This is where guidelines and clinical decision support systems come in. Imaging referral guidelines are a way to systematically organise knowledge about the appropriateness of the different imaging modalities and their diagnostic value for a given clinical scenario. These guidelines tell doctors in which cases an x-ray is the best option for diagnosis, for example, or whether a magnetic resonance imaging (MRI) exam is preferable over a computed tomography (CT) scan for a particular condition. Given the complexity of medical imaging, guidelines are an essential tool to support doctors in deciding what is best for their patients. In Europe, the availability of evidence-based referral guidelines is mandated by the EURATOM Basic Safety Standards (BSS) Directive, the European Union’s radiation protection legislation, while the United States has gone a step further by requiring the use of guidelines via a decision support mechanism starting in 2019.

Every imaging exam needs to be medically justified, and the justification process has several steps. In the case of modalities using ionising radiation, such as plain radiography and CT, the responsibilities and process for justifying the patient’s exposure to radiation are defined by law. Justification in medical imaging means that the expected medical and diagnostic benefit is greater than the associated risk. Making sure that the referral is appropriate for the patient and his or her condition is the first step in the justification process. Referral guidelines are the knowledge base that help doctors determine how appropriate various modalities are in a given situation, and clinical decision support systems are the IT tools that make guidelines user-friendly.

CDS can go a long way in addressing these issues. One of the first steps in developing a CDS mechanism for imaging referrals is to...
turn the guidelines for appropriate referrals into actionable rules in an algorithmic, software-compatible format. These guidelines are often supplemented with additional recommendations based on expert consensus to broaden the coverage of clinical scenarios, and to increase the amount of structured information that is used in the process and captured by the system, which can be analysed to further improve the guidelines over time. The digital format also allows updated guidelines to be brought to the user in much shorter intervals. In addition, the system’s recommendations can be adapted to reflect national regulations, local guidelines or institutional circumstances, for example taking into account the availability of certain types of imaging equipment. If an evidence-based guideline recommends the latest technology as the most appropriate option, this is of little use in practice to doctors and patients if the equipment is not available at their location.

IMPLEMENTATION AND USE OF CDS SYSTEMS

CDS systems can be used as stand-alone portals that doctors consult similarly to text-based guidelines, with the already noted advantage of being dynamic taking into account particular parameters. However, using a separate portal without access to the patient’s record as well as other IT programmes the doctor would otherwise use, is not an efficient way to embed referral guidelines in clinical practice. An important condition to facilitate the use of CDS systems is the existence of an electronic referral workflow into which they can be integrated. Speed is an important factor in healthcare delivery – even more so in emergency scenarios, as we shall see later – and doctors do not have the option of spending extra time consulting guidelines to fill in forms. The widespread adoption of hospital information systems, electronic patient records, and computerised physician order entry (CPOE) systems has led to the development of streamlined IT workflows into which CDS systems can be seamlessly integrated.

In its integrated form, a CDS system does not interrupt the clinical workflow; it simply changes an existing process and adds valuable information for the doctor. By communicating with, for example, a hospital information system, CDS automatically pre-selects key patient parameters such as age and gender that are relevant for selecting the appropriate exam, while the doctor selects a structured indication based on the patient’s symptoms, which previously was done as free text. In most referral forms, the doctor still has the option to add further observations that may help the radiology department carry out the examination, but the use of structured indications makes referrals much more consistent and clear than a free text request. With this information, the CDS returns feedback on the appropriateness of the exams that are available at the radiology department the patient is to be sent to. Usually, this information is presented by grouping the available exams into categories in descending order of appropriateness, perhaps aided by colour coding in green, yellow and red to make it visually clearer (Figure 1).

Different configurations are possible. For example, a common way of incorporating CDS alerts is to only display them if the doctor is about to request an exam that is not appropriate to the patient’s condition according to the guidelines. It should be noted that it is always the professional that makes the final decision, as CDS has a strictly advisory function in supporting this decision. Needless to say, no software is perfect, and a doctor may be able to take into account information that a digital record cannot. However, the fact that users are being made aware of guidelines, in real time and at the point of care, is a significant improvement, providing doctors with important additional information to take into account when making healthcare decisions for their patients. Hospitals that have implemented CDS in the United States have experienced a significant change in referral patterns, as doctors can now make their decisions using evidence-based recommendations either by selecting a more appropriate exam or by concluding that in a given case imaging is not justified at all. Having up-to-date evidence at doctors’ fingertips has important educational benefits while making medical practice more consistent and reducing variation and the risk of medical errors. Requesting the right test the first time saves resources, time and money.

