Reducing inappropriate diagnostic practice through education and decision support

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Abstract

Objective. To quantify non-compliance of diagnostic practice with recommendations in Diagnostic Imaging Pathways and the impact of interventions to reduce non-compliance.

Design. Retrospective audits, followed by intervention and re-audits.

Setting. Emergency department (ED) of Royal Perth Hospital.

Participants. Six hundred and thirty-eight patients (first audit) and 423 patients (second audit) presenting to the ED with one of the four conditions: suspected pulmonary embolism, ankle injury, suspected renal colic or non-traumatic acute abdominal pain.

Interventions. Education of clinicians on Diagnostic Imaging Pathways recommendations for the four conditions. Decision support through the introduction of request forms, which required ‘proof’ of adherence to diagnostic pathways.

Main outcome measures. Percentage of patients with a deviation from recommended diagnostic practice.

Results. Overall, 56% of patients had evidence of inappropriate diagnostic practice prior to interventions, with a reduction of 16% following the interventions.

Conclusion. The reduction was significant but inappropriate practice was not eliminated. For as long as decision-support systems are ‘stand-alone’ applications, achieving full compliance is dependent on continuous and expensive processes of education and enforcement. A better understanding of why clinicians fail to follow recommended practice is required, and decision support must be better embedded into clinical workflow.

Keywords: clinical audit, diagnostic guidelines, education, decision support, medical imaging

Introduction

Inappropriate imaging is a significant problem in the health service sector. Studies report that up to one-third of radiology and pathology examinations are partially or totally unjustified [1, 2] and surveys of clinicians show that 93% rate ‘inappropriate imaging’ as a problem in the delivery of health care [3]. Imaging specialists commonly report that unnecessary examinations are frequently requested and that, conversely, necessary examinations are sometimes not requested. Furthermore, there are concerns regarding the lifetime risk of cancer linked to the excessive use of medical radiation, particularly for computed tomography (CT) examinations, and that an estimated one-third of CT examinations performed in a paediatric setting could be avoided or replaced by alternative approaches [4].

Inappropriate imaging examinations will aggravate a range of health service issues. First, expenditure on diagnostic imaging is a major contributor to rising health-care costs [5, 6] and inappropriate examinations stimulate this expenditure unnecessarily. Second, the supply of imaging specialists is insufficient to meet the demand for their services [7, 8] and having them waste time on unnecessary reporting exacerbates this gap between the demand and supply. Third, the flow of patients in the hospital system is constrained by the availability of medical imaging services [9] and inappropriate examinations result in inefficient diagnosis and retardation of patient flows. Fourth, patients are becoming better informed and empowered about aspects of their care [10] and exposing them to the risks of examinations (especially ionizing radiation) without compensating benefits increases the risk of litigation.

A significant threat to appropriate imaging is lack of knowledge. The task of keeping up-to-date with developments in clinical practice is increasingly difficult due to expanding research activity, clinical specialization and subspecialization,
and new applications of technology. It is difficult to acquire and maintain the necessary breadth and depth of knowledge for confident and correct decision-making. A ‘medical knowledge crisis’ is well recognized, as is the need for improved knowledge management [11] and electronic decision-support systems in the health sector. The development and deployment of decision-support systems has been suggested as a specific strategy to increase the appropriateness of diagnostic testing [5].

An application called Diagnostic Imaging Pathways has been developed at Royal Perth Hospital as an evidence-based education and decision-support tool to assist clinicians to choose the most appropriate diagnostic examinations in the correct sequence. The broad objective is to minimize inappropriate examinations and maximize diagnostic yield. More than 130 pathways covering all the major organ systems and common clinical scenarios have been developed. Imaging specialists, referring consultants and general practitioners have contributed to the pathways. A fellow is permanently employed to coordinate the development of new pathways, review and revise the pathways, and mine the literature for the best available evidence to support recommendations in the pathways. Evidence is graded according to the Oxford system. The pathways are therefore based on broad clinical consensus, supported by evidence when available, and under continuous review and development. Associated information is also provided, including teaching points and an image gallery.

