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COMMENTARY

Limitations of diagnostic reference level (DRL) and introduction of acceptable quality dose (AQD)

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It is normal for a patient undergoing a radiological examination to expect that the radiation dose he/she will receive will be within a reasonable range of standard. Do we have that "standard" dose? The precise answer is actually no. The most common approach has been to use diagnostic reference level (DRL), which is a 75th percentile of the mean doses for a sample of patients close to the standard size, typically 70 kg or, in some countries, 60–70 kg. The purpose in cases of DRL is to detect outliers (higher 25th percentile cases) from a sample. In the absence of a standard dose, there has been an erroneous tendency to assume that being below DRL means adequate optimization.[1] Removing rotten pieces of fruit is different from picking good pieces of fruit. DRLs do not provide guidance on what is achievable with optimum performance. DRLs were not developed as a tool for optimization within 75th percentile. DRLs provided good tools in previous years when the spread of doses were by a large order of magnitude and the shape of dose distribution curve was right-skewed asymmetric. There is no problem with DRL but stopping at DRL and using DRL in ways it was not supposed to be used creates problems.

In a recent article, Sutton et al[2] call into question whether DRLs are suitable for devising optimization strategies once a certain degree of optimization has taken place. They also show that doses follow a distribution not in keeping with the current concept of DRLs.

The author agrees that with enthusiasm in dose management having percolated down at various levels in imaging facilities and there being paucity of reports that document substantial cases falling outside the DRL, the role played by DRL is becoming smaller.

Furthermore, there are a number of problems with the way DRLs have been used such as:

(1) There has been a tendency to use DRL as a *de facto* dose limit that should not be exceeded, which becomes detrimental to patients of higher body build who actually need doses higher than the DRL value to get adequate image quality. DRLs are not a border between good and poor medical practice.
(2) Despite nearly 30 years of existence, DRLs for adults have been confined to representative standard patient or phantom. Larger fractions of patients are currently non-standard. The fundamental problem is that we do not have the means of proving dose figures that would be appropriate for large patients.
(3) DRLs were developed for a defined technology, and it was envisaged that they would be updated when technology changes, this has rarely happened except in the UK. Many countries in the world use DRLs that have been developed by other countries.
(4) DRLs were not meant to be used for an individual patient, whereas current need is for optimization of dose to an individual patient.
(5) DRLs reflect upon facility and on outcomes from retrospective analysis, whereas optimization currently needs to deal with the prospective situation of optimization for a patient at hand.
(6) Most dose surveys for DRLs have assumed acceptable image quality rather than confirming and documenting it.

Another concept of "achievable dose" propagated in 1999 by the National Radiological Protection Board (now Public Health England) and recently adopted by the National Council on Radiological Protection and Measurements also suffers from some of the limitations of DRL and has thus not picked up much in preceding years.[2,3] Recently, reference ranges have been propagated to cover the range of 25–75%, but the concept of range only helps is removing outliers; in this case, lower values in addition to the higher ones.[4] Furthermore, it is questionable if one should use dose value for lower range as that can imply ignoring better technology that may exist in many centres in which diagnostic quality can be obtained at doses <25% of the national dose distribution.

Not withstanding the useful role played by DRL in the process of optimization, newer approaches are needed to support optimization of patient protection to remove

lacunae listed above. The quantity should not be dependant upon a standard-sized patient but relate to the patient at hand, and it should provide the dose value needed for diagnostic quality that the technology being used can prospectively provide for an individual patient.

The following description addresses these issues and provides newer solutions:

While questioning the usefulness of DRL, Sutton et al[2] did not provide a solution. Our article provides background for the solution before proposing a possible solution in acceptable quality dose (AQD).

Patient's age, weight or cross section: the approach so far has been to use body weight in cases of adults or age and/or weight in cases of children. Weight is one step ahead of age. Correcting the value by the effective cross section of a body part to yield size-specific dose estimates in CT has been attempted.[5] But, it adds an element of manual work and one still needs the concept of DRL or another to use it for optimization. Furthermore, modern imaging equipment are normally digital with the capability to assess attenuation, such as in CT, through scan projection radiograph and use it to modulate milliampere in every rotation (tube current modulation in CT) and provide optimized exposure except in very small or very large patients where further manual selection may be needed. The patient attenuation properties are being used by equipment to optimize exposure based upon image quality/noise in CT chosen by the operator or speed of detector information in radiography. So, the crucial factor is image quality. Since dose, image quality and patient's body build are all relevant, a concept having combined consideration of these three is needed. Dividing adult patients in weight slots of 10 kg each can take care of body habitus. Weight being an easily measurable quantity, it can be retained for categorization purpose. Similarly for children, one can have slots of 5 kg each.