This leads us to another crucial advantage of embedding referral guidelines digitally through CDS: it makes reliable data on appropriateness available for analysis. The data gained from this process can be analysed, and findings can be used to reduce unnecessary radiation exposure, improve the efficiency of workflows, reduce waiting times, or even support long-term investment decisions in healthcare systems by giving a clearer picture of the need for different imaging modalities.

Because it affects imaging referrals from all departments, the implementation of a CDS system is an endeavour for a whole enterprise or hospital, not just for a radiology department alone. A shared understanding is needed.
and the leadership of the project has to be jointly agreed from the beginning with the hospital management and the clinical departments involved.

**CDS IN RADIOLOGY – ACR AND ESR EXPERIENCE**

The use of CDS for radiology referrals was pioneered at Massachusetts General Hospital in the United States almost 15 years ago. The introduction in the United States almost 15 years ago, the ACR’s Appropriate Criteria are a national standard for imaging referrals, and the widespread adoption of CDS have yielded impressive results. These guidelines have been available through the decision support system ESR iGuide in Europe since 2016, when the first pilot projects started in European countries.

**CDS IN THE EMERGENCY DEPARTMENT**

The emergency department is different from other departments in a healthcare organisation not only because of the types of patients that they see and their pathologies but also because of the issue of time which impacts healthcare delivery in two ways. First, emergencies can happen at any time of day (or night), any day of the week, any time of the year. It is obviously a significant difference if a patient comes to a hospital during regular working hours on a weekday, or whether an injury occurs during the early hours of a Sunday morning, both in terms of the staff that is present and potentially in the facilities that are available. For example, some community hospitals may switch off their MRI machines on weekends or public holidays.

The second way time makes a difference is in the speed with which an emergency has to be dealt with. In some cases, stroke being an example, mere minutes can literally make all the difference in the world. This means that the margin for delays in the emergency department is infinitely smaller than in ‘regular’ healthcare situations.

The editorial of a British Journal of Radiology edition dedicated to emergency radiology identified the major challenges for radiology in the emergency department (ED) as, inter alia, finding a common language between different groups of physicians, finding the human, economic and technical resources for round-the-clock coverage, and reducing costs by choosing the appropriate technique for each case. CDS helps address each of these challenges. The clinical indications in a CDS system are structured and based on coherent terminology, and the introduction of CDS therefore necessarily creates a common language between radiology and other departments, including the emergency department. In addition, each exam associated with an indication has an appropriateness rating, creating a standard framework in which medical decisions for radiology referrals are made. And if a decision that is not in line with the guidelines is taken, it can be discussed and justified in reference to this common framework.

CDS supports consistent coverage round-the-clock as it is continually available independent of the time of day or staff on duty. What is more, CDS can help alleviate fluctuations in the number, experience and expertise of the staff available at any given time, helping to guide imaging referrals towards the most appropriate option, thereby also contributing to the optimal use of the available technical resources. This in turn leads to optimisation of costs by improving the appropriateness of referrals and, consequently, the diagnostic yield of the exams carried out, improving the cost-benefit ratio for healthcare organisations, professionals and patients.

In recent years radiology exam volumes in the ED have increased significantly compared to long-term trends. While the benefits of emergency imaging and its impact on physicians’ diagnoses and treatment decisions are well-documented, it is not clear whether this increase is entirely justified for medical reasons or whether imaging is being overused, and if so what the reasons for such overuse are, and if there is room to slow this growth by avoiding unnecessary exams. In fact, there is no evidence that the higher number of imaging exams being carried out lead to a corresponding improvement in patient outcomes. Some studies have identified the concept of ‘defensive medicine’ – doing a medical examination for fear of adverse legal consequences without medical justification – as part of the reason for the increase in exam volumes for certain modalities which are not clinically justified. The use of evidence-based medicine and the application of referral guidelines have been suggested as possible remedies. Therefore, with it being the most effective tool for the incorporation of evidence-based guidelines in clinical practice, CDS can help optimise the quality of care, safety and outcomes for ED patients.

To do so effectively and in a coordinated way, evidence-based knowledge is a prerequisite. This is something CDS can help provide thanks to the structured information captured in the process, which provides a much clearer picture of what imaging is used for and it enables doctors to detect trends that warrant closer inspection, and this can in turn lead to the optimisation of clinical decision making.
To effectively use CDS in the ED, it is important to have procedures in place to ensure the process is certain pre-defined, well-tested and routine. For most common emergencies, there are already familiar benefits of being able to monitor what is taking place. Being able to detect trends or patterns and optimising processes based on this information can streamline the cooperation between the ED and the radiology department to the benefit of patients.

