exposed or at-risk persons compared to the incidence of the disease in unexposed persons?

(A) Odds ratio
(B) Risk factor
(C) Relative risk
(D) Experimental event rate

Key: C
Rationale: Relative risk is the ratio of incidence of a given disease in exposed or at-risk persons to the incidence of disease in unexposed persons. It is calculated in cohort or prospective studies.
References: Dawson B and Trapp RG. Basic and Clinical Biostatistics. 4th edition, 2004; p. 412.

283. For patients with breast cancer with brain metastases, the histologic subgroup with the most favorable prognosis is:

(A) basal (ER/PR negative, HER2 negative).
(B) luminal A (ER/PR positive, HER2 negative).
(C) HER2 (ER/PR negative, HER2 positive).
(D) luminal B (ER/PR positive, HER2 positive).

Key: D
Rationale: The breast cancer specific GPA (Grade Prognostic Assessment) is a prognostic index with median survival ranging from 3.4 months to 25.3 months based on KPS, age and genetic subtype.
References: Sperduto IJROBP 82, 2012.

284. For a WHO grade I meningioma, the expected 10-year local control following 50-54 Gy fractionated irradiation is:

(A) <50%.
(B) 70%.
(C) 80%.
(D) >90%.

Key: D
Rationale: Local control ranges from 90% to 100% following radiotherapy.
References: Gondi, J Neurooncol 99, 2010.

285. The whole-organ radiation tolerance dose for the kidney is low, whereas small volumes can tolerate much higher doses. This is because the kidney:

(A) contains functional subunits that are arranged in parallel.
(B) shows a strong dependence on overall treatment time.
(C) manifests radiation injury within 3 months of irradiation.
(D) has a small functional reserve.

Key: A
Rationale: By convention, normal organs are classified as "serial" or "parallel", by analogy with electrical circuits. A serial organ is one where a severe injury at any anatomical point in the structure will produce a severe functional loss. The classical example of this is the spinal cord. If there is major damage to the cord at any level, from a small dosimetric hot spot for example, all function can be lost below that level. Examples of parallel organs are the kidneys and the liver.
References: Chapter 14 in Joiner and van der Kogel (eds.). Basic Clinical Radiobiology, Fourth Edition, 2009.

286. The BEST way to track response to treatment of myeloma patients is to follow the:

(A) ESR.
(B) LDH.
(C) IgG levels.
(D) M-protein.

Key: D
Rationale: Understand the significance of M-protein. Measuring M-protein is the best way to assess multiple myeloma.
References: NCCN MM Guidelines MS-2.

287. For a patient to develop the gastrointestinal syndrome from radiation exposure, but not the cerebrovascular syndrome, s/he received an acute dose in the range of:

(A) 0.1 – 1 Sv.
(B) 1.1 – 5.9 Sv.
(C) 6 – 25 Sv.
(D) >25 Sv.

Key: C
Rationale: The gastrointestinal syndrome develops after acute doses of 8-10 Sv, although some of the signs and symptoms of the syndrome are noted after doses as low as 6 Sv. The threshold dose for the cerebrovascular syndrome is typically quoted as greater than 25 Sv, although different published sources can differ widely.
References: Chapter 11 in Shrieve DC and Loffler JS (eds). Human Radiation Injury, 2011.

288. The expected 3-year survival rate for a 55-year-old male, a never smoker with a p16 (+) T3N2bM0 squamous cell carcinoma of tongue base is:

(A) 30%.
(B) 50%.
(C) 70%.
(D) 90%.

Key: D
Rationale: This patient has a p16 positive squamous carcinoma of the oropharynx and has never smoked. Data from prospective studies [1,2] showed that the prognosis in this highly favorable subset of cases, even with stage III and IV disease is excellent with over 90% 3-year survival. There is a strong agreement between tumor HPV status as determined by in situ hybridization and expression of biomarker p16. Tumor p16 status is a well-established prognostic factor in oropharyngeal cancers [2].
References: Fakhry C, Westra WH, Li S, et al. Improved Survival of Patients With Human Papillomavirus – Positive Head and Neck Squamous Cell Carcinoma in a Prospective Clinical Trial. J Natl Cancer Inst 2008; 100: 261-269.
Ang KK, Harris J, Wheeler R, et al. Human Papillomavirus and Survival of Patients with Oropharyngeal Cancer. N Engl J Med 2010; 363:24-35.

289. What is the MOST common pathology for male urethral cancers?

(A) Adenocarcinoma
(B) Squamous cell carcinoma
(C) Transitional cell carcinoma
(D) Undifferentiated carcinoma

Key: B
Rationale: Approximately 80% of all male urethral cancers are squamous cell carcinoma.
References: Devita et al, Cancer, 9th Edition.

290. Tumor lysis syndrome (TLS) is BEST managed with:

(A) calcium.
(B) hydration.
(C) hypothermia.
(D) magnesium.

Key: B
Rationale: General knowledge of complications arising from the treatment of leukemias and lymphomas with chemotherapy. The foundation of TLS management is hydration.
References: NCCN NHL Guidelines MS-15.

