The Diagnostic Radiology Lifecycle

Standardised Terminology for the Process Stages of a Diagnostic Radiology Episode

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Final Draft

June 9th, 2023

Executive Summary

Diagnostic radiology contains a large body of specialist terminology relating to its business processes and workflow which are not standardised in usage across organisations. This makes communication error prone, especially for clinical and management teams working with and assessing performance between radiology services.

In this document, we attempt to define a standard workflow for diagnostic imaging episodes from the point of referral to result delivery by defining and detailing each of the timepoints on the journey of an examination through four key stages: *pre-acquisition, acquisition, post-acquisition* and *result delivery*.

We also make an attempt to describe common terms of reference used when prioritising radiology episodes.

Introduction

Diagnostic radiology is heavily process driven, meaning that it is amenable to standardisation of the terminology used to describe the stages and status points in the workflow at a given time point between referral and result delivery.

In spite of there being an 'unwritten recognition' of the most common points of the workflow (*vetting, acquisition, reporting etc*) by those experienced in working in radiology services, it remains a largely undocumented business process which is lacking in standards of measure and statistical reporting. In many instances, inferred terminology has been adopted through naming conventions used by vendors who supply radiology technology solutions (RIS and PACS). Variability between vendors therefore requires adoption of new terminologies with a change of vendor or solution. The radiology software industry has never been provided a set of standard terminology as a point of reference, which would explain the inconsistency.

Diagnostic radiology lacks a common standardised language for the communication of processes, statistical analysis and performance benchmarking.

As a consequence, radiology is often perceived as confusing and difficult to understand by staff outside of the specialism. Mistakes in terminology, measurement and performance analysis are commonplace when radiology services are externally benchmarked at a local, regional and national scale.

In a clinical setting, the lack of standardised terminology for important episode statuses such as *priority* (routine, urgent etc) can have a damaging effect on care delivery. The importance of standardisation is particularly pertinent when radiology is scaled to a regional or national network level, where *study priorities* may be conflicting between participating sites. Furthermore, priorities driven by different issues can be confused. An escalation of priority for administrative reasons (e.g. need to discuss at MDT) is different from an escalation of priority for clinical impact on immediate management (e.g. trauma or critical limb ischaemia).

The cost of an urgent study to the radiology department is higher than that of a routine study - including additional administrative, radiological and radiographic burden: Squeezing a patient into a non-existent slot and interrupting a radiologist to issue a priority report.

Scope of this Standard

In this document, we define the following standards for diagnostic radiology:

- The stages a radiological examination passes through (The Radiology Lifecycle)
- Standardised terms for the actions in the Lifecycle
- Standardised terms for statuses in the Lifecycle
- Suggested standards for priority status for radiological episodes distinguishing between administrative and clinical priorities.

The Benefits of Standardising The Radiology Lifecycle

Adoption of standard terms of reference for a radiological episode would offer a number of key benefits.

1. A set of standard terminology for all vendors to incorporate into software processes.
2. Improved communication around radiological episodes amongst radiology staff.
3. Improved understanding of radiological processes by staff outside of radiology.
4. Clear and consistent timepoints in a patient journey to measure progress and for statistical analysis of performance at differing levels of granularity.
5. Standard timepoints to improve the accuracy of statistical analysis and benchmarking of radiology services at a local, regional and national scale.
6. Safer patient care due to the use of standardised statuses of radiological episode priority
7. Ability to see the impact of imaging on the total patient journey from presentation to medical services to formal diagnosis and initiation of treatment.

The Radiology Lifecycle

As a requested study passes through predictable process stages, it moves through a lifecycle which is completed at the point that acquired imaging has been reported and results have successfully been delivered. Broadly speaking, the cycle can be divided into three main stages (Figure 1).

Figure 1: The Radiology Lifecycle in overview stages

Pre-acquisition refers to largely administrative tasks which are essential in the accurate preparation, planning and scheduling of the study.

Acquisition refers to the attendance for the capture of medical images, and their post-processing to make ready for reporting.

Post-acquisition tasks take place after the patient has attended. The images are interpreted and formally reported. Results are delivered to referrers.

Breaking down the process of diagnostic radiology into these three core stages creates two natural points of measurement for the monitoring of performance of a radiology service, comparison and benchmarking.

Time to acquisition (tAcquisition) is the time between referral and image acquisition. It is frequently misinterpreted as the endpoint for the measure of completion in radiology by patients,

clinicians and other staff monitoring performance. However, it merely results in images being ready to progress to the post-acquisition stage.

