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CAD for Mammography and MR Mammography: What are the Pros and Cons

Author

Prof. Ansagar Malich

Head of Division

Department of Diagnostic

Radiology

Suedharz-Hospital

Nordhausen

Nordhausen, Germany

ANSGAR.MALICH@SHK-NDH.DE

CAD technology is widely used in radiology, to analyse breast lesions, lung nodules, prostate glands, lymph nodes, bone structures and many other features. In the past decade, CAD technology has undergone significant refinement and is now a highly sensitive technology. In this review, the pros and cons of CAD are summarised.

CAD on Mammograms

Most studies regarding CAD systems report on those that are used with analogue films. With the increasing number of full field digital mammograms, most CAD companies focused on the development of related CAD systems. These tools are mainly available directly on the workstations. This saves time as it can be used in daily routine in one step. The application of CAD for mammography differs thus from other CAD options, which are developed for use at the PACS and not at the workstation.

The most relevant value of a diagnostic system is its sensitivity and specificity, obtained under conditions close to routine workflow, that is, CAD performance in screening of mammograms. Regarding detection rate, the number of false positive markers is of outstanding importance for the clinical usability of CAD, due to the overall low number of malignancies within the screening population (approx. 6 out of 1000 screened cases).

FDA approval studies can't be considered as the most relevant for clinical routine being mainly performed with initial software releases causing a highly sensitive detection of cancers (for masses ranging from 75% to 85%, for microcalcifications ranging from 98% to 99%) associated with very low specificity (high number of falsely detected structures, 87% and 95%, respectively for masses and microcalcifications using Second Look for example, similar for Imagechecker). In other clinical studies, overall sensitivities of about 90% were reached. Typically higher sensitivities for microcalcifications than masses were found on several systems in various studies.

CAD Performance on Priors

According to published data, 89 out of 115 missed cancers, (30 out of 35 missed microcalcifications and 58 out of 80 missed masses, i.e. 86% versus 73%) were detected using a CAD system. This value increased with more updated software versions used and the extent of the CAD performance was proven by other CAD systems with similar results. Most non-detected malignancies are visible as masses. A relevant number of missed cancers (about 40%) were seen by the radiologists and misinterpreted as benign. Despite this encouraging data, it is still questionable whether the higher detection rate of CAD really causes a higher detection rate for the radiologist.

CAD as an Aid to the Radiologist

Many factors influence performance, including selection criteria of the cases, the number of included cases and of cancers, the radiological experience of the participating radiologists, the experience in the use of CAD of the participating radiologists etc. Also, diagnostic strategies differ among the United States, Great Britain and continental Europe due to differing ways. Consequently, results on the clinical impact of CAD differ significantly. Butler and colleagues reported on a detection rate of about 87% of those cancers not being localised at the clinically suspicious region. Thurfjell et al. found an increased sensitivity (from 80 to 84% and 67% to 75%, respectively) due to the additional use of CAD prompts.

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These values were going along with an unchanged (experienced radiologist) and a slightly decreased specificity (non experienced radiologist).

Contradicting these findings, Marx et al. Reported an unchanged sensitivity of the participating radiologists when using CAD vs. without (80.6% vs. 80.0%) and a slightly increased specificity (83.2% vs. 86.4%). This effect, however, was statistically not significant. Similarly, Malich et al. could not verify a significant diagnostic effect of an additional CAD application on official test case samples in Germany. All these studies are synergic regarding the high sensitivity of CAD, which is usually higher than the radiologists value. A number of other studies report an unchanged sensitivity of the radiologists when using CAD prompts.

Clinical and Financial Effect of CAD

Freer and Ulissey found in a screening population, a slightly increased recall rate of 7.7% (vs. 6.5%) with the additional use of CAD but an increased detection rate of malignancies as well. Similar effects were found by most other authors. Contradicting this, Marx et al. found a decreased rate of recommended interventions associated with the use of CAD. With CAD usage, the number of additionally false positive lesions did not increase, the number of unnecessary biopsies, however, decreased, mainly in the screening group. In screening, CAD systems seem to increase the detection rate of malignancies. This effect seems to be associated with an increased recall rate. Most additionally detected malignant lesions in the prospective screening trials were DCIS (75%).