A few things need to be considered when implementing CDS in the emergency department. For example, there needs to be an option to bypass the system if necessary. The doctor is always best placed to decide if time is of the essence, and appropriateness may be of secondary importance in a given set of circumstances. However, even though CDS may be seen as an extra step in the referral process, it does not necessarily add time to it; on the contrary, it can actually save valuable time. In the ED it is even more important than in other departments that staff is well-trained in using CDS to make sure the referral process is completed as quickly as possible. An experienced user will be just as quick in completing a CDS referral as they would otherwise be, and, as we have seen in cases in which the doctor on duty may be less familiar with a particular situation, CDS can be a valuable advisory tool significantly speeding up the decision making process. As for the radiology department, referrals that went through the CDS process are guaranteed to have a clear indication associated with them, along with information on the appropriateness of the requested exam. In many cases, this can avoid the need for consultations with the referring physician to clarify an unclear reason for the exam, and it reduces the time spent on vetting referrals or approving examinations.

In the United States, where CDS systems have been in use for a number of years, including in emergency departments, studies have demonstrated that they can have a significant impact on the improvement of patient care. A study on the introduction of CDS using the ACR Appropriateness Criteria in Los Angeles demonstrated that they can have a significant impact on the improvement of patient care. A study on the introduction of CDS using the ACR Appropriateness Criteria in Los Angeles demonstrated that they can have a significant impact on the improvement of patient care.

For most common emergencies, there are certain pre-defined, well-tested and routine procedures in place to ensure the process is as smooth, fast and efficient as possible. To effectively use CDS in the ED, it is important to understand in which cases it provides added value, and how possible disruption can be kept to an absolute minimum.

There are some obvious advantages. The ED is not specialised for a certain body area or a particular type of disease. Therefore, the range of possible scenarios and patient pathologies is unlimited, and no doctor can be an expert in every type of situation. By making comprehensive guidelines available within the native workflow, CDS can be an extremely useful support tool in cases where, e.g., a junior doctor is on duty during a night shift, or even if a more experienced doctor encounters a patient with a condition where there is no pre-defined pathway in place and the most appropriate imaging exam may not be immediately clear. It also helps with regard to consistent practice, making sure patients with the same condition are sent to the most appropriate imaging desk regardless of whether they visit the fully staffed ED during peak hours or in the middle of the night.

In addition, using CDS in the ED has the already familiar benefits of being able to monitor what is taking place. Being able to detect trends or patterns and optimising processes based on this information can streamline the cooperation between the ED and the radiology department to the benefit of patients.

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Many studies on CDS in the ED have focused on pulmonary embolism as the clinical indication to evaluate the impact of CDS. It has been shown that the introduction of CDS has decreased the volume of CT in these scenarios, while increasing the yield of the exams actually carried out. This means that CDS makes the use of CT in evaluating acute PE more targeted, avoiding radiation exposure for patients that do not need it (Figure 2).

Other studies have shown that an option to bypass or override CDS – even though this may be necessary in certain exceptionally urgent cases – can have a negative effect on the appropriateness of imaging. One study analysing the effect of overriding CDS concluded that the yield of CT for acute PE was more than twice as high with CDS compared to referrals without decision support. The odds of surviving acute PE were more than 50 percent lower when providers overrode rather than followed the decision support guidelines.

FIGURE 2

CDS can significantly improve the appropriateness, and consequently the diagnostic yield, of ED referrals.
SUMMARY

Guidelines and other tools supporting evidence-based medicine in practice are becoming more and more important as medicine in general, and the specialty of radiology in particular, is becoming ever more complex. The sheer endless amount of scientific information and medical data coupled with the rapidity of technological innovation make necessary the ability to collate and maintain huge amounts of medical knowledge, and to make it available in a meaningful, practical and concise way within healthcare workflows. This is essential in order to maximise the benefits made possible by these developments. Clinical decision support systems are the most effective tool to help healthcare organisations carry out this function.

FIGURE 3

Pulmonary embolism is a good example to demonstrate the benefits of CDS; through more targeted use of CT, diagnostic yield is increased while unnecessary radiation exposure is reduced.

This article was commissioned by EuroSafe Imaging, the ESR’s flagship campaign to support and strengthen medical radiation protection across Europe.