The Diagnostic Imaging Pathways software is delivered electronically from a single source, and has been available from the ‘desk-top’ of personal computers in all public hospitals throughout Western Australia for more than 2 years. The software application is also available from the Internet [12]. The application is endorsed by national colleges, accredited by the Health On The Net Foundation [13] and meets standards for partnership with HealthInsite [14] and the Joanna Briggs Institute [15].

Some Australian studies have evaluated compliance with diagnostic guidelines and reported reductions in unnecessary testing following an intervention [16–20]. One recent report documents a 15.1% reduction in imaging costs with direct savings of $1.8 million annually [16]. Whilst clinicians at the Royal Perth Hospital are encouraged to comply with Diagnostic Imaging Pathways recommendations via regular reminders at ‘Grand Rounds’ and clinico-radiological meetings, in the medical newsletter and in the orientation and in reminders at ‘Grand Rounds’ and clinico-radiological meetings, the development of new pathways, review and revise the pathways, and mine the literature for the best available evidence to support recommendations in the pathways. Evidence is graded according to the Oxford system. The pathways are therefore based on broad clinical consensus, supported by evidence when available, and under continuous review and development. Associated information is also provided, including teaching points and an image gallery.

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The main objectives of this study were to quantify non-compliance of diagnostic practice with Diagnostic Imaging Pathways recommendations and the impact of interventions to reduce non-compliance.

**Methods**

**Study design**

Four clinical conditions that have diagnostic pathways in Diagnostic Imaging Pathways were targeted, namely suspected pulmonary embolism [21], ankle injury [22], suspected renal colic [23] and non-traumatic acute abdominal pain [24]. Retrospective audits of all referrals for medical imaging from the emergency department (ED) of Royal Perth Hospital in the four groups were carried out, followed by interventions and second retrospective audits. The second retrospective audit commenced in the week following cessation of the interventions.

**Participants**

A standardized methodology was used to select patients for the first and second audit, thus ensuring as far as possible that all referrals in specified periods were relevant to the targeted conditions and pathways.

First, computerized searches of the ED Information System (EDIS) and the Radiology Information System (RIS) using specified dates were carried out to identify all the potential referrals to be audited. Using the ankle injury group to illustrate, the objective was to identify all referrals with an acute ankle or mid-foot injury between the dates of 1 January 2007 to 31 March 2007 (pre-intervention) and 1 January 2008 to 31 March 2008 (post-intervention). The search of EDIS used the following terms: ankle injury, inversion injury, ankle fracture, ankle sprain, foot injury and foot fracture. The RIS was searched to identify patients referred from the ED for ankle or foot radiography.

The medical records of the potential auditable referrals were then reviewed. Only patients for whom the four targeted diagnostic pathways applied were to be filtered for inclusion in the study. Standardized inclusion and exclusion criteria were applied. Again using the ankle injury group to illustrate, the inclusion criteria required each patient’s medical notes to contain documented evidence of a presentation to ED with an episode of acute blunt ankle or foot trauma as defined in a study by the developer of the Ottawa ankle rules (OAR) [25]. All patients were at least 18 years old at the time of presentation to the ED. Exclusion criteria were based on a previous study [26] and included: pregnancy, isolated injury of the skin, referral with radiographs from outside the hospital, more than two painful injuries, reassessment of an injury, intoxication, diminished sensation on the lower extremities, communication barrier, gross swelling, sensory or cognitive impairment. Additional exclusion criteria included: obvious ankle/foot deformity, neurovascular compromise, injury occurring more than 3 days prior to presentation at the ED and open wounds.

Table 1 gives the period of the first and second audits and the number of referrals from the ED included in the audits.

