Learning from the plain film competency assessment in the Singapore radiology residency programme

Martin Weng Chin H'ng, FRCR[1], Joshua Guo Xian Wong, MSc[2], David Soon Yiew Sia, FRCR[3], Winston Eng Hoe Lim, FRCR[4], Daniel En Shen Wong, FRCR[1]

[1]Department of Diagnostic Imaging, Tan Tock Seng Hospital, [2]Office of Clinical Epidemiology, Analytics and Knowledge, Tan Tock Seng Hospital, [3]National University Health Services (NUHS), Level 3, National University Hospital, [4]SingHealth & Senior Consultant, Department of Diagnostic Radiology, Tan Tock Seng Hospital

ABSTRACT

Introduction: The national Plain Film Competency Assessment (PFCA) was held to allow passing Residents to report plain radiographs independently and thus perform on-call night duties. Our study aimed to investigate factors influencing performance in this exam.

Methods: This was a retrospective study of data from 2012-20. Training data included previous experience in radiology as well as number of reported films (total and by body regions) whilst examination data comprised these scores as well as error analysis (classified as False Positives, False Negatives or Incorrect Abnormality) for the main and repeat sittings.

Results: Up to 222 residents were included for statistical analysis. Those with previous radiology exposure were more likely to pass, 85.1% compared to 68.9% (c=0.03) and had higher scores, 85.1 versus 81.3 ($p<0.01$). The number of co-reported films did not affect passing even after excluding those with previous experience. Chest and limb radiographs made up at least three-quarters of the reported films, with residents passing these whilst failing those from the abdominal, skull and spine regions. There was no significant difference between their improved scores after undergoing remediation of either one or four months in duration. However, error analysis after remediation revealed a lower combined percentage of False Positives and Negatives.

Conclusions: Experience in a radiology posting after graduation facilitated passing. Although we could not establish an association between the number of reported films and passing, there was an imbalance in the variety of reported films, which should first be resolved.

KEYWORDS:
Diagnostic Radiology; Plain film training and assessment; Residency Programme; Fellow of the Royal College of Radiology (FRCR) Examination

INTRODUCTION

Postgraduate specialist medical training in Singapore adopted the American-style Accreditation Council for Graduate Medical Education International (ACGME-I) system in 2010.[1] After graduating from medical school and completing the compulsory one-year internship, doctors can continue rotating through various medical disciplines as a Medical Office Posting Exercise Medical Officer (MOPEX-MO), which is a non-trainee position, or begin specialist training by joining the Residency Programme (RP). In radiology RP, local hospitals are divided into three clusters (Central, Western and Eastern). The training program in each cluster is helmed by a Programme Director (PD) based in the Sponsoring Institution with Residents rotating in-and-out of that hospital to Participating Sites (other hospitals within the same cluster) and occasionally across clusters.

Amidst the availability of higher-order imaging modalities and image-guided interventions expanding in tandem with artificial intelligence, the interpretation of plain radiographs remains a fundamental tenet of radiology.[2,3] Therefore, Residents spend a large portion of the initial year of their 5-year programme learning to interpret them. Prior to the RP, traineeship resembled an apprenticeship, where feedback from "buddy" reporting and/or in-house assessments determined whether a trainee could report independently and perform on-call night duties.[1,4] These had a degree of subjectivity and were conducted within the respective institutions instead of at the national level, making them an improper gauge of a trainee's preparedness for this task. Unfortunately, this method continues to be applicable to the radiology MOPEX-MOs. With the RP, ACGME-I mandated that every film be co-reported with a specialist and signed out by the latter, but allowance was given for Singapore to hold a national Plain Film Competency Assessment (PFCA) mid-way through their first year of residency training (RY1) to allow passing residents to report independently and perform night calls. Despite being granted this latitude, the passing residents are continually audited to ensure patient safety.[5]

