Computer-aided detection and diagnosis for chest imaging

Clinical Policy ID: CCP.1496

Recent review date: 9/2024

Next review date: 1/2026

Policy contains: chest radiography; ClearRead; computer-aided detection; computer-aided diagnosis; computed tomography; lung cancer; RapidScreen; solitary pulmonary nodule.

AmeriHealth Caritas Next has developed clinical policies to assist with making coverage determinations. AmeriHealth Caritas Next's clinical policies are based on guidelines from established industry sources, such as the Centers for Medicare & Medicaid Services (CMS), state regulatory agencies, the American Medical Association (AMA), medical specialty professional societies, and peer-reviewed professional literature. These clinical policies along with other sources, such as plan benefits and state and federal laws and regulatory requirements, including any state- or plan-specific definition of medically necessary, and the specific facts of the particular situation are considered, on a case by case basis, by AmeriHealth Caritas Next when making coverage determinations. In the event of conflict between this clinical policy and plan benefits and/or state or federal laws and/or regulatory requirements, the plan benefits and/or state and federal laws and/or regulatory requirements shall control. AmeriHealth Caritas Next's clinical policies are for informational purposes only and not intended as medical advice or to direct treatment. Physicians and other health care providers are solely responsible for the treatment decisions for their patients. AmeriHealth Caritas Next's clinical policies are reflective of evidence-based medicine at the time of review. As medical science evolves, AmeriHealth Caritas Next will update its clinical policies as necessary. AmeriHealth Caritas Next's clinical policies are not guarantees of payment.

Coverage policy

Computer-aided detection or computer-aided diagnosis for chest imaging is investigational/not clinically proven and, therefore, not medically necessary.

Limitations

No limitations were identified during the writing of this policy.

Alternative covered services

- Unaided chest radiography.
- Unaided chest computed tomography.

Background

A solitary pulmonary nodule represents an early-stage T1 round or oval lesion in the lung parenchyma measuring less than 3 cm in diameter with discrete margins and no associated abnormality (Hansell, 2008). Most often, solitary pulmonary nodules are screen-detected or incidental findings on chest radiography (National Cancer Institute, 2022). They present a diagnostic challenge in the absence of a biopsy, as these lesions are often benign and asymptomatic, and the differential diagnosis can be extensive. The objective of the workup is to differentiate malignancies requiring intervention from benign lesions that can be observed safely.

Low-dose computed tomography is the recommended screening modality for lung cancer, as it has sufficient sensitivity and specificity to detect early–stage disease in high-risk populations and could prevent a substantial number of lung cancer–related deaths (Krist, 2021). The harms associated with low-dose computed tomography are false-positive results leading to unnecessary tests and invasive procedures, incidental findings, short-term increases in distress due to indeterminate results, overdiagnosis, and radiation exposure (Jonas, 2021). Current nodule evaluation protocols on computed tomography (e.g., Lung CT Screening Reporting & Data System [Lung-RADS]) are designed to reduce false-positive results and associated invasive procedures (American College of Radiology, 2023a).

Compared to computed tomography, chest radiography is widely available and less costly, and offers lower radiation exposure (Jonas, 2021). However, false positive findings are common, and it lacks sufficient resolution to detect the earliest, smallest stage lung cancers or provide reliable information on other nodule characteristics visible on computed tomography, which could confound malignancy assessment. Therefore, chest radiography is insufficiently sensitive to serve as an effective screening modality for reducing lung cancer mortality but can provide information on nodule size and location, presence of calcium in the nodule, and growth over time, which can inform the probability of malignancy.

A computer-aided detection system is dedicated computer software that detects potential abnormalities on diagnostic radiology exams (U.S. Food and Drug Administration, 2022). Through pattern recognition and data analysis, the system highlights suspicious areas of irregularity on a previously acquired and interpreted medical image for the radiologist to reassess, with the goal of improving reader performance in the intended use population. It acts as a “second reader” and may overcome the limitations of chest radiography and avoid the risks associated with computed tomography and biopsy by improving sensitivity and reducing the number of false positive findings.

