American Journal of
Oral Medicine and Radiology

ISSN - 2394-7721

www.mcmed.us/journal/ajomr

Research Article

EFFECTIVENESS OF SHORT-TERM FEEDBACK WITH CAD IN NODULE DETECTION ON CHEST RADIOGRAPHS

Dr. Dharma Teja Kanneganti*

Assistant Professor, Department of Radiology, Sri Lakshmi Narayana Institute of Medical Sciences & Hospital, Osudu, Pondicherry - 605502

ABSTRACT

The objective of this study was to investigate whether the combination of short-term feedback and electronic images with computer-aided detection (CAD) could enhance the performance of readers in identifying nodules on chest radiographs (CXRs). A total of 140 CXRs were utilized, each subset of 35 being independently interpreted by six readers in varying sequences. CAD was employed to evaluate the presence, location, and diagnostic certainty of nodules. Following each subset, readers received feedback on their performance. Area under the curve (AUC) and sensitivity were calculated for readings with and without CAD, considering the impact of time and CAD. The study reported a standalone CAD sensitivity of 59.6%, with an average of 1.9 false-positives per image. However, despite a slight increase in AUC over time, this enhancement was not statistically significant. Moreover, although sensitivity improved and specificity decreased over the study period, CAD did not exert a significant influence on these outcomes. Furthermore, regarding readers' ability to differentiate true-positive from false-positive lesions and effectively utilize CAD, the provision of short-term feedback did not result in demonstrable improvements in their abilities. In summary, the study findings suggest that the addition of short-term feedback alongside CAD does not significantly enhance the performance of readers in detecting nodules on CXRs or in effectively utilizing CAD assistance.

Key words:- Chest radiographs, Computer-aided detection (CAD), Nodule detection, Feedback, Sensitivity.

Access this article online		
Home page: http://www.mcmed.us/journal/ajomr		Quick Response code
Received: 25.06.18	**Revised**:10.07.18	**Accepted**:06.08.18

INTRODUCTION

Various computer-aided detection (CAD) systems have been developed for chest radiography, exhibiting sensitivities ranging from 34% to 78% for detecting small focal opacities. Studies evaluating CAD's impact on radiologists' performances have shown mixed results, with some demonstrating significant improvements and others showing no influence. The selection of lesions and study groups can affect CAD system outcomes, with lesion conspicuity influencing algorithm results. Certain studies have shown that CAD can enhance radiologists' sensitivity in detecting pulmonary nodules, particularly in cases where bronchiogenic tumors were initially missed. Additionally, CAD has been found to be more accurate than observers in detecting lesions that radiologists typically overlook. However, challenges arise in distinguishing true-positive from false-positive CAD candidates, hindering the successful implementation of CAD systems. A lack of experience and confidence in CAD analysis among readers may contribute to their difficulty in effectively utilizing CAD assistance. Training programs, ranging from 1-day sessions to 4-week periods, have been shown to improve reader sensitivity and CAD performance. However, structured learning curves for CAD implementation in chest radiography are lacking, with estimated learning periods of around 2 years. This study aims to investigate how short-term feedback impacts readers' confidence in

Corresponding Author
Dr. Dharma Teja Kanneganti

CAD analysis and their ability to differentiate true-positive from false-positive CAD candidates. By assessing the interaction between readers and CAD systems, the study seeks to elucidate strategies for enhancing the effectiveness of CAD-assisted chest radiography interpretation.

METHODOLOGY

Population of the study

This retrospective study included 140 patients from our institution's data archive. Patients were included if two-view chest radiographs (CXR) and thoracic CT shown no or a single nodular opacity within six weeks of the chest radiograph. Axial CT images showed nodules ranging in diameter from 5 to 15 mm and without calcifications. There were 140 patients with a single CT-proven nodule and 84 controls. The CXR excluded those with multiple nodular opacities or pathological features. The study has been approved by the Ethics Committee and informed consent has been waived due to its retrospective nature.

Nodules in lungs

A thoracic CT served as the reference standard and revealed a single nodular opacity in 56 patients. In consensus, the degree of conspicuity of the CXR lesion was determined by a board-certified chest radiology specialist and an unrelated research resident.

Acquiring images

CXRs were acquired digitally using a chest stand that was specifically designed for this purpose. The non-linear multi-frequency processing was used. The manufacturer has recommended a number of processing parameters, which have been implemented as standard procedures at our institution. We evaluated both the postero-anterior and lateral views.

