

# Editorial: The Radiology Fellowship as a Pre-Doctoral Training Equivalent

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## Abstract

In the academic environment, particularly in the traditional sciences, a trainee vested for advanced education often will pursue a master's with a doctor qualifying examination to ascertain their capability for their continuation into advanced independent doctoral study with the ultimate goal being the completion of a dissertation and defensive dissertation with the trainee subsequently being given the Ph.D. or Sc.D. This model is emulated in the European training system, wherein medical training is equivalent to a baccalaureate, residency training may result in a dissertation equivalent to a master's thesis, and junior faculty training often results in the completion of a doctoral exam. In the American medical training system, particularly in radiology, the residency training, which qualifies a candidate for subspecialty performance at the diagnostic radiology level or radiation oncology level, is equivalent to many master's programs and often is conjoined with curricula in basic physics and, depending on the institution, research methodology or other proscribed curricula. In those areas for which the subspecialization training in fellowship has been very uniquely and explicitly described, such as: interventional radiology, nuclear medicine, pediatric radiology, and neuroradiology, certificates of added qualification can be viewed as doctoral qualifying exams. These exams are not necessarily designed to ascertain the high level of competence or expertise, but rather a level of ability in the subspecialty areas. These examinations, consequently, which may or may not have written, but do have oral components of defense associated with them, are very similar to scientific doctoral qualifying exams.

Those trainees that have passed those certifications and pursue academic careers effectively may produce results equivalent to a dissertation with defense when they generate independent publications and present these results at appropriate subspecialty research meetings. Areas in

radiology that do not have explicitly defined certificates, such as body imaging, MRI, musculoskeletal radiology, and chest radiology, consequently have no equivalent opportunity for the candidates to be able to, at least in their mind, establish that they have completed an adequate curriculum that could allow them to be independent investigators. At our institution, we have a magnetic resonance imaging fellowship with concentration in body imaging, which includes thoracic and abdominal magnetic resonance imaging along with cardiovascular and musculoskeletal MRI. As such, the broad breadth of the training provided at our fellowship requires very explicit understanding of the applied principles of MRI physics in protocol design. The goal is that trainees have accomplished this minimal level of expertise so that excellent diagnostic studies can be performed by them in the future either for clinical or research purposes. In addition, such minimal training can allow the confident fellow in their further career to be able to feel confident in their understanding for protocol design and potentially invent a research project design.

Consequently, we have designed a CAQ equivalency exam, which we present here as a model. As in most doctoral qualifying exams, there is no explicit right or wrong answer, but rather these are mechanisms for which the candidate may explore thinking patterns, exercise independent thinking and individual judgement ideally with appropriate literature to justify the decisions they have made. Thus, answers that may be more than adequate at this point in time may be insufficient in a few years henceforth. As such, we feel that this exam meets the criteria of a doctoral qualifying exercise, since discourses with the appropriate faculty allow exploration of a candidate's abilities and deficiencies in a non-explicitly judgmental manner. In addition, this allows the candidate who has completed the exam to be able to, in

their own mind at least, feel that they have obtained a high level of competency to prepare them for independent practice or research. We present the exam herein to the community as an example and hope that this may open a dialog in discourse for other non-CAQ certified training opportunities, to be able to provide their fellows with similar opportunities for self evaluation.

### **MR QUIZ FOR FELLOWSHIP/FINAL EXAM**

1. You are performing a turbo-spin echo sequence with a TR of 4000, TE of 150, turbo factor 16, field of view of 40cm squared, with a 256 x 256 matrix, and NSA of 4 (averages).
  - a. What is the time of acquisition of this study?
  - b. Approximately how many interleaved slices will you obtain?
  - c. What is the spatial resolution per pixel?
3. You are using a 1 Tesla magnet with a bandwidth of 220 hertz. What is the chemical shift artifact and how many pixels will it comprise?
4. You are using a non-spoiled gradient recalled echo 2 dimensional imaging sequence with a flip angle of 30 degrees, and in order to increase contrast between slow flowing blood and stationary tissue you have increased the TR to 45 milliseconds.
  - a. What was the original optimal flip angle?
  - b. What is the current new optimal flip angle? Hint: Consider the ernst equation
6. You have a 2 dimensional gradient echo study with a TR of 125 milliseconds and a TE of 10 milliseconds.
  - a. How many slices approximately do you expect to obtain in a single stack
  - b. If you need to add 2 more slices to cover the anatomy of interest, describe two ways of performing this and the trade-off of each of these techniques, and what factors may need to be compensated accordingly.
8. You are performing a cardiac gated study of a possible intracardiac mass, and you wish to perform a cine sequence; the patient's heart rate is 80 beats per minute.
  - a. What is the maximum number of phases to the cardiac cycle that can be obtained using a gradient recalled echo sequence with a TR of 10 milliseconds and a TE of 2 milliseconds?
  - b. What is the minimum number of images that may be obtained of phases through the cardiac cycle?
10. You have a .5 Tesla magnet and you need to perform in and out of phase imaging, what echo times will give you in phase and out of phase sequences?
11. You are going to be performing a single shot dynamic gradient echo 3D MRA of the thigh in a patient. The acquisition will take 23 seconds and the contrast test bolus injection arrives at approximately 45 milliseconds. What is your optimal delay time between initiating contrast injection and initiating scan acquisition in this study?
12. You need to perform a T2 weighted cardiac gated image in the chest with an echo time of approximately 100 milliseconds. The heart rate is 50.
  - a. What R to R interval will you be considering
  - b. Approximately how many slices do you expect to obtain during this sequencing
  - c. Where in the cardiac cycle do you expect initial imaging to begin?
14. What is the inversion time of fat and what other materials and in what state will have inversion times of similar magnitude, assuming a study performed in a 1 Tesla magnet? What are the implications of this information?
15. What is the range of acceptable gadolinium doses for a 10 pound baby? Please show calculation.
16. Design a protocol for graft versus host disease complications imaging and rationalize each

sequence for the protocol accordingly. Order in what you believe to be the most important to least important sequences.

17. Patient with known melanoma presents with a solitary pulmonary nodule. Design an MR sequence to ascertain if this may represent metastatic disease and justify each sequence used in the protocol.
18. Patient with possible aortic venous malformation in the chest, seen on CT, is presented for an MR. Design a protocol and rationalize the sequences you have suggested.
19. Patient presents for MR of the shoulder and has known permanent tattoo markings overlying a suspected mass. What protocol adjustments would you want to consider, if any, and why?
20. A pregnant patient, at approximately 20 weeks gestation, has been shot with a 45-caliber bullet and there is a concern that the bullet may have transgressed the major uterine artery along with the external iliac artery and possibly vein.
  - a. Would you MR this patient?
  - b. What risk and benefit considerations

would you discuss with the patient and the referring physicians?

- c. What protocol would you use? Justify each sequence and their objective.

22. You are going to be performing an MR arthrogram using 10ml of sterile saline and either .1 or .3 ml of gadolinium DTPA with post-arthrographic images being a conventional spin echo sequence with a TR of 500, TE of 20 milliseconds, slice thickness of 5mm. What will the difference in signal between the two gadolinium concentrations be?

This represents the completion of the MR Fellowship Exam. You are honor bound to have done your best; however, any and all resources, including conferring with each other, technologists, and various staff to assist you in approaching these problems is allowed, though encouraged only after you have attempted to tackle the question on some level by yourself. Obtaining a score of 80% or better would demonstrate exemplary mastery of the concepts necessary for being an independent MR investigator. A score of less than 50% would warrant assistance with a directed reading list.

## References

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