**Interventions**

All junior medical officers (Interns and Resident Medical Officers) working in the ED, approximately 15 in number, were required to attend a single education session, which was repeated over a 2 week period to capture all shift patterns. Attendees were advised that referrals for medical imaging with four targeted clinical conditions (suspected pulmonary embolism, ankle injury, suspected renal colic, non-traumatic acute abdominal pain) were required to be justified.
abdominal pain) should comply with diagnostic pathways in Diagnostic Imaging Pathways. Specific instruction was given on the indications for imaging as specified in Diagnostic Imaging Pathways, including appropriateness criteria to be applied when requesting an examination (see Table 2). Handouts summarizing the content of the education sessions were given to attendees. All ED clinicians, including four consultants, were also reminded at daily hand-over meetings about Diagnostic Imaging Pathways, the referrals being targeted and the need to follow Diagnostic Imaging Pathways recommendations.

A form of ‘decision support’ was also provided to the ED referrers. Modified imaging request forms were introduced. The forms contained a stamp that prompted the referrer to provide data to show that the request was appropriate. For patients with suspected pulmonary embolism, the stamp contained the Wells criteria for pre-test probability of a pulmonary embolism and required the calculation of the score. For ankle injury, the stamp contained the OAR and required identification of the specific clinical features. For non-traumatic acute abdominal pain, the stamp required information about perforation, obstruction, ingested foreign body or severe pain of unknown origin requiring opiate analgesia. Inclusion of the stamp on imaging request forms and provision of the information was mandatory for these three conditions.

The interventions outlined above ensured that all ED clinicians requesting diagnostic imaging for the four clinical conditions knew the diagnostic pathways and the preconditions for requesting examinations.

Interventions also involved educating the imaging providers about the introduction of ‘decision support’ for referrers. Clinical heads of sections and the Chief Medical Imaging Technologist were enlisted as champions and they advised all staff about the introduction of modified request forms and the importance of ensuring that information required by the stamps was provided. Incomplete or unstamped request forms were to be declined by the attending imaging technologist and immediately returned to the requesting clinician for appropriate completion in order for the imaging request to be processed. A presentation was given by one of the investigators to all imaging technologists to ensure that stamps were completed. There were also regular reminders at staff meetings about the study and the audits being undertaken.

### Audits

All available medical records of patients, which met the criteria for inclusion in the targeted conditions, were searched by single investigators. The investigators referred to standard lists of items when registering an event in the medical records as ‘non-compliant with Diagnostic Imaging Pathways recommendations’. Table 2 lists the items of inappropriate diagnostic practice for each of the four conditions. The same investigator searched the records in the first and second audits to ensure consistency between the audits in the application of the lists of non-compliant items.

### Analysis

Chi-square tests compared the first audit (pre-intervention group) and second audit (post-intervention group) with...
Table 2 Appropriateness criteria* used in the education of referrers about the indications for imaging that are specified in Diagnostic Imaging Pathways

<table>
<thead>
<tr>
<th>Pathways audited</th>
<th>Appropriateness criteria to be applied when requesting an imaging examination</th>
<th>Items in medical records counted as inappropriate diagnostic practice in the first and second audits</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Suspected pulmonary embolism’ [21]</td>
<td>A radionuclide scan or a CT pulmonary angiogram is appropriate only if the risk assessment using the Wells criteria is ≥2, or if the Wells score is &lt;2, but there is a positive D-dimer blood test</td>
<td>Failure to use the Wells criteria (NB: when no Wells score was recorded, the project team calculated the score retrospectively based on the clinical history recorded in the notes). Use of D-dimer blood test despite a Wells score ≥2 Failure to request a D-dimer blood test despite a Wells score of &lt;2 Use of CTPA or VQ scan despite a low Wells score plus a negative D-dimer Use of CTPA in addition to a VQ scan when the VQ scan had yielded an unequivocal result.</td>
</tr>
<tr>
<td>‘Ankle injury’ [22]</td>
<td>An ankle and/or foot X-ray series is appropriate only if the application of the OAR yields a positive result.</td>
<td>No evidence of OAR use Use of X-ray despite negative findings from OAR</td>
</tr>
<tr>
<td>‘Suspected renal colic’ [23]</td>
<td>An LDCT is the first appropriate examination. A kidneys, ureters and bladder X-ray (KUB) is appropriate as a follow-up if a calculus is viewed on LDCT</td>
<td>Failure to request an LDCT as the primary diagnostic imaging investigation Failure to perform further imaging following a negative or equivocal result obtained from a KUB as the primary imaging modality Failure to perform a KUB (if not already performed) following a positive LDCT/CT result for conservatively managed patients</td>
</tr>
<tr>
<td>‘Non-traumatic acute abdominal pain’ [24]</td>
<td>Imaging is appropriate only if there is evidence/suspected perforation, obstruction, ingested foreign body and severe pain of unknown origin requiring opiate analgesia</td>
<td>Evidence that a patient received an abdominal X-ray for reasons other than those recommended in the pathway</td>
</tr>
</tbody>
</table>