There have been opposing views regarding mastering image-interpretation exams, such as the PFCA, with some believing it to be number-based and others contending it to be time-dependent.[4,6] Our prerequisite of having co-read a minimum of 600 films to be eligible to sit for the PFCA had been an arbitrary one, and if the volume was an issue, this number would need to be tweaked. The remediation period had also been raised from one to four months, starting from the fourth year of conducting this exam, with the unvalidated assumption that a longer duration would serve this purpose better. Hence, the objectives of our study to investigate (1) the

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Corresponding Author: Martin Weng Chin H'ng
Email: martin_hng@ttsh.com.sg

number and variety of films, (2) the period of remediation, and (3) other experiential factors that may influence performance in the PFCA comes at a timely juncture as it has been almost a decade since its inception. Given the enduring British influence in training, our residents also sit for the Fellow of the Royal College of Radiology (FRCR) Part 2B (final) Examination as early as RY3.[1] We hope that our findings will benefit PDs and their residents during plain film training and in preparing for both the PFCA as well as the FRCR 2B, which the former was modelled after.

MATERIALS AND METHODS

Study design

PFCA parallels the rapid reporting component of FRCR 2B albeit with simpler parameters.[5] First, it comprised two papers (Papers A and B) with 30 questions each instead of one paper in the FRCR, with the pass mark arbitrarily set at an average of 80% compared to 90% for the latter.[5,7-9] We envisaged that a single paper of 30 questions might not be representative, if biased by exam anxiety or unfamiliarity with the equipment, this being their first major hurdle after beginning residency.[10,11] Instead of having a solitary 60-question paper that would have been too strenuous, we simply doubled the number of papers to maintain the format. Second, each paper in the PFCA was allotted 60 min (with a half-hour interval in between) in contrast to 35 min in the FRCR.[7,11] Each paper consisted of a mixture of normal and abnormal films (40-60% of each), chosen to replicate those typically encountered during daily work.[7] If an abnormality was identified, the candidate had to fully describe the pathology. The PFCA was administered and marked by a board of examiners selected from different training hospitals across Singapore as well as by expertise in those body regions. The main sitting (1st attempt) was held around the 7th month after commencing training. For unsuccessful candidates, there was one resit (between 2012-14) in the 8th month, or two resits (from 2015-20) in the 11th (2nd attempt) and 12th (3rd attempt) months. After the initial few runs, the committee was able to adjust several variables which then formed a blueprint for subsequent sittings. One of these was stratifying abnormal films into easy, moderate and difficult grades, with approximately half of them being easy. Another was having an almost equal proportion of truncal (i.e. chest, abdominal, skull and spine) as well as appendicular (i.e. limb) radiographs, reflecting those from general practice and the emergency department. The last was having a longer period of remediation with the belief that it may fulfil its intended purpose and yield better results.

Error analysis was only provided for failing candidates to guide remediation. These were classified into “False Positive” (i.e. identifying a normal film as abnormal), “False Negative” (i.e. missing to observe an abnormality) and “Incorrect Abnormality.”[5] Whilst the first two were more perceptual in nature, the last group dealt with cognitive errors.[12] It usually includes mixing-up the sides, erroneous spelling (e.g., coronoid versus coracoid), or incorrect nomenclature (e.g., metatarsal instead of metacarpal) but occasionally reflects insufficient experience and hence attributing abnormality to the inappropriate structure (e.g., mediastinal instead of pulmonary mass) or inability to conclude accurately (e.g., diagnosing malignancy rather than benignity). This was a local initiative afforded to candidates to guide them in their formative years with the mode of remediation left to the respective PDs.