Time to Report (tReport) is the time interval between completion of the acquisition stage and the delivery of a result back to the referrer having been interpreted and reported.

Division of the Radiology Lifecycle into these key stages allows a service to monitor the balance of capacity against demand for both image acquisition and reporting capacity. Business Intelligence (BI) tools may be used to monitor these metrics of performance in realtime and alert service managers to degradation in performance against a defined standard.

With the added help of Artificial Intelligence (AI) tools, heuristic monitoring of these metrics against historical performance trends may act as an early warning system to predict future service degradation. Using longer term predictive modelling, AI tools could also help to forecast growth needs in service provision in acquisition (equipment and staff) and reporting (staff, equipment and desk space) providing useful data for business cases and financial planning.

The Radiology Lifecycle - Stages and Steps in Detail

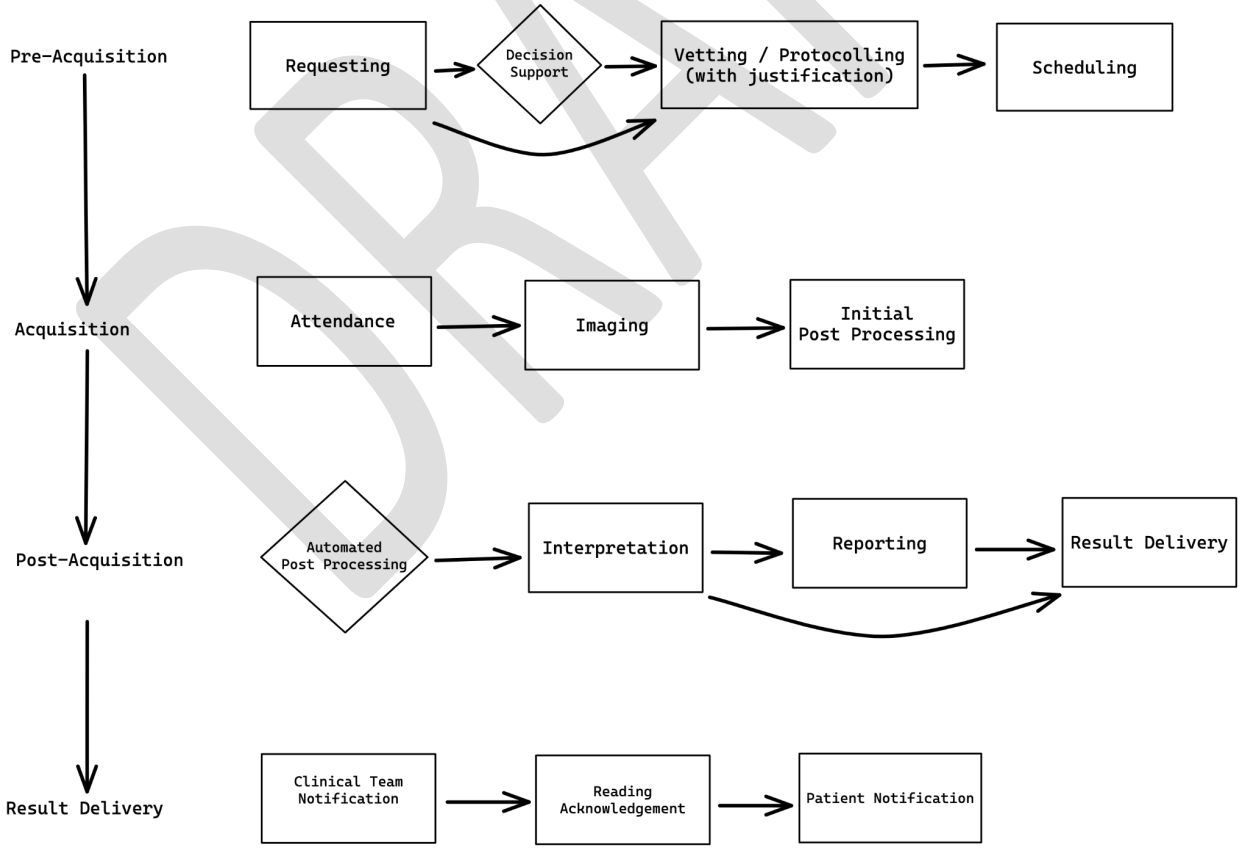

Figure 2: The Radiology Lifecycle in detail. Standardised terminology for the journey of a diagnostic radiology episode from request to result delivery.