CAD

The CAD system was commercially available (IQQA- Chest; EDDA Technology, Princeton Junction, NJ, USA). It detects nodules within a diameter range of 5-15 mm on PA radiographs. Image analysis is automatically performed after acquisition; therefore, radiographs can be read immediately, but results are displayed on demand. Candidates (semitransparent circles) mark zero to five suspicious areas.

ANALYSIS

The study involved six observers of varying experience: five radiology residents and one radiology specialist with 15 years of chest film reading. There were two observers in this study with no previous experience with CAD, while the other four had used different CAD systems in previous studies. CAD was not used in clinical routines by observers. Each subset was composed of 35 radiographs composed of lateral radiographs and PA radiographs. In each subset, a total of fourteen cases with a single nodular opacity were included in each subset. For the four subsets, we ensured that nodule con- spicuity and CAD stand-alone sensitivity were equal. Each observer read a subset of thirty-five PA and lateral chest radiographs before and after CAD markings were available as part of a single reading session. Five levels of confidence were available, from 5 to 3 (equivocal) to 1. Anatomical location of suspected lesions was indicated in the data sheet. There were separate tests with and without CAD results. As soon as CADs were available for lesions seen during unassisted reading, readers could modify their confidence levels. A single nodular opacity was indicated on images, along with lesions that were smaller than 5 mm and calcified should be ignored. When CAD results were available, they could be magnified, window/level adjusted, and grey-scale reversals could be performed. The four subsets of CXRs are read differently by all observers.

DATA ANALYSIS

CAD's stand -alone performance using two methods: a sensitivity calculation and a false-positive rate. The four subsets were compared using a one-way analysis of variance (ANOVA) combined with Tukey's posthoc analysis. Sensitivity, specificity, and AUC calculations were performed for readings that had CAD results as well as those that did not.

If the lesions were correctly localised, ratings 4 and 5 were considered positive for calculating the sensitivity. CAD as a second reader is controversial regarding whether it should discharge lesions identified by primary unassisted reading or only add potential lesions. To analyze the data, we considered all lesions preserved as an add-on.

A Cochran Q test and repeated measurements logistic regressions were used to compare all three methods. McNemar's test was used separately for each reader in pairwise comparisons. This study compared the performance of the first two subsets and the last two subsets in order to evaluate feedback's impact. A SPSS 17 program was used to conduct the analysis. The significance level was set at P 0.05, which is considered to be a significant level.

RESULTS

Group study

The mean age of the patients was 61 years, with no significant differences among the four subsets. There were a total of 14 patients with a single nodule and 21 patients who were negative controls. 30 % of nodules were high conspicuous, 23 % moderately conspicuous, 30 % low, and 16 % very low in size. Except for the effects of smoking on particular facets of the brain, as well as the focal lesion involved in the study, no pathological feature was observed in the diseased or control groups.

Stand-alone CAD software

A standalone CAD detected 32 of 56 nodules, resulting in a mean sensitivity of 57% per subset. Depending on the level of conspicuity, sensitivity ranged from 100% to 54 %, 44 % to 22 %. It is important to note that 260 FP candidates were generated by CAD with an mFP of 1.9. There was a significant difference between subsets 3 and 4 (P000.024) based on the mFP for the different subsets. It was 0.31 (32/103) for the positive predictive value, and 0.35 (13/37) for the negative predictive value.

Subsets 1 and 2 performance of readers

As a result of CAD, it was not found to have a significant impact on sensitivity, specificity, or AUC (Table 1). AUC increased from 0.77 without CAD to 0.79 with CAD, but not significantly. Add-on CAD resulted in greater sensitivity (65% vs. 69%) but reduced specificity (79 vs. 76%). By using CAD, discharge of lesion candidates increased sensitivity by 6% and specificity by 8%. The differences listed did not reach statistical significance.

Subsets 3 and 4 reader performance

The use CAD did not change sensitivity, specificity, or AUC (Table 2). In comparison with the reading sessions conducted during the first two days of the study, readers increased their sensitivity to 71 % while decreasing their specificity to 75 %. AUC increased from 0.83 to 0.85 with CAD, but the difference was not significant. As sensitivity remained unchanged with CAD ,specificity increased when lesions were discharged. Statistically, none of these differences reached a statistically significant level.