Study population and eligibility criteria

First year residents would undergo an initial six months of supervised reporting. They co-reported these films with senior staff, with the latter signing out the final report until they passed the PFCA. Residents were required to keep a log of the number and types of plain radiographs that they had co-read, and a minimum of 600 films were required before they were eligible to sit for this exam.[5]

Statistical analysis

We conducted a retrospective study using data from 2012 to 2020. All resident data collated by the respective PDs and the examination data collected by the PFCA examination committee were reviewed. Data from the PDs included previous experience in radiology (categorized based on intensity of exposure) as well as the number of films (total and proportion by body regions) co-reported since beginning residency training. Given the retrospective nature of this study, our figures were retrieved from resident logbooks as well as Patient Archiving and Communication Systems (PACS). The examination data included scores and sub-scores for the main and repeat sittings. All data were anonymized and tabulated in password-protected Microsoft Excel 2018. Pearson’s and intra-class correlation coefficients were calculated for the pair of papers of the main sitting, but not for the resits that had fewer candidates. Associations between categorical variables were tested using Pearson’s chi-squared test, or Fisher’s exact test if at least one of the expected cell counts was < five. Independent and paired t-tests were employed when there were two categories of continuous variables, while One-way Analysis of Variance (ANOVA) was employed when there were more than two of these, against nominal-level variables. All Statistical analyses were performed using IBM SPSS Statistics (version 29.0; IBM Corp., Armonk, NY, USA). Statistical significance was declared if the p-value was less than 0.05. This study was approved by the National Healthcare Group Domain Specific Review Board (reference no. 2020/01225).

Outcome measures

When considering previous experience, the PDs graded the RP applicants according to whether they had performed an elective in radiology as an undergraduate or had worked as a radiology MOPEX-MO before joining the RP. There was even a handful who had come from abroad seeking employment in Singapore, and they had to enrol in the RP despite already passing the FRCR and accredited as a specialist in their home country. This was because their training program may not have been recognized by the Singapore Accreditation Board. Groups without and with previous experience were compared with respect to their ability to pass on their 1st attempt and their obtained scores to determine if this made a difference.

In order to determine the effect of number and variety of co-reported films, passing and failing residents on the 1st attempt were compared with respect to the number of radiographs they reported in total and by body regions, with

corresponding scores for the latter. We postulated that passing residents were likely to have reported more radiographs and performed better for each body region.

To study the effect of a shorter versus longer remediation period, the number who passed the resit and their scores were compared. The same was performed with regards to their error analysis subsequently. We hypothesized that a longer period of remediation would improve these outcomes.

Given that there were a pair of papers in each attempt, it would be beneficial to study the effect one paper had on the other. We hypothesized that residents would perform less consistently on the 1st sitting resulting in a lower correlation between pairs of papers and larger difference in these scores. For residents who passed one paper, the likelihood ratio of them passing the PFCA if it was Paper A was calculated for each sitting. We envisaged that the effect of anxiety on performance would be more profound on the initial rather than subsequent sitting.

Error analysis was performed for all candidates for the purpose of this study. The shift from False Positive or Negative towards Incorrect Abnormality may suggest acquisition of radiological proficiency with concomitant reduction of perceptual errors, and hence a lower tendency to over- or under-call an abnormality.

RESULTS

There was a total of 222 Residents across this period, averaging 20-32 Residents per year. They were divided into the following three clusters: 61 (from the Central Cluster), 54 (from the Western Cluster) and 107 (from the Eastern Cluster). Review of the examination data revealed that 165 passed in one attempt, 46 in two attempts and 8 after three attempts. The remaining three either did not pass after exceeding the maximum number of tries or had dropped out before then.

Results of the 1st attempt

The average scores for the Central, Western and Eastern Clusters were 83.5 (SD=7.7), 82.2 (SD=6.6), and 82.2 (SD=7.5), respectively, which were not statistically significant (p=0.496). The 165 residents who passed scored 86.0 (SD=4.3), while the 57 who failed scored 72.6 (SD=4.7); the difference in their scores was significant (p<0.01).

Did previous rotation through radiology influence passing?