291. High dose systemic methotrexate is an appropriate therapy for which tumor?

(A) Ocular melanoma
(B) MALT orbital lymphoma
(C) Breast cancer metastatic to retina
(D) Ocular lymphoma without CNS involvement

Key: D
Rationale: Ocular lymphoma arises in the retina often co-exists with primary CNS lymphoma. Similar to primary CNS lymphoma this tumor is primarily managed with systemic therapy based upon high dose methotrexate with or without radiation therapy.
References: NCCN guidelines for CNS Tumors version 1.2012.

292. A recently (2012) published study on the bladder cancer patterns of pelvic failure, suggests that in ≥ pT3 patients with negative margins, failure occurred predominantly in the:

(A) iliac/obturator nodes and uncommonly in the cystectomy bed and/or presacral nodes.
(B) para-aortic nodes and uncommonly in the mediastinal and supraclavicular lymph nodes.
(C) cystectomy bed and/or presacral nodes and uncommonly in the iliac/obturator nodes.
(D) inguinal nodes and/or presacral nodes and uncommonly in the para-aortic nodes.

Key: A

Rationale: The study in this question is worth reviewing, as pelvic failures after cystectomy are a significant problem that has been largely underreported in the surgical literature. The publication provides detailed failure statistics and diagrams for multiple pelvic locations. Based on the patterns of failure, the authors suggest that adjuvant RT protocols should target at least the obturator and iliac regions in stage ≥pT3 patients with negative margins, and coverage of the presacral nodes and cystectomy bed may be warranted for stage ≥pT3 patients with positive margins.

References: Baumann BC, Guzzo TJ, He J, Vaughn DJ, Keefe SM, Vapiwala N, Deville C,Bekelman JE, Tucker K, Hwang WT, Malkowicz SB, Christodouleas JP. Bladder Cancer Patterns of Pelvic Failure: Implications for Adjuvant Radiation Therapy. Int J Radiat Oncol Biol Phys. 2012 May 30. [Epub ahead of print] PubMed PMID: 22658217.

293. Compared to radiation alone, chemoradiation in anal cancer improves:

(A) overall survival.
(B) colostomy-free survival.
(C) distant metastases-free survival.
(D) disease-free survival.

Key: B

Rationale: Both trials showed a statistically significant improvement in local control as well as in colostomy free survival. Overall survival was not statistically different between the two arms. Both trials used 5FU + Mitomycin C in the chemoradiation arms.

References: UKCCCR, Lancet 348:1049-54, 1996. EORTC, Bartelink et al., JCO 15(5):2040-49, 1997.

294. Which of the following is NOT a characteristic of irradiated ataxia telangiectasia cells?

(A) Contain more residual DNA damage than wild-type cells

(B) Have steep, shoulderless X-ray survival curves

(C) Lack the extrinsic apoptotic pathway

(D) Are deficient in G_1 checkpoint control

Key: C

Rationale: ATM is tumor suppressor, "caretaker" gene whose biallelic inactivation or loss causes the extreme sensitivity to ionizing radiation and cancer proneness characteristic of patients with this clinical syndrome. The ATM protein is an apical kinase that participates in the sensing of DNA damage, the recruitment of repair proteins, and the coordination of the processes of DNA repair and cell cycle checkpoint control. Cells from patients with AT do not experience the G1 phase checkpoint and exhibit high levels of residual DNA damage after irradiation and extreme radiosensitivity as a consequence of having steep, shoulderless x-ray survival curves. And while the apoptotic response to DNA damage is often defective in AT, the extrinsic apoptotic pathway (which is unrelated to the DNA damage response and p53 activation) remains intact.

References: Chapter 3 in Joiner and van der Kogel, Basic Clinical Radiobiology, Fourth Edition, 2009.

295. A 23-year-old male presents with a painless enlarging right testicular mass over a one month duration. Beta-HCG, AFP, and LDH are within normal limits. A transinguinal orchiectomy demonstrates a 3.1 cm classic seminoma. CT of the abdomen and pelvis shows a 2.3 cm interaortocaval lymph node at the level of L2 and an adjacent 1.4 cm preaortic lymph node. What is the MOST appropriate next step in the management of this patient?

(A) Radiotherapy to the retroperitoneum consisting of 20 Gy in 10 fractions

(B) Radiotherapy to the retroperitoneum and hemi-pelvis consisting of 25.5 Gy in 15 fractions

(C) Surveillance because adjuvant radiotherapy is associated with increase mortality due to secondary malignancies and cardiac disease

(D) Radiotherapy to the retroperitoneum and hemi-pelvis consisting of 20 Gy in 10 fractions followed by a 10 Gy boost in 5 fraction to the lymph nodes

Key: D

Rationale: This patient has Stage IIA disease based on the CT findings. It is not uncommon to have cross-over from right to left. Surveillance in not appropriate in Stage IIA disease. The hemi-pelvis should be included for Stage II disease because retrograde spread is possible. A boost to gross disease is indicated for Stage II disease.