The U.S. Food and Drug Administration (2001) has approved one medical imaging analyzer for detection of solitary pulmonary nodules measuring 9 mm to 30 mm in size — RapidScreen™ RS-2000 (Riverain Medical Group, Miamisburg, Ohio, also marketed under the trade name ClearRead Xray). The device is intended for use as an aid only after a physician has performed an initial interpretation of the radiograph.

Computer-aided diagnosis refers to software that both identifies suspicious regions and characterizes the lesion (e.g., benign versus malignant) (U.S. Food and Drug Administration, 2022). Computer-aided diagnosis systems assess disease in terms of the likelihood of malignancy or by disease type, severity, stage, or recommended intervention. These systems integrate nodule characteristics and most often use the area under the receiver operating characteristic curve measurement to distinguish the nodule.

The U.S. Food and Drug Administration (2021) has approved one computer-aided diagnosis system — the Optellum® Virtual Nodule Clinic (Optellum Ltd., United Kingdom) — for use in tracking, assessment, and characterization of incidentally detected pulmonary nodules on computed tomography. The Optellum system generates a Lung Cancer Prediction Convolutional Neural Network score to be used by a pulmonologist or radiologist to assess each abnormality independently. It is indicated for patients who meet the following criteria, regardless of smoking history:

- Age 35 or older.
- Has between one and five incidentally detected solid and/or semisolid pulmonary nodules measuring 5 mm to 30 mm in diameter.
- Has no other history of cancer in the past five years.
- Has no thoracic implants that impact the nodule appearance.

Findings

The findings indicate that computer-aided detection and computer-aided diagnosis in lung imaging show potential for improving diagnostic accuracy, particularly in identifying small nodules and reducing interpreter error. However, the current body of evidence is limited by variability in study designs and the retrospective nature of most research, leading to uncertainties regarding the impact on clinical outcomes (American College of Radiology, 2023b). Computer-aided detection systems may serve as a "second opinion" by enhancing radiologists' confidence in distinguishing benign from malignant nodules on high-resolution computed tomography, but its role in interpreting chest radiography is not mentioned (American College of Radiology, 2023b).

A practice parameter for the performance of thoracic computed tomography, developed collaboratively by the American College of Radiology, the Society of Advanced Body Imaging, the Society for Pediatric Radiology, and the Society of Thoracic Radiology, provides guidelines for performing high-quality thoracic computed tomography scans, emphasizing the need for knowledge in normal anatomy, pathophysiology, and computed tomography techniques (American College of Radiology, 2023c). The document addresses the role of computer-aided detection software, which can assist in the evaluation of lung nodules, airways, emphysema, coronary artery calcification, and pulmonary emboli. Computer-aided detection is presented as a tool to enhance the accuracy of diagnoses by highlighting potential areas of concern that may require further investigation by radiologists (American College of Radiology, 2023c).

Regarding computer-aided diagnosis for lung cancer detection using computed tomography, a systematic review by Amir (2016) evaluated the accuracy of computer-aided diagnosis across 14 low-to-moderate quality studies involving 1,868 computed tomography scans. The review found that aided radiologists' interpretation significantly improved accuracy, with eight out of nine studies showing a receiver operating characteristic curve area of 0.8 or higher (Amir, 2016). Jin (2023) conducted a systematic review analyzing 75 studies published between 2017 and 2022 on machine learning algorithms for computer-aided diagnosis of lung nodules in chest computed tomography images. The review found that deep learning methods, particularly convolutional neural networks, outperformed conventional machine learning approaches, achieving 100% sensitivity for nodule detection, a dice similarity coefficient of 0.9906 for nodule segmentation, and an accuracy of 99.17% for classifying nodules as benign or malignant (Jin, 2023).

For computer-aided detection using chest radiography, Haber (2020) conducted a systematic review of seven studies and found an average sensitivity of 58.67% with a mean false positive rate of 2.22 per image. However, the review failed to confirm a correlation between sensitivity and false positive rates, with most studies being retrospective and inconclusive, requiring further validation through larger, prospective analyses (Haber, 2020). Earlier studies published prior to 2010, including four observational studies, presented mixed results with similar limitations (de Hoop, 2010; Li, 2008; Szucs-Farkas, 2010; White, 2009).