False Positive Markers

Up to 40% of the non-detected malignant lesions were masses not overlooked but wrongly judged as benign by the radiologist. Tools associated with a high number of false positive results will probably not cause a significant increase in the detection rate of malignant lesions because the radiologist expects wrong markings per case and probably would not change the decision due to that high rate. As stated by a couple of authors, the recently developed software versions of both systems decreased the number of false positives from 30 - 56%, which might affect the impact of correct CAD markings on falsely as benign categorised lesions for the diagnosing radiologist. Nevertheless, the ratio of false positive markers per case is still the major limitation of clinical application of CAD.

Extensions of Current Uses of CAD

Due to the high detection rate of microcalcs it was examined whether the negative predictive value is sufficient to apply CAD prior to the radiologist in order to exclude any microcalc-associated malignant or premalignant structure. Resulting PPV of 60.1% and NPV of 86% do not support the clinical use of CAD as a primary diagnostic tool to exclude suspicious microcalcifications, yet. Both in Scandinavia as well as in Germany, the used CAD systems failed the requirements of the screening programmes due to the insufficient specificity despite the high sensitivity values. Additionally CAD did not support the analysing radiologists enough, to pass the official tests required for screening in Germany.

CAD in Breast MRI

CAD for breast MR uses an entirely new class of temporal features. Its central feature is the automated analysis of time versus percent of enhancement curve using the market leader Confirma, which offers six different curve types highlighting the related parts of the entire lesion using six different colours. The curve type characteristics can be modified for each observer. The system of CADSciences is based on calculations of permeability and extracellular volume fraction and uses the calculations introduced by Toft. Thus, both technologies offer similar images but the underlining calculations differ significantly.

CAD MR systems offer analyses of the entire lesion and distributions of enhancement curves in relation to the whole enhancing lesion. Furthermore automated motion corrections are embedded (usually 2D), multiplanar reconstructions and maximum intensity projections are available, usually depending on the technology and software version used. Additionally MR-guided localisation of enhancing breast tumours can be supported by commercially available systems. An automated volume calculation of the entire enhancing lesion is integrated in the analysis process.

Diagnostic Benefits

The application of CAD offers for the first time the option to analyse the dynamic uptake of the whole lesion in a computer-based display. It has been reported that CAD application causes time saving during the analysis of the images. Taking into account technological options and additional diagnostic data, using CAD in MR it should be possible in future, to stage and grade a breast tumour automatically on the images obtained by the computer. If initial results are proven, lymph node clarification (TN-status) can be integrated in the CAD analysis process. These three aims could help to improve the role of interventional treatment of breast tumours (tumour heating or freezing) without surgery. This however, is not yet available and requires still further software development.

Limitations

Till now, CAD-based analysis of dynamic breast MR images exclusively focus on dynamic data. It has been published recently, that morphologic features are of major importance as well, especially including T2w imaging. Thus, the currently available CAD systems do not yet replace the analysis of the entire examination, but shorten the evaluation of the contrast uptake only and induce a more reliable analysis. Depending on the

presets, CAD systems are in part unable to highlight segmental enhancements, being the most relevant feature for non-invasive premalignant lesions. Diagnostic potential of currently available systems varies significantly. Whereas CADSciences technology is highly sensitive it seems to be significantly less specific compared to the currently available Confirma CAD solution.

There is still no optimal 3D motion correction available. Resulting analysis of enhancement pattern of a breast lesion is not congruent among the different CAD systems, but differs significantly. Similar results were observed regarding the volume calculation of a breast lesion. Volume calculation is limited to enhancing structures of a lesion.

This causes a miscalculation of tumours after presurgical chemotherapy, for instance, because these lesions are characterised by necrotic components as well.

Conclusion

CAD systems are developed to assist the human reader in the detection of breast cancer. This development seems to be necessary due to financial and logistical problems associated with the double reading of radi-ologists.

CAD systems on the market are highly sensitive and are characteristically more sensitive than the radiologist, mainly in the detection of malignant microcalcifications and masses.

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