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PROF. DR.SC. BORIS BRKLJAČIĆ,
born in Zagreb, Croatia, completed his radiology education with his Croatian board exam in 1994, having already been awarded his MD by the University of Zagreb School of Medicine in 1988. In addition to working as a consultant radiologist at the University Hospital Merkur in Zagreb from 1994 to 2001, he undertook a visiting fellowship in ultrasound at Thomas Jefferson University in Philadelphia, PA, USA, between 1993 and 1998. While working as an assistant professor in radiology from July 2002 and as an associate professor from 2007 in Zagreb, he also completed his education in breast MRI at the Memorial Sloan Kettering Cancer Center in New York City in 2007. Since November 2007, Prof. Brkljačić has been a full ordinary professor in radiology at the University of Zagreb School of Medicine. Chairing the Department of Diagnostic and Interventional Radiology at University Hospital Dubrava in Zagreb since October 2001, he is currently also serving as Vice-Dean for Science at the University of Zagreb Medical School (2015–2018). Prof. Brkljačić is editor-in-chief of the Journal of Ultrasound (SIUMB) and sits on the international editorial board of Ultraschall in der Medizin – European Journal of Ultrasound. A respected expert in breast imaging and vascular and interventional radiology, in addition to 101 papers in peer-reviewed journals he has published two textbooks and over 50 book and textbook chapters, and is an experienced speaker with over 220 invited lectures at international meetings and institutions to his name.

Prof. Brkljačić has actively represented the radiology profession at the national, European and international levels, having served as president of the Croatian Society of Radiology from 2008 to 2012; chairing the Advisory Committee of the Croatian Ministry of Health on Radiology since 2004 and being a member of the International Society for Strategic Studies in Radiology since 2011. Following a number of committee-level positions in the European Society of Radiology, most recently as Chairman of the Communications and External Affairs Committee from 2014-2017, Prof. Brkljačić was elected to a five-year term on the Board of Directors in 2017 and is the ESR’s incumbent 2nd Vice-President (2017-18).

The emergency department is a clinical setting with unique challenges, and healthcare organisations meet these challenges in different ways. Due to these unique circumstances, the delivery of healthcare in emergency situations sometimes does not make optimal use of the available resources. Staffing issues, lack of availability of equipment, variability and lack of standardisation, defensive medicine, time pressure, financial constraints and other factors can negatively affect the quality and safety of patient care. The use of imaging in the emergency department is one important part of the complex processes at work, and the introduction of CDS in different settings has shown promising results for quality of care and patient safety in emergency radiology. The implementation of a decision support system for radiology referrals needs to be tailored by the radiologists and referring physicians and other stakeholders to the particulars of emergency medicine in order to be successful. The following aspects including technical integration, the quality of the guidelines, training and educating staff on using CDS, the seamless introduction of CDS as a normal part of the IT workflow, and how to make it an accepted element in the overall cycle all need to be considered. If done properly, implementing CDS to utilise referral guidelines in the emergency setting can be valuable for improving the quality and safety of healthcare for patients.
PROF. LUIS DONOSO BACH, MD, PHD
is Director of the Diagnostic Imaging Department at the Hospital Clinic of Barcelona, University of Barcelona, Spain.

Prof. Donoso was born in Sabadell (Barcelona) in 1955. He received his MD from the School of Medicine of the Autonomous University of Barcelona in 1981. He completed his residency in radiology at the Hospital de Sant Pau in Barcelona, in addition to earning a PhD in medicine from the Autonomous University of Barcelona in 1992. Prof. Donoso was appointed Chairman of the Radiology Department of the UDIAT Diagnostic Centre in 1992, becoming its Executive Director in 1998. Since 2006 he has also led the Diagnostic Imaging Department at the Hospital Clinic of Barcelona and has served as Professor of Radiology at the University of Barcelona.

Prof. Donoso has been involved in many research projects. Early in his career, his research activity focused on abdominal imaging, especially regarding liver disease. His emphasis has shifted to digital imaging and the development and implementation of IT in diagnostic radiology. Under his leadership, a large R&D team was built at UDIAT, leading to several patents and products widely used throughout Spain. Prof. Donoso has given numerous lectures at prestigious universities, congresses, and courses. Altogether he has published over 90 articles and seven book chapters.

Prof. Donoso has always been active in the professional societies, from the regional to the international level. He served as Vice-President of the Spanish Society of Radiology (SERAM) from 1996 to 2002 and as president from 2002 to 2006. From 2008 to 2016 he was the President of the Spanish Foundation of Radiology. He was the Secretary General of the International Society of Radiology from 2012 to 2014 and president-elect from 2016. Since 2000, he has served the European Society of Radiology (ESR) in various capacities, including as ESR President from 2015-2016. Recently he was nominated president-elect of the International Society of Strategic Studies in Radiology (IS3R).

Prof. Donoso has received numerous honours for his contributions to the discipline, including the Gold Medal of the Spanish Society of Radiology and the Gold Medal of the Interamerican College of Radiology (CIR) as well as honorary memberships in the Argentinean Society of Radiology, the Chilean Society of Radiology, the Mexican Federation of Radiology, the Italian Society of Radiology, the French Society of Radiology, the German Society of Radiology, the Mexican Society of Radiology, the Serbian Society of Radiology, the Swedish Society of Radiology, the Radiological Society of North America, and the Honorary Fellowship of the American College of Radiology.