Integrating artificial intelligence (AI) with the radiology reporting workflow (RIS and PACS): Guidance on implementation of AI brought in during the COVID-19 pandemic

Standards

1. AI must be integrated in the reporting (radiology information systems [RIS] and picture archiving and communication systems [PACS]) workflow in such a way that it does not add extra burden to radiologists.
2. The accuracy (sensitivity and specificity) of the AI algorithm must be clearly displayed for radiologists and others making decisions on patient management.
3. AI findings must be communicated to RIS using existing, widely used, global technical standards (HL7).
4. AI findings must be communicated to PACS using existing, widely used, global technical standards (DICOM).
5. The workflow must be robust enough to ensure AI analysis must be complete and available on PACS, before a human reporter starts image interpretation.

Background and purpose of the document

AI will play a significant role in radiologists' future working lives. Pre-analysis of images by computers will help radiologists issue actionable reports. This document does **not** advise radiologists **which** AI solution they should buy, or on the ethical issues around use of AI. This document does not discuss AI solutions for workflow and radiology management efficiency either.

This guidance document is limited to the inclusion of AI for image analysis. It is aimed at helping radiologists integrate AI solutions into the reporting workflow, without increased burden. Careful analysis of the reporting workflow and understanding of interoperability standards are both essential for the safe integration of AI. The purpose of this paper is to support radiologists who are involved in AI procurement in their departments.

AI assisting image interpretation for radiologists

Computer analyses of radiology images for detection of specific conditions are emerging rapidly, for example the detection of breast lesions, brain bleed, stroke, fracture, aortic dissection and lung nodules to name a few. Human interpretation will take into account a wide range of information including – but not limited to – the patient's symptoms and signs, previous images, blood tests and histopathology report. Radiologists will understand the limitations of the computer algorithms and will often challenge interpretations made by computers. Radiologists will continue to issue the human actionable report, which is personalised to the patient. Actionable reports will provide a tentative diagnosis, potential differential diagnoses and advice on the next steps of patient management (which is often dictated by local circumstances and availability of services).[1]

[1] https://www.rcr.ac.uk/system/files/publication/field_publication_files/bfcr181_standards_for_interpretation_reporting.pdf

Radiologists will continue to hold medicolegal responsibility for image interpretation.

AI technology will enhance the reporting workflow for radiologists in two ways:

1. Medical image analysis: this provides computer pre-analysis of the radiology images, to help detect and classify abnormalities on images
2. Computer assisted triage: this helps prioritisation of reporting worklists, when an abnormality is detected by AI.

AI assisting emergency doctors

Computer-generated reports by AI algorithms will also assist emergency patient management and help emergency doctors, for example by identifying lung shadows, pneumothorax and other matters of relevance to a patient presenting with a chest complaint.

Mitigating risks associated with AI adoption

There must be a declaration accompanying every computer-generated analytic report about its limitations – including both sensitivity and specificity. It is vital that doctors on the front line and radiologists are mindful of the limitations, and do not consider computer-generated reports to be 100% accurate, all the time. A vendor must provide simple guidance on the meaning of sensitivity and specificity for doctors using the system, and it should be related to the particular AI algorithm with specific examples. So each time an AI package is adopted, it is accompanied by a clinically specific document that describes what the specificity and sensitivity means in the context of the particular pathology. This is about the human interface of technology adoption and mitigating risks to patients.

Technology components and interoperability requirements

The four main technologies that will be expected to work co-operatively for a radiology department are:

1. Scanners/modalities
2. RIS
3. PACS
4. AI platforms (containing one or more AI Algorithms).

They must support interoperability standards like DICOM and HL7 communications as explained in the Appendix of this document.

Summary

AI image pre-analysis is likely to have a very positive impact on radiologists' future working lives if properly integrated into the reporting workflow.

Appendix

A. AI platforms:

What are AI platforms?

AI platforms and AI algorithms are the new technologies that will need to work collaboratively with existing technologies – modalities, RIS and PACS. AI platforms will contain various types of AI algorithms for image analysis. Small, niche vendors and research groups may develop many of these algorithms. Images sent from the modalities to PACS will be pre-analysed by AI image-analysis platforms. These platforms will identify the modality and body parts within the study (using the DICOM header metadata) and apply the appropriate AI algorithm to the study. For digital radiography, AI algorithms may detect fracture in the appendicular skeleton, pneumothorax, rib fracture, consolidation, tube placement, pleural effusion and lung nodule(s) on a chest X-ray. On computed tomography (CT) head studies, AI algorithms will detect skull fracture, brain haemorrhage, brain infarct, brain tumour and so on. On magnetic resonance imaging (MRI) of the brain AI algorithms will include detection of multiple sclerosis (MS), stroke, brain bleed and tumour. On body CT AI algorithms will detect liver lesions, lung nodules and vertebral body fracture. On mammography AI algorithms will assess for suspicious lesions or calcification. If the algorithm detects an abnormality, the AI platform will perform a standard DICOM Query/Retrieve[2] for a prior similar study from PACS for analysis and comparison.

a. Input into the AI platform (from modalities, RIS and PACS)

It is essential that the AI platforms only begin analysis when the radiographer has completed the examination and sent the full study to the AI platform for analysis. The three steps defined below are essential to reduce any risk associated with AI implementation.