Reader-CAD interaction

TP CAD candidates were rejected by 17 % of six readers. 16 vs. 16 in both first and last subsets. The majority of dismissed TP candidates (16/32) had low conspicuity nodules with 28 % having very low conspicuity lesions with 22 % (7/32) having moderately conspicuous nodules. For readers 1 to six, there was a total of 1/1, 0/0, 6/4, 1/1, 1/0, 1/1 and 1/1 of rejected true-positive CADs. As a result of the pooled analysis of the data, there was no significant decrease in the number of FP CAD candidates accepted from a total of ten made in the first two readings to six made in the second and third readings.

Table 1: False-positive (FP) computer-aided detection (CAD) candidates and nodule conspicuity

Subset	Total CAD FP	Nodule conspicuity			
		1	1	2	3
A	112	4	3	3	3
B	140	2	3	2	2
C	104	3	3	4	3
D	164	1	1	1	2

Table 2: Reader performance without and with CAD for subsets 1 + 2 and 3 + 4. Parentheses indicate confidence intervals

	Sensitivity		Specificity		AUC	
	1+2	3+4	1+2	3+4	1+2	3+4
No CAD	66 %	71 %	80 %	75 %	0.77	0.83
CAD with possible discharge	67 %	71 %	81 %	78 %	0.79	0.85
CAD add-on	70 %	72 %	77 %	75 %	0.79	0.86

DISCUSSION

Chest radiographs of two views frequently miss small primary lung cancers despite being visible in retrospect. For primary lung carcinomas, miss rates range from 20% to 90%. Recent reports suggest CAD can help readers detect lung tumours initially missed by radiologists. Neither paper included observer performance; thus, it is unclear whether radiologists would have used CAD to accept these true-positive candidates. It is equally impossible to quantify the risk of accepting a candidate who is falsely positive. It has been demonstrated in the past that an interaction between CAD and observer is critical for the detection of T1 tumors in patients who participated in CT screening trials. CAD correctly annotated 5 to 16 cases of cancer initially missed by observers. Readers rejected 80 % of these correctly annotated lesions. It may have been due to their unfamiliarity and lack of trust in the CAD algorithm that the readers failed to discern true lesions from false lesions. In the current study, short-term feedback was tested on digital chest radiography to detect pulmonary nodules. After interpreting each of the four subsets, we hypothesized that individual feedback would help readers gain a better understanding of the CAD algorithm, which leads to increased acceptance and identification of true-positive candidates. There was a small improvement across sessions 1 and 2 and 3 and 4, indicating a small training effect. Readers reported detecting a greater number of nodules in the last two sessions compared with the first two. A total of three pairs of sessions were conducted, in none of them, did CAD significantly influence reader performance. Neither true-positives nor false-positives were significantly affected by feedback. CAD improved performance overall, but the differences weren't significant.

The lowest and very lowest conspicuity accounted for 78% of those dismissed as true-positive, suggesting that readers lacked credibility in CAD candidates. Despite feedback, dismissals of true-positives did not change between sessions 1 and 2. CAD and the use of CT colonography and mammography are rarely evaluated in the literature. CT colonography showed a higher improvement in observer performance after only one day of training compared to mammography, which required four weeks of training. CT and radiography have different perception and learning rules. It appears that CAD can be used more efficiently to reduce perception errors when the lesions are clearly defined, whereas CAD can differentiate lesions with low conspicuity. Additionally, most of the CAD candidates who were dismissed were true-positives with very low to very low visibility lesions. The readers miss high and moderate suspicion lesions because of "intentional blindness," which means they take advantage of CAD more effectively and easily. Under study conditions, proving this effect is more difficult owing to readers' especially high alertness when examining radiographs. Although 5 out of 6 readers in our study were residents, the sensitivity for the first two subsets was 65 %, and for the last two it was 70 %. Due to this high baseline sensitivity, CAD results may have limited further sensitivity increases. Diagnosing low- or very-low-conspicuity lesions requires both visual localisation and correct differentiation from surrounding "anatomical" noise. Based on our findings, CAD does not significantly impact reader behavior for this type of lesion.