We divided previous exposure in radiology into four categories in order of increasing intensity

- Level 0 (n=138) – no previous experience in radiology
- Level 1 (n=10) – undertook a radiology elective during their final year of medical school. Such attachments were usually up to one month in duration. The experience gained was very general, and although they may be taught the basic principles of reading plain radiographs, they would not have co-reported any of these.
- Level 2 (n=68) – previous rotation through radiology as a MOPEX-MO
- Level 3 (n=6) – post-graduate specialist from overseas with FRCR

As the first two levels excluded radiology reporting, it was sensible to combine these. We found that 68.9% of those in Levels 0 and 1 passed at their 1st attempt compared to 83.8% of those from Level 2 and 100% of those from Level 3 which was significant (c=0.041). Their respective scores were 81.3 (SD=7.3), 84.8 (SD=6.9) and 89.2 (SD=4.3), which was also statistically significant (p<0.01).

Effect of number and type of co-reported films

Missing logbook data involving seven Residents (across all clusters) as well as incomplete data of 19 Residents from the Western Cluster due to a cluster PACS upgrade availed us with 196 Residents for the subsequent calculations.

They co-reported an average of 1539.4 (SD=706.1) films before their 1st attempt. The 146 (72.4%) residents who passed co-reported an average of 1567.8 (SD=725.7) films. The 50 residents who did not pass co-read an average of 1456.4 (SD=644.9) films. This difference was not statistically significant (p=0.337). As residents with previous radiology exposure (Levels 2 and 3) would have had a higher number of films unaccounted for, 127 residents from Levels 0 and 1 were considered separately. The 87 who passed the co-reported 1642.7 (SD=800.4) films compared to the remaining 40 who co-read 1471.0 (SD=681.4) films, but the difference was not statistically significant (p=0.242). Chest and limb radiographs made up at least three-quarters of the reported films (Table I). On the average, residents had passing sub-scores for these body regions but failing sub-scores for the abdominal, skull and spine films. More specifically, unsuccessful residents had failing sub-scores in almost all body regions.

Period of remediation

Fifty-six candidates underwent remediation (one had dropped out after the 1st attempt). Twenty Residents took the resit within a month and 36 after four months. With the shorter remediation, 90.0% passed whilst with a longer remediation 77.8% passed, with no significant difference in the pass rate (c=0.318). The former showed an increase in scores from 71.9 to 83.2 (p<0.001) and the latter, an increase in scores from 73.0 to 83.0 (p<001). Despite the better scores after remediation, the improvement between these two groups was also not significant (p=0.920).

Comparison between the pair of papers in each attempt

The Pearson and intraclass correlation coefficients for the two papers of the main sittings were 0.337 and 0.495, respectively. There were 65 Residents who passed only one paper on their 1st attempt. The likelihood ratio of passing the 1st attempt if they passed Paper A was 1.87. This likelihood was reduced to 0.83 in their 2nd attempt. The difference in scores between the pair of papers in each attempt between those who passed and those who failed was not statistically significant, albeit with a narrower interval for the former on both occasions (Table II).

Error analysis

In the 1st attempt, those who failed had a relatively higher percentage of False Positives and Negatives but lower Incorrect Abnormalities, all of which were not significant (Table III). Repeaters, regardless of whether they passed or failed, showed an increase in Incorrect Abnormalities to

Table I: Distribution of reported radiographs by body regions as a proportion (%) of total films reported, and their corresponding sub-scores, stratified according to Residents who failed or passed the 1st attempt of the PFCA