*Standard items used by the auditors when registering an event in the medical records as ‘non-compliant with Diagnostic Imaging Pathways’.

Results

Table 3 summarizes the results of the first and second audits and comparisons between the two. In both audits of each of the pathways, the incidence of more than one deviation from the recommended pathway was very low. For example, for ‘ankle injury’ [22], three of 115 patients in the first audit (3%) and two of 57 patients in the second audit (3%) had two deviations. There were no patients with more than two deviations.

In regard to ‘suspected pulmonary embolism’ [21] the interventions achieved only a 13% overall reduction in inappropriate diagnostic practice. To illustrate, 17% of patients in the second audit still had the D-dimer blood test applied inappropriately and 5% of patients still underwent at least one CTPA or VQ scan despite having a low Wells score and a negative D-dimer test.

For ‘ankle injury’ [22], the interventions were somewhat more successful in achieving a 28% overall reduction in inappropriate practice. However, 44% of patients in the second audit were still not assessed according to the OAR and 5% of patients had a negative OAR outcome but still received an inappropriate X-ray.

In regard to ‘suspected renal colic’ [23], the number of patients receiving an initial inappropriate X-ray fell from 53 to 6%. But overall, 49% of patients in the second audit were still not assessed according to Diagnostic Imaging Pathways recommendations; for example 80% of patients did not have further imaging after a positive low-dose non-contrast multi-detector (LDCT) result.

In the ‘non-traumatic acute abdominal pain’ [24] group, there was a 17% reduction in the number of patients respect to the incidence of non-compliance with the pathways.
receiving an inappropriate X-ray of the abdomen. However, 37% of patients still received an inappropriate X-ray.

Examples of inappropriate diagnostic practice included failure to carry out an initial clinical assessment (e.g. failure to apply the OAR), failure to act on a test correctly and providing an unnecessary examination (e.g. provision of a CTPA or VQ scan despite a low Wells score plus a negative D-D-dimer test) and failure to provide an imaging examination when it was indicated (e.g. failure to provide an X-ray examination following the detection of a renal calculus with a LDCT). In summary, the interventions resulted in only a 16% reduction in the incidence of inappropriate diagnostic practice, with 40% of patients in the second audit still showing evidence of at least one deviation from the recommended diagnostic pathways.

Discussion

In an environment in which Diagnostic Imaging Pathways software is readily available and compliance is regularly encouraged, it was disconcerting to find evidence of at least one incidence of inappropriate diagnostic practice in more than half of the patients whose records were audited. It was perhaps even more disconcerting to find that interventions based on well developed and directed programmes of education, along with targeted methods to ‘force’ greater compliance, whilst significantly reducing inappropriate practice fell well short of eliminating the phenomenon.

The four diagnostic pathways that were targeted were developed with input from ED clinicians. The pathways were endorsed by the Head of the ED and by the Director of Imaging Services. There was consensus agreement that the process of diagnosing patients should follow the recommended pathways.

The results of the study prompt the question of why did requesters not follow recommendations? This study endeavoured to eliminate reasons such as ‘not being aware that recommendations exist’, ‘not having time to learn about recommendations' and ‘not understanding the importance of recommendations’. Other possible reasons such as ‘not having the knowledge or time to carry out a pre-examination clinical assessment’, ‘not believing in the validity of a recommendation’ and ‘succumbing to patients’ expectations’ were more difficult to address. It was evident that requesters sometimes attempted to subvert procedures, e.g. stamps for request forms were ‘lost’, inaccurate prerequisite information was provided, pressure was placed on providers to accept a request without prerequisites.