296. Which of the following best describes the change in relative biological effectiveness (RBE) as a function of LET? The RBE at:

(A) 10 keV/μm 100 keV/μm
(B) 10 keV/μm ≈ 50 keV/μm
(C) 50 keV/μm 1000 keV/μm
(D) 50 keV/μm

Key: C
Rationale: As LET increases, ionizations are spatially grouped closer together. This spacing is most effective at producing biological damage at an LET of about 100 KeV/μm. Above this level, more dose is deposited in a sensitive target than is required leading to dose "wastage". Another way to think about this is that the number of ionizations per unit dose is constant. Increasing the LET increases the number of ionizations along a particle track while reducing the number of tracks required to produce a specific dose. Targets hit by these tracks will certainly be damaged but as there are fewer tracks, the number of targets hit will be reduced.
References: Chapter 7 in Hall and Giaccia, Radiobiology for the Radiologist, Seventh Edition, 2012.

297. Which of the following is a TRUE basic principle of the meta-analysis?

(A) Unpublished data are included.
(B) Controversial trials are excluded.
(C) Data from single arm trials are included.
(D) Underpowered randomized trials are excluded.

Key: A
Rationale: Only data from randomized trials should be included. No patients should be excluded from analysis. All relevant trials should be included in the analyses.

298. The randomized clinical trial comparing thoracic radiation of 45 Gy given in once-daily to twice-daily in addition to current chemotherapy for limited-stage SCLC demonstrated:

(A) 10% 5-year survival benefit with twice-daily radiation.
(B) Similar 5-year survival rates for both radiation regimens.
(C) 60% local failure rate with twice-daily radiotherapy.
(D) Significantly worse long term toxicity with twice-daily radiation.

Key: A
Rationale: Four cycles of ciplatin plus etoposide and a course of radiotherapy (45 Gy, given either once or twice daily) beginning with cycle 1 of the chemotherapy resulted in 5-year survival rates of 26% for patients receiving twice-daily radiotherapy vs 16% for patients receiving once-daily radiotherapy, for limited-stage small-cell lung cancer.
References: Turrisi AT, Kim K, Blum R, et al. Twice-daily compared with once-daily thoracic radiotherapy in limited small-cell lung cancer treated concurrently with cisplatin and etoposide. N Engl J Med 1999; 340:265-271.

299. What is the MOST common histology for tumors of the ethmoid sinus?

(A) Adenocarcinoma
(B) Esthesioneuroblastoma
(C) Adenoid cystic carcinoma
(D) Squamous cell carcinoma

Key: D
References: Devita textbook.

300. The time interval between radiation therapy and clinical manifestation of injury to slow or non-proliferating normal tissues can be as long as:

(A) 2 years.
(B) 5 years.
(C) 10 years.
(D) >10 years.

Key: D
Rationale: There is no evidence to suggest that the incidence of late normal tissue complications reaches a plateau. Patients can be at risk for certain complications even > 10 years after exposure.
References: Jung et al. Radiother Oncol 2001; 61:233-246; Jagsi et al., Cancer 2007; 109:650-657.

301. Based on the multi-institutional phase I/II trial of SBRT (Rusthoven et. al. (JCO 2009)) for liver metastases, what mL volume of normal liver should be spared?

(A) 100
(B) 250
(C) 700
(D) 1250

Key: C
Rationale: The protocol dose constraints for normal liver (total liver minus cumulative GTV) specified that a minimum volume of 700 mL should receive a total dose less than 15 Gy. From the surgical literature, we know that 75% to 80% of a non-cirrhotic liver can be safely resected. Assuming that the average liver is 2000 mL, then 25% would be 500 mL. Conservatively, they required that 700 mL should be spared (i.e. should receive less than 15 Gy).
References: Rusthoven et al. “Multi-institutional Phase I/II Trial of Stereotactic Body Radiation Therapy for Liver Metastases.” JCO 27(10): 1572-78, 2009.

302. For a patient with T3N2bM0 squamous carcinoma of the base of tongue, IMRT compared to 3D-CRT is:

(A) more effective in reducing xerostomia.
(B) associated with less mucositis.
(C) contraindicated due to a high risk of marginal miss.
(D) not indicated since only ipsilateral nodes need to be treated.

Key: A

Rationale: Parotid glands are typically irradiated during treatment of oropharyngeal cancers, unless special technical precautions are taken [1, 2]. A multi-center randomized study showed that IMRT is superior to conventional radiotherapy techniques in sparing parotid gland function and reducing xerostomia [3]. A risk of missing the tumor increases with any conformal treatment technique, including IMRT. However, data from multiple institutions shows excellent cure rates with IMRT in the treatment of node positive

References:
Lee N, Puri DR, Blanco AI, et al. IMRT in Head and Neck cancers: an update. Head & Neck —DOI 10.1002/ hed April 2007.

Eisbruch A, Ten Haken RK, Kim HM, et al. Dose, volume, and function relationships in parotid salivary glands following conformal and intensity-modulated irradiation of head and neck cancer. Int J Radiat Oncol Biol Phys 1999; 45:577-587, 3.

Nutting CM, Morden JP, Harrington KJ, et al. Parotid-sparing intensity modulated versus conventional radiotherapy in head and neck cancer (PARSPORT): a phase 3 multicentre randomized controlled trial. Lancet Oncol 2011; 12: 127–36.