1. All DICOM studies from modalities must go to the AI platform first, before arriving in PACS for display.
2. HL7 ORM message from RIS with ‘status complete by radiographer’ must act as a trigger to start the AI platform image analysis (if there is an AI algorithm for that study type). A lag time should be introduced to allow for the study to arrive into the AI platform before image analysis begins.
3. AI platforms must be capable of performing a DICOM Query/Retrieve from the local PACS, so that when an abnormality like a lung nodule is detected, the AI algorithm should be able to do a Query/Retrieve for prior similar studies from PACS for the patient, and do a comparison for rate of growth analysis. The same analogy would apply for liver lesions, MS plaques and so on.

This three-step imaging and information workflow will prevent inadvertent reporting of images by radiologists before the pre-analysis by the relevant AI algorithm has taken place.

b. Outputs from AI platforms (into RIS and PACS)

Standard outputs from AI image analysis platforms must include the following:

1. Graphical representation of the region of interest (of the detected abnormalities) or mark-ups/pointers. These should always be output using DICOM standards, so that they can be viewed in PACS viewers.

   There are various options in DICOM for communicating graphical outputs:

[2] http://otechimg.com/otpedia/entryDetails.cfm?id=229

i. **DICOM SR (structured report)** and **DICOM segmentation standards** are preferred. They are robust interoperability standards for both graphics and text. This is seeing slow adoption by PACs and AI platform vendors.

ii. **DICOM presentation states** is commonly used in clinical PACS today. It has a toggle on-off option for graphics.

iii. **DICOM overlay** also has toggle on-off option for graphics.

Note that use of secondary capture (burned in pixels) is not an acceptable image formatting. This gives limited functionality with, for example, no ability to toggle on or off the overlay imaging information

2. AI abnormalities detected (or the text classification of abnormalities) will be output as text data: for example, fracture, haemorrhage, consolidation, infarct, pleural effusion and so on. This text data must be output in two formats:
    i. **DICOM SR** – to communicate to PACS in DICOM format
    ii. **OBX5 HL7** in the HL7 ORM message to communicate with a RIS.
3. Image analysis is complete notification – HL7 notifications to RIS that image pre-analysis by the AI platform is complete is essential for patient safety. Such a notification will allow the RIS to move the exam into the reporting worklist for the human reporter. Output from the AI platform should be 'ORC 5 – A' as per HL7 Table 0038. A stands for 'some but not all results available'.
4. AI alerts – Some abnormalities maybe classed as critical within the AI platform (this will be defined by the customer as part of the AI platform implementation within a hospital) – for example brain haemorrhage would be considered an alert-able abnormality. When this is detected, an alert should be sent in the HL7 OBX 8 field – 'A'.
5. Declaration/disclaimer: The AI platform should always send out a declaration which includes:
    i. A list of the abnormalities that were evaluated by the algorithm/s in the platform and applied to the study (for example for CT head – brain haemorrhage, skull fracture, brain infarct and so on)
    ii. The sensitivity and specificity of the applied algorithms for each abnormality evaluated.

    This declaration should be communicated as a PDF wrapped DICOM structured report format, which is added as an additional series on PACS.

B. PACS supporting AI workflow

When implementing an AI platform, radiologists must ensure that their PACS is capable of:

1. Displaying DICOM graphical information and DICOM SR (segmented region of interest [ROI] areas and text overlay) from AI – which can be toggled on and off by the PACS viewer icon. This requires support of DICOM SR display, DICOM presentation state standards and so on (as described above).
2. Displaying the declaration information from AI platform about the algorithms applied to the study. This should include the sensitivity and specificity for each of the abnormalities detected.

C. RIS supporting AI workflow

When implementing an AI platform, radiologists must ensure that their RIS is capable of receiving an additional HL7 ORM message from the AI platform and has additional data fields to parse the data sent:

1. Trigger for human reporting support

   Currently human reporting is triggered when the radiographer makes a status change to exam completed on RIS. With AI image pre-analysis implementation, radiographer status completion will trigger AI platform image analysis. Once image pre-analysis is complete, it will provide an outbound HL7 ORM with ORC 5–A (partial results available), which in turn should trigger human reporting workflow within RIS (that is, it moves the exam to d*ictation worklist* within RIS).

2. Additional data fields in RIS for r*eporting worklist* prioritisation

   Currently, reporting prioritisation by individual reporters takes into account many RIS data items which are sorted and filtered by radiologists. These include:

   i. Referral location type (A&E, inpatient, outpatient or GP)
   ii. Modality type (CT, MRI, DR and so on)
   iii. Speciality of the referrer (for example ENT, paediatrics, gastroenterology etc)
   iv. Referrer's urgency (for example urgent or routine)
   v. Intended reporter (work allocation by operators)
   vi. Date and time of exam completion.

   Radiologists prioritise their work based on the session being worked. For example during an emergency duty or on-call period, the radiologist will filter out all the CT and MRI for A&E and inpatient referrals.

The **additional data fields** required in RIS *reporting worklists* with AI implementation are:

1. 'AI abnormalities' – will be populated by data items like fracture, lung nodule, haemorrhage, and so on sent in the OBX5 field of HL7 ORM message from the AI platform. This information should be stored in the RIS database, and used by radiologists for filtering and sorting of reporting worklists.
2. 'AI alerts' – The platform should also send 'AI Alerts' in OBX 8, when abnormalities requiring alert are detected, for example brain haemorrhage.

References

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