Pre-Acquisition Stage

Throughout this Lifecycle stage, the patient's status may be considered to be *waiting* or *on a waiting list*.

Requesting and Decision Support

A radiological episode begins with a request (also commonly known as *order*), which is usually created by a referrer using an electronic referral system, and formerly paper-based forms. In an electronic referral pipeline, there may be clinical decision support software which provides assistance in choosing the most appropriate modality and examination for the situation such as iRefer from The Royal College of Radiologists.

Conditional logic in electronic forms helps the radiology department to gather mandatory data at the point of referral, which reduces the burden of administrative work and limits or restricts referrals missing process critical, safety or legally required information (i.e.. Affected side, glomerular filtration rate, Pregnancy status).

Vetting and Protocolling

Both processes are usually carried out as a single step.

Requests are interpreted to ascertain whether the information provided allows the study to progress to scheduling. Protocolling goes hand in hand with vetting and relates to the selection of the correct study modality and specific imaging protocol to best answer the clinical questions in the referral.

Most vetting is still carried out by humans who naturally apply criteria to the process, though these are seldom defined.

1. Mandatory information has been accurately completed.
2. The imaging modality and examination appear correct for the clinical situation and questions in the available information.
3. The referrer (or associated team) are allowed to request the examination and is capable of receiving, interpreting and appropriately acting on the radiological report.

During the process, the 'vetter' may change the modality and/or examination and might require further dialogue with referrers if the information provided is unclear. Some electronic referral systems offer a mechanism for electronic feedback, though the commonplace default terminology used (rejection) is not recommended.

The protocol chosen acts as a means of communication to the administrative teams who carry out resource bookings and radiographic staff who will acquire the images. The protocol often dictates when and how the episode can be fulfilled, and who is suitable to carry it out. In large, multisite departments and regional imaging networks, standardised, published imaging protocols for appropriate pathways are considered a good idea to help achieve consistency in

imaging services. This is especially helpful in pathway driven care, during review at MDT meetings and in cross site reporting environments.

When a study involves the use of radiation, justification (under IRMER criteria) is also carried out during the vetting and protocolling step.

Standard Operating Procedures (SOP) in imaging departments should ensure that protocolling is undertaken in a timely manner following receipt of the imaging referral to prevent delay in progressing the request to the scheduling stage.

Scheduling

All departments operate some form of booking diary, which is often connected to the DICOM modality worklist for each resource. Episodes which have been accepted, vetted and protocolled can be progressed to the booking diary or waiting list until the appropriate appointment can be offered to a patient.

Scheduling should take place as soon as possible following receipt of the imaging request.

Acquisition Stage

When the patient attends the imaging department, undergoes pre-study checks and has successfully been imaged, acquisition is complete. This is often straightforward but depends on the accuracy and thoroughness of the pre-acquisition stage to prevent unexpected cancellation or rescheduling. It is often a more challenging and chaotic process in the acute clinical setting with more unexpected and unpredictable presentations.

Attendance

When the patient arrives in the department, there will usually be a check in process to confirm core data such as demographics and suitability for the examination planned. This process usually also records these details so that staff in a resource know that a patient has arrived and is ready to be imaged.

Imaging

The acquisition of medical images for the episode. This step occasionally involves an *on table* review (ideally signalled in advance) and further adapted images or sequences.

Initial Post Processing

The images are reviewed by the radiographers who would alert a radiologist if a suspected critical finding has been observed during acquisition. They would also carry out basic image post processing to improve presentation of the study: cropping, planar alignment, windowing and labelling. Multiplanar reformatting may also be carried out for cross-sectional modalities.

The final images are sent to PACS ready for review on a radiology workstation. The status of the study is usually, automatically changed by the RIS/PACS software to indicate readiness for reporting. In some instances, the study may be assigned to a specific worklist or radiologist for their attention.

Post-Acquisition Stage

Once a patient has attended, images have been acquired and processed into a format ready for review, they enter this stage. Review and reporting are a pivotal part of the Radiology Lifecycle often overlooked or miscalculated in benchmarks that consider acquisition to be the end of the process. When measuring time from acquisition to reporting, an important decision and distinction to make is 'working days' vs chronological days when reporting is not often as well-resourced outside of the emergency setting.