Further evidence includes a randomized controlled trial by Mazzone (2020) involving 1,424 participants, which compared computer-aided detection with conventional methods in chest radiography. The trial found that while 29 participants had an actionable lung nodule, only two were later confirmed as lung cancer, both of which were

diagnosed unaided (Mazzone, 2020). The authors concluded that more evaluation is needed to determine if computer-aided detection is effective as a lung cancer screening tool (Mazzone, 2020). Wang (2022) conducted a study comparing diagnostic outcomes of low-dose computed tomography scans with computer-aided detection versus conventional diagnosis in patients at elevated risk of lung cancer. The study found significantly higher diagnosis rates using computer-aided detection (11% vs. 7%, P = .0345) (Wang, 2022). Additionally, Toda (2023) reviewed the performance of computer-aided detection software in diagnosing pulmonary nodules and masses in 453 participants, showing a significant improvement in detecting nodules and masses by reducing the number of missed lesions (Toda, 2023). Murchison (2022) further supported these findings in a study with 314 participants, where radiologists demonstrated significantly higher sensitivity in detecting pulmonary nodules with computer-aided detection versus without (80.3% vs. 71.9%, P < .01) (Murchison, 2022).

Finally, a systematic review by Devnath (2022) examined the use of computer-aided detection in diagnosing pneumoconiosis, further expanding the evidence base for computer-aided detection applications in various pulmonary conditions. Despite these promising results, the retrospective nature and variability in inclusion criteria across studies remain key limitations, leaving uncertainty about the impact of computer-aided detection on clinical outcomes, particularly in differentiating between asymptomatic screening populations and clinical populations with a higher pre-imaging probability of malignancy (Devnath, 2022)

In 2024, we reorganized the findings section and added a new practice parameter document by the American College of Radiology and others (2023 c) and a new systematic review (Jin, 2023). No policy changes warranted.

References

On August 8, 2024, we searched PubMed and the databases of the Cochrane Library, the U.K. National Health Services Centre for Reviews and Dissemination, the Agency for Healthcare Research and Quality, and the Centers for Medicare & Medicaid Services. Search terms were “computer assisted radiographic image interpretation (MeSH),” “image processing, computer assisted (MeSH),” “solitary pulmonary nodule (MeSH),” and "computer-aided detection.” We included the best available evidence according to established evidence hierarchies (typically systematic reviews, meta-analyses, and full economic analyses, where available) and professional guidelines based on such evidence and clinical expertise.

21CFR892.2060. Radiological computer-assisted diagnostic software for lesions suspicious of cancer.

21CFR892.2070. Medical image analyzer.

American College of Radiology. Lung CT Screening Reporting & Data System (Lung-RADS). https://www.acr.org/Clinical-Resources/Reporting-and-Data-Systems/Lung-Rads. Published 2023. (a)

American College of Radiology. ACR Appropriateness Criteria®. https://www.acr.org/Clinical-Resources/ACR-Appropriateness-Criteria. Published 1995. Last updated 2023. (b)

American College of Radiology, Society of Advanced Body Imaging, Society for Pediatric Radiology, Society of Thoracic Radiology. ACR–SABI–SPR–STR practice parameter for the performance of thoracic computed tomography (CT). American College of Radiology. Published 2023. Accessed August 2024. https://www.acr.org/-/media/ACR/Files/Practice-Parameters/CT-Thoracic.pdf. (c)

Amir GJ, Lehmann HP. After detection: The improved accuracy of lung cancer assessment using radiologic computer-aided diagnosis. *Acad Radiol.* 2016;23(2):186-191. Doi: 10.1016/j.acra.2015.10.014.

de Hoop B, De Boo DW, Gietema HA, et al. Computer-aided detection of lung cancer on chest radiographs: Effect on observer performance. *Radiology.* 2010;257(2):532-540. Doi: 10.1148/radiol.10092437.

Devnath L, Summons P, Luo S, et al. Computer-aided diagnosis of coal workers' pneumoconiosis in chest X-ray radiographs using machine learning: A systematic literature review. *Int J Environ Res Public Health*. 2022;19(11):6439. Doi: 10.3390/ijerph19116439.

Haber M, Drake A, Nightingale J. Is there an advantage to using computer aided detection for the early detection of pulmonary nodules within chest X-ray imaging? *Radiography (Lond)*. 2020;26(3):e170-e178. Doi: 10.1016/j.radi.2020.01.002.