	Central Cluster		Western Cluster		Eastern Cluster[a]		Average
	Fail	Pass	Fail	Pass	Fail	Pass	
No. of Residents	18	41	10	40	21	75	205
%Chest (SD)	45.2 (9.6)	43.6 (11.6)	33.9 (11.7)	36.4 (7.3)	49.9 (8.1)	50.7 (7.3)	45.1 (10.9)
Sub-score (SD)	67.4 (14.1)	86.7 (11.5)	70.7 (17.6)	81.4 (13.3)	74.3 (12.7)	85.3 (11.0)	81.4 (13.7)
%Limbs (SD)	36.2 (9.5)	37.3 (10.2)	45.7 (12.4)	42.9 (9.3)	25.4 (8.1)	26.8 (7.3)	33.6 (11.3)
Sub-score (SD)	79.7 (7.7)	91.0 (6.3)	80.2 (6.1)	88.6 (5.8)	77.3 (6.6)	90.6 (5.7)	87.5 (8.0)
%Abdomen (SD)	11.5 (2.4)	11.9 (3.7)	10.1 (2.9)	9.7 (2.5)	15.8 (6.9)	13.6 (4.0)	12.3 (4.3)
Sub-score (SD)	70.7 (18.4)	88.9 (10.5)	59.0 (12.8)	79.1 (13.9)	67.8 (13.7)	81.5 (14.4)	79.1 (15.8)
%Skull (SD)	0.9 (0.7)	1.0 (0.6)	0.5 (0.6)	0.6 (0.6)	1.9 (1.0)	1.7 (1.0)	1.2 (1.0)
Sub-score (SD)	64.4 (22.8)	73.4 (21.8)	80.8 (16.7)	81.5 (24.6)	57.9 (26.0)	78.4 (23.7)	74.9 (24.1)
%Spine (SD)	6.3 (1.7)	6.3 (2.3)	9.9 (2.9)	10.5 (2.5)	7.1 (1.6)	7.2 (1.6)	7.7 (2.8)
Sub-score (SD)	63.6 (19.2)	76.3 (15.6)	70.7 (15.7)	81.6 (12.2)	64.0 (13.8)	75.3 (10.8)	74.3 (14.5)

[a] Ten Residents were excluded due to incomplete data by body regions

Table II: Difference in scores between the pair of papers between those who passed versus those who failed in each attempt

	Passed Mean (SD)	Failed Mean (SD)	Significance
1st attempt – difference in scores	7.5 (5.4)	8.1 (6.4)	0.481
2nd attempt – difference in scores	6.4 (5.0)	9.7 (7.3)	0.099

Table III: Comparison of error analysis between those who passed versus those who failed in each attempt

	Passed Mean (SD)	Failed Mean (SD)	Significance
1st attempt			
False positive (%)	24.83 (15.8)	28.38 (12.2)	0.128
False negative (%)	31.71 (16.4)	33.33 (14.6)	0.516
Incorrect abnormality (%)	43.46 (18.3)	38.29 (16.5)	0.064
2nd attempt			
False positive (%)	25.88 (17.8)	24.37 (8.8)	0.797
False negative (%)	26.38 (15.2)	26.57 (8.5)	0.485
Incorrect abnormality (%)	47.74 (19.4)	49.06 (10.6)	0.419

Table IV: Error analysis for repeat candidates in each attempt as well as after stratifying them according to their duration of remediation

	1st attempt Mean (SD)	2nd attempt Mean (SD)	Significance
False positive (%)	27.16 (12.1)	25.58 (16.4)	0.605
False negative (%)	30.51 (12.4)	26.42 (14.0)	0.142
Incorrect abnormality (%)	42.33 (11.7)	48.00 (17.9)	0.048
Short remediation (n=15)[a]			
False positive (%)	32.69 (10.5)	24.87 (17.0)	0.186
False negative (%)	24.16 (9.8)	26.29 (13.1)	0.655
Incorrect abnormality (%)	43.15 (12.1)	48.84 (14.9)	0.266
Long remediation (n=36)			
False positive (%)	24.85 (12.2)	25.87 (16.3)	0.774
False negative (%)	33.16 (12.5)	26.48 (14.6)	0.051
Incorrect abnormality (%)	41.99 (11.6)	47.65 (19.2)	0.108

[a] Five Residents were excluded due to incomplete data

almost 50% on the 2nd attempt. A paired-sample t-test revealed that this increase was significant overall (Table IV). Both short and long remediations confirmed these increases, but not significantly.