Automated Post Processing

Artificial Intelligence (AI) tools carry out a *primary read* of studies by parsing image data and metadata relating to the episode to offer an opinion based on their machine learning algorithms. The result is often delivered as a labelled secondary capture which the radiologist can observe as additional evidence during their formal review process.

Interpretation

The person carrying out the review process opens the imageset for the episode in a DICOM viewer (often part of a PACS) and uses the inbuilt tools to review the different image series. Historical images and reports are compared when relevant to the examination under active review.

During the interpretation process, the reviewer may also make use of additional tools such as 3D and multiplanar reconstruction of original source data, as well as tools for advanced and specialist study review (CT colonography, vascular imaging, bone modelling etc).

Reporting

The authoring of a formal, medicolegally binding report which will form a part of the patient medical record is one of the most important steps in the completion of the imaging Lifecycle. It is most commonly carried out by a radiologist, but also other allied health professionals such as a reporting radiographer.

Either after or during review of the imageset a report is authored to describe the findings, reach a differential diagnosis and advise on management or further investigations. This process is usually accelerated by the use of Voice Recognition (VR) software to translate speech to text after adequate training. Text macros also increase productivity.

This seemingly simple sequence of events becomes more complex with the introduction of multiple report authors, either for additional specialist opinion or supervision of training.

Associated terminology is also confusing and has not been standardised: *checking, co-authoring, provisional reporting etc.*

Checking Reports

Assumes a single report authored by one person, read, reviewed and issued by another who is usually acting as a supervisor.

Co-authoring

Implies multiple authors contribute to a single body of text report. Final review and issue are carried out either by the original author, having received additional opinions *or* by a supervising author with adequate privileges to issue the report. Co-authoring is a complex workflow which in our experience is error prone due to the number of users involved, with differing software roles and permissions.

Provisional Reporting

A report is authored with a standardised phrase indicating it to be a *provisional report* which will be reviewed and double read by a second reader (often a senior supervisor). The report is issued at the point of reporting such that it becomes visible to referrers who can initiate care but are asked to read the second review. Provisional reporting remains common in the on-call setting.

Addendum Reporting

An additional report is concatenated to the end of the original report without changing its content. Addenda are used in a wide range of contexts: MDTM outcomes, secondary specialist reading and supervision being common.

Result Delivery

When a report has been authored, it enters a state of completion for which we observe a wide range of terms to describe the state: *completed, verified, authorised*, *signed off*. All of these terms result in the issue of a report to downstream medical record or result systems such as an Electronic Medical Record system (EMR). There is a wide range of variability in the mechanisms used to deliver results dependent on integrations with other information systems used in the service, their features and compatibility.

Notifications

Critical alerting is an important component of the result delivery process which allows important and unexpected findings in the report to be delivered to the referrer with increased priority, in an attempt to expedite timely care. The ability to deliver a critical alert in a reliable and automated manner is highly dependent on the downstream information systems being capable of receiving (HL7) alert messages and initiating an appropriate push notification to the referrer.

Manual alerting methods dependent on human factors should be considered a last resort and are far more prone to failure and inconsistency.

The topic of failsafe critical alerts, with delivery receipt and acknowledgement is a complex topic addressed elsewhere in the Royal College of Radiologists catalogue of guidance.

Notifications should initially be sent to the clinical team who requested the investigation. Upon receipt, a digital acknowledgement or read receipt should be captured so that the radiology service is aware of successful report delivery.

Once this process has completed, the results should be shared with the patient in the correct clinical context. This process has most commonly been carried out in person, in a clinic or hospital setting but increasingly patients have access to results through digital applications or patient portals. Radiology reports often contain volumes of technical and anatomical detail which are not authored for the layperson. This is an important consideration when architecting patient result solutions, especially when handling sensitive results requiring consultation and counselling, or when the patient has consequent questions.

Standardising Priority Status for Radiological Examinations

In radiology, priority status is assigned to examinations for a multitude of reasons and there is a lack of consistency across organisations and sites. Broadly speaking priority of an episode is often dictated by the following factors:

- **Direct clinical importance** where a delay in medical imaging negatively impacts on a patient's morbidity or mortality in the condition being investigated.

- **External performance factors** where a delay in patient care arises due to failure to fulfil medical imaging and, it is considered the rate limiting step for the intended care pathway (outpatient appointment, surgical procedure etc).

- **Organisational importance** where targets have been set against which performance is measured on a care pathway involving medical imaging.

