



Integrating artificial intelligence with the radiology reporting workflows (RIS and PACS)

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Foreword

1. Standards

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

2. Background and purpose

It is recognised that artificial intelligence (AI) will play a significant role in radiologists' future working lives. Pre-analysis of images by computers will help radiologists to issue actionable reports.

This purpose of this guidance is to help radiologists integrate AI solutions into the reporting workflow without increased burden. Careful analysis of the reporting workflow and understanding of interoperability standards are essential. It is hoped that this guidance will support radiologists who are involved in AI procurement in their departments.

This guidance is limited to the inclusion of AI for image analysis.

This guidance does **not**:

- Advise radiologists **which** AI algorithm solution they should buy
- Advise on the ethical issues around the use of AI
- Discuss AI solutions for workflow and radiology management efficiency.

3. AI assisting image interpretation for radiologists

Computer analyses of radiology images for detection of specific conditions are emerging rapidly, for example in the detection of breast lesions, brain bleed, stroke, fracture, aortic dissection, lung nodules and so on. Human interpretation takes into account additional information such as a patient's symptoms and signs, previous images, blood tests and histopathology report. Radiologists understand the limitations of computer algorithms and will often challenge interpretations made by computers. With that in mind, radiologists will continue to issue the human actionable report, personalised to the patient, even after the implementation of AI algorithms. Actionable reports provide a tentative diagnosis, potential differential diagnoses and advice on the next step of management (often dictated by local circumstances and availability of services).¹

Radiologists will continue to hold medicolegal responsibility for image interpretation.

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

1. **Medical image analysis:** providing computer pre-analysis of radiology images to help detect and classify abnormalities on images
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2. **Computer assisted triage:** helping with prioritisation of reporting worklists when an abnormality is detected by AI.

4. AI assisting emergency doctors

Computer-generated reports by AI algorithms will assist emergency patient management and help emergency doctors, for example by identifying fractures, lung opacities, pneumothorax and so on.

5. Mitigating risks associated with AI adoption

A declaration must accompany every computer-generated analytic report about its limitations – sensitivity and specificity. It is vital that all doctors, including 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 this should be related to the particular AI algorithm with specific examples. Each time an AI package is adopted, it must be 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.

6. 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 algorithm).

They must support interoperability standards like DICOM and HL7 communications as explained in [Appendix 1](#).

7. 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 1.

AI platform

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, lung nodule on a chest X-ray and vertebral fragility fractures. For computed tomography (CT) head studies AI algorithms may detect skull fracture, brain haemorrhage, brain infarct, brain tumour and so on. For magnetic resonance imaging (MRI) of the brain AI algorithms may detect multiple sclerosis (MS), stroke, brain bleed and tumour. For body CT, AI algorithms may detect liver lesions, lung nodules, vertebral body fracture. For mammography AI algorithms may assess for suspicious lesions or calcification. If the algorithm detects an abnormality, the AI platform will query and retrieve a prior similar study from PACS for analysis and comparison.

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

It is essential that 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 operator (commonly the radiographer) must act as a trigger to start 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. The AI platform must be capable of performing a DICOM query retrieve from the local PACS so that when an abnormality such as a lung nodule is detected, the AI algorithm is able to do a query–retrieve for prior similar studies from the PACS for the patient. This will allow 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.

NB: It should be possible for radiographers to send the images from modalities directly to PACS if required (should the AI platform crash or have delays).

Outputs from AI platforms (into RIS and PACS)

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

- **Graphical representation** of the **region of interest** (of the detected abnormalities) or mark-ups/pointers should always be output using DICOM standards so that they can be

viewed in the PACS viewers.

There are various options in DICOM for communicating graphical outputs.

1. DICOM SR (structured report) and DICOM segmentation standards are preferred. They are robust interoperability standards for both graphics and text. These standards are now being slowly adopted by PACS and AI platform vendors.
2. DICOM presentation states – commonly used in clinical PACS. It has a toggle on-off option for graphics.
3. DICOM overlay – this too has toggle on-off option for graphics.

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

- **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:
 1. DICOM SR – to communicate to PACS in DICOM format
 2. OBX5 HL7 in the HL7 ORM message to communicate with a RIS.
- **Image analysis** is complete notification. This is an HL7 notification to RIS that image pre-analysis by the AI platform is complete. It 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 0038.²'A' stands for 'some but not all results available'.
- **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 alert-able anomalies are detected an alert should be sent in the HL7 OBX 8 field – 'A'.
- **Declaration/disclaimer:** The AI platform should always send out a declaration which includes the:
 1. List of the abnormalities that were evaluated by the algorithm/s in the platform and applied to the study (for example, for CT head this might be brain haemorrhage, skull fracture, brain infarct and so on)
 2. Sensitivity and specificity (or true/false positives and true/false negatives maybe used) of the applied algorithms for each of the abnormality evaluated.

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

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 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 previously).
2. Display the declaration information from AI platform about the algorithms applied to the study. This should include the sensitivity and specificity for each of the abnormality detected.

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 by the AI platform.

1. Trigger for human reporting

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

2. Additional data fields in RIS for reporting worklist prioritisation

Currently, reporting prioritisation by individual reporters take into account many RIS data items which are sorted and filtered by radiologists. These include referral location type (emergency department, inpatient, outpatient or general practitioner), modality type (CT, MRI, DR and so on), speciality of the referrer (for example, ear, nose and throat, paediatrics, gastroenterology and so on), referrer's urgency (for example, urgent or routine), intended reporter (work allocation by operators) and 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 emergency department and inpatient referrals.

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

1. AI abnormalities – this list 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 radiologist for filtering and sorting of reporting worklists.
2. AI alerts – the platform should also send AI alerts in OBX 8 when alert-able abnormalities are detected such as brain haemorrhage.

This document was approved by the Clinical Radiology Professional Support and Standards Board on 28 January 2021.

References

1. The Royal College of Radiologists. *Standards for interpretation and reporting of imaging investigations, second edition*. London: The Royal College of Radiologists, 2018.
2. www.hl7.org/fhir/v2/0038/index.html (last accessed 18/2/21)

Further reading

1. <https://slideplayer.com/slide/3898364/> (last accessed 22/2/21)
 2. www.dclunie.com/papers/SIIM2010_Clunie_PACSDoesntDo.pdf (last accessed 18/2/21)
 3. www.dclunie.com/papers/CMIMI_2018_David_Clunie_StandardizingAIAnnotationsDICOM.pdf (last accessed 18/2/21)
 4. http://dicom.nema.org/dicom/2013/output/chtml/part03/sect_C.9.html#table_C.9-2 (last accessed 18/2/21)
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