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Radiology residents' skill level in chest x-ray reading

C. Fabre[a,*], M. Proisy[b,c], C. Chapuis[b], S. Jouneau[c,d], P.-A. Lentz[b], C. Meunier[b], G. Mahé[c,e], M. Lederlin[b,c,f]

[a] *Department of Radiology, University Hospital of Angers, 49933 Angers, France*
[b] *Department of Radiology, University Hospital of Rennes, 35033 Rennes, France*
[c] *University of Rennes 1, UEB, 35043 Rennes, France*
[d] *Department of Pneumology, University Hospital of Rennes, 35033 Rennes, France*
[e] *Department of Vascular Medicine, University Hospital of Rennes, 35033 Rennes, France*
[f] *LTSI, Inserm U1099, University of Rennes 1, 35043 Rennes, France*

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Abstract
Rationale and objectives: To evaluate the mean skill level of radiology residents in chest X-ray (CXR) reading, with regard to cognitive mechanisms involved in this task and to investigate for potential factors influencing residents' skill.
Materials and methods: Eighty-one residents were evaluated through a test set including CXR expected to mobilize detection skills ($n = 10$), CXR expected to mobilize interpretation skills ($n = 10$) and normal CXR ($n = 4$). For each radiograph, residents were asked to answer three questions: Does this radiograph show normal or abnormal findings? Does it require complementary computed tomography study? What is your diagnosis? Residents' answers were evaluated against an experts' consensus and analyzed according to year of residency, attendance at CXR training course during residency and the average number of CXR read per week.
Results: Residents' mean success rate was 90.4%, 76.6% and 52.7% for the three questions, respectively. Year of residency was associated with better diagnostic performances in the detection CXR category ($P = 0.025$), while attendance at CXR training course was associated with better performances in the interpretation CXR category ($P = 0.031$). There was no influence of the number of CXR read per week.
Conclusion: These results may suggest promoting systematic CXR theoretical training course in the curriculum of radiology residents.

* Corresponding author. Service de radiologie C, CHU d'Angers, 4, rue Larrey, 49100 Angers, France.
E-mail address: clementfabre0@neuf.fr (C. Fabre).

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Nowadays, despite the outstanding performances of computed tomography (CT) in thoracic diseases, CXR is still the most commonly used imaging modality worldwide [1]. Numerous studies have shown that CXR remained critical for decision-making and that a wrong interpretation could adversely modify patient management [2—4]. Paradoxically, CXR reading is less and less taught today, even though it is one of the more demanding in terms of cognitive load and experience. Indeed, the ever-increasing popularity of CT and the subsequent need for education on this technique has mechanically decreased the time dedicated to CXR teaching and learning. Over the past few years, the French residents in medical imaging only received a single 30 min lecture on CXR within the whole theoretical training course delivered by the French College of Radiology Teachers [5]. In 2017, the European School of Radiology (ESOR) did not provide any specific training course about CXR for the European Diploma in Radiology (EDiR) [6].

Now that clinical practice evaluation, certification processes and quality performance measurements take an increasingly important place in healthcare [7,8], it is necessary to have the same level of requirement for CXR teaching as for cross sectional imaging techniques. There is an abundant literature devoted to CXR teaching as well as several research studies in the field of pedagogy [9—12]. Furthermore, some innovative learning methods (e.g. e-learning, problem-based learning, interactive learning, simulation medicine, deep learning) might potentially be applied to CXR training [13—17]. However, these methods should be targeted towards well-identified education needs. Therefore, the indispensable prerequisite is to have a precise and objective knowledge of the mean skill level of radiology residents in CXR reading.

Although the skill level of radiology residents has already been investigated through various methodologies, these studies did not provide a comprehensive overview of this issue [18—25]. Most of them focused on a single chest disease or finding, such as pulmonary nodule, pneumothorax or pneumonia, whereas other conditions such as atelectasis or diffuse lung diseases were not evaluated. But further, those studies did not deal with the cognitive mechanisms specifically involved in CXR learning (i.e., linked to the projectional nature of CXR). While cross-sectional imaging requires reading the images just as on anatomic slices, projection radiography necessitates a more complex mental process, which may be decomposed into two tasks: detection and interpretation [26—30]. Detection task is the ability to discover radiographic abnormalities and may typically correspond to the perception of a small pulmonary nodule in a smoker or the recognition of a subtle apical opacity in a screening for tuberculosis. By contrast, interpretation task requires recruiting cognitive resources to match CXR semiology and elaborate a diagnosis. In atelectasis for instance, the main task consists in mentally comparing radiographic findings — often obvious — with previously learned models.

The objective of this study was to evaluate the mean skill level of radiology residents in CXR reading with regard to cognitive mechanisms involved in that task and to investigate for potential factors influencing resident skill.

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Materials and methods

Our institutional review board approved this study. The study design comprised 3 steps, as summarized in the flow chart (Fig. 1).

CXR selection phase

A chest radiologist (expert 1 with 10 years of experience in chest imaging), selected a set of 40 CXR from our local picture archiving and communication system (PACS; Telemis PACS-software, version 4.7, Telemis SA, Louvain-la-Neuve, Belgium). Informed consent of patients was waived by our local Ethics Committee. The radiographs should meet the following criteria to be eligible: postero-anterior chest radiographs, performed in adults, fulfilling the quality criteria published by the American College of Radiology [31], representing typical aspects of daily practice in chest radiology, matching the skill requirements of the 4th and 5th years of radiology residency published by the European Society of Radiology in the curriculum for the level II training program [32], and corresponding to a definitive, proven and single diagnosis. Furthermore, each CXR was chosen to fall into one of these 3 categories: CXR expected to mobilize detection skills ($n = 16$), CXR expected to mobilize interpretation skills ($n = 17$) and normal CXR ($n = 7$) (Fig. 2). After deidentification, the chest radiographic images were copied from PACS, converted into JPEG format and loaded onto a PowerPoint (Microsoft Corp, Redmond, Washington) slide show in a random order without mention of their category.

CXR validation phase

The 40 CXR were read by 2 independent radiologists (expert 2 and expert 3 with 19 and 8 years of experience in chest imaging, respectively) during a single one-hour session. The CXR were projected on a large screen in a darkened room, with no possibility of brightness or contrast adjustment. Each radiograph was accompanied by the same deliberately minimalist clinical information: ''Mild shortness of breath in a light smoker''. For each radiograph, the experts were asked to answer 3 questions on a printed survey sheet:

- Does this radiograph show normal or abnormal findings?
- does it require a complementary CT study?;
- what is your final diagnosis?

The answers to the first and second questions were binary while the answer to the third question was open ended. The readers were informed that some CXR examinations could be normal. It was estimated that each CXR examination could be read within 90 seconds, however, the readers were free to ask for additional time.

CXR experiment phase

A total of 81 radiology residents from 6 university hospitals of the West of France (Angers, Brest, Nantes, Poitiers, Rennes, Tours) participated to the study on the occasion of two inter-regional training courses on chest CT imaging hold at the university hospital of Nantes (France) the 6th of March 2015 and the 5th of April 2017. During these two days, an identical experiment session was organized gathering 36

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