Image quality: in the absence of acceptable methodology for scoring image quality of (say) CT scans in an objective and clinically meaningful and practicable manner, it is appropriate to have the decision by a well-informed imaging expert (radiologist) that the image is diagnostic (or serves clinical purpose) and thus acceptable. Many interpreters are good at identifying bad images but not when an image is of a higher quality than necessary. In good centres, where awareness is created about acceptance of images with some noise rather than crisp images, the radiologists can also discern images of higher than necessary quality. Awareness about what features should be visible and to what extent (like quality criteria proposed by European Commision) helps in reducing interobserver variability. The radiologist can score images on a scale of 1–10 with 10 being most optimal, and any image with score >6 can be classified as acceptable. There has been a tendency to downplay the importance of subjective assessment of image quality. On the contrary, experiences from studies that have compared objective parameters of image quality with subjective assessment have shown good correlation.

ACCEPTABLE QUALITY DOSE

This article introduces a new quantity "AQD" as given below:

- Each facility determines averaged dose values ($\pm$standard deviation) for individual examination that has images of clinically acceptable quality by well-informed imaging specialists that are classified in weight groups of 10 kg body weight for adults, *e.g.* 41–50, 51–60, 61–70, 71–80 kg and so on. A similar approach can apply to children preferably with lower weight slots of 5 kg.
- One can determine AQDs for local, regional (sub-national) and national situations.
- This AQD will serve the purpose of "standard dose" for that examination and can be compared with the AQD of another room in the same hospital or for intercomparisons between hospitals within or outside a country. It can be used to detect those situations where optimization is needed.
- AQD can be used prospectively in adjusting parameters of patients whose estimated DLP value is likely exceeding AQD $\pm$ standard deviation.
- Also, one can identify those patients in whom image quality was not diagnostic or higher than was necessary, investigate and use the outcome as lessons learnt. This shifts focus of the investigation from dose in DRL to image quality in AQD.

Image quality is primary in this approach and dose is secondary, and the approach provides provision for covering all weight groups. Thus, all three parameters: dose, image quality and patient's body build are covered.

Regulatory actions: DRL found its place in regulatory systems as early as the 1990s.[6] Currently, national bodies are supposed to establish their national DRL values. There is provision for local and regional DRLs. Furthermore, almost all regulatory systems include the use of DRL for patient protection as an optimization tool. With almost 20 years of DRL in regulatory framework, it will take substantial time for any new concept to be included in the regulatory system. But that should not prevent creativity and emergence of newer approaches to patient protection, which is becoming increasingly important with increasing reports of lack of optimization. It is common to find a number of publications documenting the lack of optimization in peer-reviewed literature every week, whereas the number of publications that report cases outside DRLs are far and few and occur only few times every year rather than every week. Regulatory actions in future should require facilities to establish their local AQDs and compare these with those of national values. It should be for national authorities to establish national AQDs, which will be averaged values derived from local AQDs. One can consider median rather than average as more representative. When facilities get accustomed to recording and classifying AQDs, the assessment of improvement can be performed frequently, say once in 6 months or annually, rather than waiting for years, which is the case currently with DRLs.

On the issue of terminology, one can argue on the superiority of diagnostic image dose, clinically acceptable image quality dose etc., but to keep it simple, the author suggests AQD.

Furthermore, this article describes the concept of AQD, and it is assumed that AQDs for different indications will need to be developed rather than confining to select few common examinations.

CONCLUSION

In conclusion, the concept of AQD has a number of inbuilt advantages, namely it starts with a facility rather than national levels and thus promotes facility-based actions; is based on clinically acceptable image quality that is the primary goal of any imaging rather than the dose that is the secondary parameter; covers all three crucial parameters, namely image quality, dose and the patient's body build; and views optimization truly from the angle of optimization rather than just exclusion of outliers.

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