Terminology of priority

No standardised terms of reference have been previously defined for the priority of medical imaging examinations. Here, we attempt to define the semantic meaning of terms commonly used when discussing the timing and execution of medical imaging.

Emergency examinations imply conditions that are life, organ or limb threatening and very fast acquisition and reporting of medical imaging (usually CT scans) contributes in an essential manner to immediate management. Emergency studies take place almost exclusively in the acute hospital setting. Interpretation and reporting usually take place quickly after the completion of the study and may involve in person, verbal or expedited initial reports for critical findings.

Examples: Major trauma, Hyperacute stroke

Urgent examinations concern the investigation of conditions where a delay in imaging results in greater morbidity or mortality. Urgency arises in both the hospital environment and outpatient setting. It indicates that a study should be prioritised above others of lesser perceived clinical need based on clinical information provided in the referral. When a study is known to be urgent, either from the point of referral or based on radiographer observations during acquisition, the report is usually expedited and could involve critical alerting or triggering of a pathway.

Examples: Suspected cancer, Pulmonary thromboembolism

Routine examinations are studies that are perceived to be of a lesser acuity than others and can safely be scheduled with a reasonable waiting period before acquisition and reporting based on the information provided in a referral.

Examples: Painful knee, Suspected gallstones

Pathway driven examinations result in expedited imaging for specific conditions which vary based on national, regional and hospital level policies and targets. Performance measures may be in place to monitor pathways, with rules specific to the imaging timeline. It is important for radiologists to carefully define these time points and measures so that medical imaging is not erroneously considered the point of delay in a pathway. A pathway often includes the review of imaging at an MDT meeting.

Examples: Cancer of unknown primary, hip fracture

Appendix 1: Standards for the communication of radiology results to patients

Communicating results to the patient

The Academy of Royal Medical Colleges in ***Standards for the communication of patient diagnostic test results on discharge from hospital*** 2016 state the following three guiding principles for communicating results:

- The clinician who initiates the test is responsible for reviewing, acting and communicating the result and actions taken to the GP and patient even if the patient has been discharged.
- Every test result received by a GP practice for a patient should be reviewed and where necessary acted on by a responsible clinician even if this clinician did not order the test.
- Patient autonomy should be respected.

Further Reading:

- ***Unlocking Solutions in Imaging: Working Together to Learn from Failings in the NHS*** Parliamentary and Health Service Ombudsman; July 2021
- ***Failures in Communication or Follow-up of Unexpected Significant Radiological Findings*** Independent report by the Healthcare Safety Investigation Branch I2018/015; 2019
- ***Standards for the communication of radiological reports and fail-safe alert notifications.*** The Royal College of Radiologists; 2016
- ***Standards for a results acknowledgement system*** The Royal College of Radiologists; 2010
- ***Recommendations on Alerts and Notification of Imaging Reports*** Academy of Royal Medical Colleges October 2022
- ***National Standards for Imaging Reporting Turnaround Times*** to be published by NHS England – *timeframe unknown*
- ***Early Identification of Failure to Act on Radiological Imaging Reports*** National Patient Safety Agency Safer Practice Notice 16; 2007
- ***Standards for the communication of patient diagnostic test results on discharge from hospital*** Academy of Royal Medical Colleges 2016

Appendix 2: Targets for imaging lifecycle stages within NHS England

Pre-acquisition: Requesting

Imaging referrals should be requested as soon as reasonably possible following the clinical decision to place the patient on a designated care plan that includes an imaging examination.

DM01: The 6 week diagnostic clock starts when the request for a diagnostic test or procedure is made and stops when the patient receives the diagnostic test/procedure. *DM01-guidance-v-5.32.pdf (england.nhs.uk)*

Faster Diagnosis Standard (FDS): for patients who are referred for suspected cancer have a timely diagnosis within 28 days of being referred urgently by their GP.

Acquisition of Imaging

NHS England National Imaging Team Perspective

Imaging acquisition should not exceed the 6-week diagnostic standard (DM01) or the 28 day Faster Diagnostic Standard (FDS). All providers should have locally agreed booking SOPs in place, in line with their local patient access policy, to ensure Imaging waits are pro-actively managed.

Post Acquisition: Reporting & Result Delivery

NHS England Imaging report turnaround time standards

Published guidance encompasses standards for the reporting turnaround time in varying referral pathways, from routine to urgent, and include arrangements that should be in place for timely reporting.

Reference Document Here

Within the standards all images should be reported, and a result provided within 4 weeks from when the scan is performed.