CONCLUSION

A longer learning period for chest radiography has not yet been proven, as for mammography. It is also essential that the number of false-positive candidates for CAD must also be further reduced. Readers will be more confident in the reliability of CAD if there are fewer false-positive candidates, and will be more able to identify underlying lesions. For the first two and last two readings, CAD caused 10 and 6 false-positives, respectively. In some cases, CAD candidates alone are not enough to distinguish true-positive from false-positive lesions. For mammography, likelihood calculations and active localisation have proven very effective. The study has a number of limitations, which are listed below. The number of nodules exceeded clinical expectations in clinical conditions. In spite of not knowing how many positive and negative cases were detected, the readers certainly detected focal lesions more readily than normally. Readers interpreted the subsets differently and CAD false-positive candidates were low, we believe that this did not influence our results.

REFERENCES

1. Li F, Engelmann R, Metz CE, Doi K, MacMahon H (2008) Lung cancers missed on chest radiographs: results obtained with a com- mercial computer-aided detection program. Radiology 246:273–280
2. Van Beek EJ, Mullan B, Thompson B (2008) Evaluation of a real- time interactive pulmonary nodule analysis system on chest digital radiographic images: a prospective study. Acad Radiol 15:571– 575
3. Bley TA, Baumann T, Saueressig U et al (2008) Comparison of radiologist and CAD performance in the detection of CT- confirmed subtle pulmonary nodules on digital chest radiographs. Invest Radiol 43:343–348
4. White CS, Flukinger T, Jeudy J, Chen JJ (2009) Use of a computer-aided detection system to detect missed lung cancer at chest radiography. Radiology 252:273–281
5. Sakai S, Soeda H, Takahashi N et al (2006) Computer-aided detection on digital chest radiography: validation test on consecu- tive T1 cases of resectable lung cancer. J Digit Imaging 19:376– 382
6. Hardie RC, Rogers SK, Wilson T, Rogers A (2008) Performance analysis of a new computer aided detection system for identifying lung nodules on chest radiographs. Med Image Anal 12:240–258
7. Xu Y, Ma D, He W (2011) Assessing the use of digital radiography and a real-time interactive pulmonary nodule analysis system for large population lung cancer screening. Eur J Radiol. doi:10.1016/ j.ejrad.2011.04.031
8. Song W, Fan L, Xie Y, Qian JZ, Jin Z (2005) A study of inter- observer variations of pulmonary nodule marking and characteriz- ing on DR images. Proc SPIE 5749:272–280
9. de Hoop B, De Boo DW, Gietema HA et al (2010) Computer-aided detection of lung cancer on chest radiographs: effect on observer performance. Radiology 257:532–540
10. Taylor SA, Burling D, Roddie M et al (2008) Computer-aided detection for CT colonography: incremental benefit of observer training. Br J Radiol 81:180–186
11. Luo P, Qian W, Romilly P (2005) CAD-Aided mammogram train- ing. Acad Rad 12:1039–1048
12. Nishikawa R (2007) Increased CAD use prompts look at advan- tages, drawbacks. Radiological Society of North America Web site. http://www.rsna.org/Publications/rsnanews/feb07/upload/ RSNANews_Feb07_CAD_Usage.pdf. Published February 2007. Last accessed 18 September 2011
13. Giger ML, Chan HP, Boone J (2008) Anniversary paper: history and status of CAD and quantitative analysis—the

image role of medical physics and AAPM. Med Phys 35:5799–5820
14. Muhm JR, Miller WE, Fontana RS, Sanderson DR, Uhlenhoop MA (1983) Lung cancer detected during a screening program using 4-month chest radiographs. Radiology 148:609–615
15. Heelan RT, Flehinger BJ, Melamed MR et al (1984) Non-small- cell lung cancer: results of the New York screening program. Radiology 151:289–293
16. Austin JH, Romney BM, Goldsmith LS (1992) Missed broncho- genic carcinoma: radiographic findings in 27 patients with poten- tially resectable lesion evident in retrospect. Radiology 182:115– 122
17. Quekel LG, Kessels AG, Goei R, Engelshoven JM (1999) Miss rate of lung cancer on the chest radiograph in clinical practice. Chest 115:720–724
18. Monnier-Cholley L, Arrivé L, Porcel A et al (2001) Characteristics of missed lung cancer on chest radiographs: a French experience. Eur Radiol 11:597–605.

Cite this article:
Dr. Dharma Teja Kanneganti. (2018). Effectiveness of Short-Term Feedback With Cad in Nodule Detection on Chest Radiographs. *American Journal of Oral Medicine and Radiology*, 5(2), 58-62.