Hansell DM, Bankier AA, MacMahon H, et al. Fleischner Society: Glossary of terms for thoracic imaging. *Radiology.* 2008;246(3):697-722. Doi: 10.1148/radiol.2462070712.

Jin H, Yu C, Gong Z, Zheng R, Zhao Y, Fu Q. Machine learning techniques for pulmonary nodule computer-aided diagnosis using CT images: A systematic review. *Biomed Signal Process Control*. 2023;79:104104. Doi:10.1016/j.bspc.2022.104104.

Jonas DE, Reuland DS, Reddy SM, et al. Screening for lung cancer with low-dose computed tomography: Updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA.* 2021;325(10):971-987. Doi: 10.1001/jama.2021.0377.

Krist AH, Davidson KW, Mangione CM, et al. Screening for lung cancer: US Preventive Services Task Force recommendation statement. *JAMA.* 2021;325(10):962-970. Doi: 10.1001/jama.2021.1117.

Li F, Engelmann R, Metz CE, Doi K, MacMahon H. Lung cancers missed on chest radiographs: Results obtained with a commercial computer-aided detection program. *Radiology.* 2008;246(1):273-280. Doi: 10.1148/radiol.2461061848.

Mazzone PJ, Obuchowski N, Phillips M, et al. Lung cancer screening with computer aided detection chest radiography: Design and results of a randomized, controlled trial. *PLoS One.* 2013;8(3):e59650. Doi: 10.1371/journal.pone.0059650.

Murchison JT, Ritchie G, Senyszak D, et al. Validation of a deep learning computer aided system for CT based lung nodule detection, classification, and growth rate estimation in a routine clinical population. *PLoS One*. 2022;17(5):e0266799. Doi: 10.1371/journal.pone.0266799.

National Cancer Institute. Lung Cancer Screening (PDQ®) — Health Professional Version. https://www.cancer.gov/types/lung/hp/lung-screening-pdq. Updated May 13, 2022.

Szucs-Farkas Z, Patak MA, Yuksel-Hatz S, Ruder T, Vock P. Improved detection of pulmonary nodules on energy-subtracted chest radiographs with a commercial computer-aided diagnosis software: Comparison with human observers. *Eur Radiol.* 2010;20(6):1289-1296. Doi: 10.1007/s00330-009-1667-0.

Toda N, Hashimoto M, Iwabuchi Y, et al. Validation of deep learning-based computer-aided detection software use for interpretation of pulmonary abnormalities on chest radiographs and examination of factors that influence readers' performance and final diagnosis. *Jpn J Radiol*. 2023;41(1):38-44. Doi: 10.1007/s11604-022-01330-w.

U.S. Food and Drug Administration. Guidance for industry and Food and Drug Administration staff computer-assisted detection devices applied to radiology images and radiology device data — premarket notification [510(k)] Submissions. https://www.fda.gov/media/77635/download. Published July 3, 2012. Updated September 28, 2022.

U.S. Food and Drug Administration. Optellum™ Virtual Nodule Clinic. Optellum Ltd. United Kingdom. Approval letter K202300. https://www.accessdata.fda.gov/cdrh_docs/pdf20/K202300.pdf. Published March 5, 2021.

U.S. Food and Drug Administration. RapidScreen™ RS-2000. Approval order P000041. https://www.accessdata.fda.gov/cdrh_docs/pdf/P000041A.pdf. Published July 12, 2001.

Wang D, Cao L, Li B. Computer-aided diagnosis system versus conventional reading system in low-dose (< 2 mSv) computed tomography: Comparative study for patients at risk of lung cancer. *Sao Paulo Med J*. 2022;141(2)::89-97. Doi: 10.1590/1516-3180.2022.0130.R1.29042022.

White CS, Flukinger T, Jeudy J, Chen JJ. Use of a computer-aided detection system to detect missed lung cancer at chest radiography. *Radiology.* 2009;252(1):273-281. Doi: 10.1148/radiol.2522081319.

Policy updates

9/2021: initial review date and clinical policy effective date: 10/2021

9/2022: Policy references updated.

9/2023: Policy references updated.
9/2024: Policy references updated.