DISCUSSION

Radiology teaching in medical schools is usually transmitted via lectures or opportunistic visits to the radiology department, while those for non-trainees are usually conducted by non-radiology personnel.[13] Unfortunately, nearly two-thirds of our residents enter RP under such circumstances. We found a statistically significant difference in passing the PFCA on their 1st attempt, and with higher scores, by residents who had had radiology experience after graduating compared to those without. This affirms our current practice of encouraging those intending to join radiology to rotate through as a MOPEX-MO beforehand, rather than dive straight into the RP. In addition to gaining insight into this specialty before committing, it is believed that this exposure facilitates swifter comprehension of radiology concepts upon commencing training.[5] An understanding of the sigmoid learning curve may explain why time spent as a radiology MOPEX-MO is not futile.[14]

We did not find a significant difference between the number of films read by those who passed or failed, even when those with previous experience were excluded. The poor association between the number of films reported and passing could be explained by these confounders. It should be noted that the predominant films reported by the residents were chest and limb radiographs, which the majority would have passed. With an almost equal weight given to the truncal region, lack of exposure to films in these domains (save for chest radiographs that were performed not only for diagnosis but also for screening and to complete pre-operative workup) is likely to explain their failing sub-scores on average. This situation may stem from a dearth of performance of such films nowadays or perhaps a lack of confidence, causing residents to shy away from reporting them.[10] Residents should be cognisant that it is not merely the number of films in as much as their variety.[6] Training gaps should be supplemented with additional tutorials and residents taking their own initiative to gain proficiency. Therefore, we postulate that the need to tweak the minimum number is not as crucial (seeing that it had been more than twice surpassed) as compared to the spread of films, which should be implemented at the PD level.

A comparison between the pairs of papers in each attempt provides us with the following insights:

- The likelihood ratio of them passing the 1st attempt if they passed Paper A was 1.87, or an increase of approximately 15%.[15] The findings suggest that a good start in Paper A bodes well, whereas a poor performance may be detrimental enough not to be compensated by better performance in Paper B. A survey by Yeung et al. found that about one-third of respondents felt that anxiety negatively affected their performance in the rapid reporting component of the FRCR 2B exam, despite being the least stressful of the three sections.[11] However, as a stand-alone entity in the PFCA and being their first high-stakes assessment in residency, the level of perceived anxiety could be much higher. A strategy to alleviate this would involve better preparation in a similar mock setting.[11]
- Error analysis showed a higher percentage of Incorrect Abnormalities for those who passed rather than failed the 1st attempt (approaching significance, p=0.064) as well for all repeaters in the 2nd attempt (which was significant, p=0.048). The shift towards being classified as an Incorrect Abnormality rather than a False Positive or Negative should be viewed favorably as reflecting a lower tendency to over- or under-call a radiographic abnormality, which can be harder to remediate.

Khan et al., who held their pre-call assessment initially after six months, and in the latter stage after 12 months (rather similar to us), found no difference in performance between cohorts at these time points, but instead discovered an improvement that occurred, at earliest, midway through their second year.[4] Their findings suggest the existence of other factors, such as the spectrum of films and diversity in training, which may accelerate the attainment of higher-order proficiencies, including honing perceptual and cognitive skills required for image interpretation.[16] Similarly, we did not find a significant difference between our residents undergoing short or long remediation, which occurred during RY1. The only way to validate the findings of Khan et al. is to conduct another assessment in RY2. Nevertheless, it is assuring that Tan et al., who audited resident plain film reporting data from our RPs (from 2012 to 2018) found a favorable major discrepancy rate of 0.04-1.13% (mean 0.34%) as compared to American data of 1.4-1.5%.[5]

LIMITATIONS

Despite the nine-year period of study, the numbers remain small in this niche specialty. Under-estimated numbers may arise from delay entering logbooks, patchy entry once the minimum criteria had been reached, PACS upgrade, or when the dictating radiologist failed to designate the trainee as a co-reader.[17] Ours and future studies would benefit from considering the number of prior films co-reported while rotating through as a MOPEX-MO in radiology.

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