A related question is why did providers fail in their ‘gatekeeper’ function? This study should have eliminated reasons such as ‘insufficient time to educate requesters’ and ‘difficulty obtaining prerequisite information’. However, it was evident that providers sometimes effectively colluded with requesters in accepting examination requests that were clearly inappropriate. We do not understand all the possible reasons why, but technologists reported that they were sometimes coerced into accepting request. It is possible that some deviations from recommendations were justifiable in particular circumstances but there is no record of why incomplete or incorrect request forms were accepted.

This study has a number of limitations. Interventions could only include education and paper-based decision support because technology was not available to permit electronic requesting linked to electronic decision support. The interventions obviated the need for clinicians to access Diagnostic Imaging Pathways for decision support. Whilst it would have been interesting to have measured whether the interventions affected the rate of access to the application, data were not collected. The continuing high rates of non-compliance following the interventions took the investigators by surprise and a behavioural analysis of requesters and providers had not been planned. This paper does not quantify expenditure on unnecessary examinations, time wasted by imaging specialists, retardation in the flow of patients or the exposure of patients to risks without compensating benefits. However, the high rates of inappropriate practice that have been sampled are likely to be endemic and should be of concern to health service directors and managers. Requesting practice in relation to only four of more than 130 clinical scenarios encompassed by Diagnostic Imaging Pathways was audited, and the results do not allow for an in-depth analysis of patterns of inappropriate diagnostic practice. For example, findings should not be extrapolated to conclude whether overall there is there is less inappropriate diagnostic practice relating to the early steps in pathways compared with later steps, or to compare the number of unnecessary examinations requested to the number of wrong examinations requested or to the number of indicated examinations not provided.
For as long as Diagnostic Imaging Pathways is a ‘stand-alone’ application, achieving compliance with recommendations will be dependent on continuous and expensive processes of education and enforcement. More of the same kind of effort to improve compliance as reported here is neither sustainable, nor will it ever be sufficiently effective. Decision support must be better embedded into clinical work flow than has been achieved to date. Paper-based processes of requesting should be replaced by an electronic requesting system, and the steps in completing an electronic request should be linked to guidelines afforded by Diagnostic Imaging Pathways. ‘Smart’ functionality is required. For example, requesters should be alerted on-line to provide prerequisite information. Requesters should have access to the status of their request. Non-compliant requests should require consultation with a provider to override a recommendation. Providers should have access to requesting patterns that can indicate the need to educate or advise particular requesters.

This type of electronic decision-support system has been reported elsewhere. An initiative at the Massachusetts General Hospital achieved on-line ordering of radiology examinations linked to the American College of Radiology Appropriateness Criteria [27]. The initiative has controlled the growth in supply of expensive examinations, decreased ordering variability and improved clinicians’ knowledge of indications for radiology examinations. Another initiative at the Children’s Hospital of Winnipeg linked an electronic requesting system to the Canadian Association of Radiologists guidelines for the use of diagnostic imaging [28]. Physicians are advised on-line of a more appropriate examination if the one being requested is inappropriate. Physicians accept the initiative and change or abandon ordered tests that are inappropriate. A system linked to decision support at the Brigham and Women’s Hospital [29] aimed at improving consultation between referring physicians and radiologists to ensure appropriate use of medical imaging. Obstacles to changing physician behaviour were overcome and more than 3500 physicians were reported to use the system.

The development of an electronic system to alert clinicians to a request that may be inappropriate is perhaps easier to envisage than one that can alert a clinician that an examination has not been requested but should be! In designing an electronic decision-support system for imaging requests we must anticipate human behaviour, predict how the system might be subverted by a determined requester or provider, and therefore incorporate functionality that reduces the scope for subversion. We therefore need to more fully understand the factors (technological, systemic and political) that inhibit the implementation of clinical guidelines and the methods by which clinicians’ behaviour can be changed [30]. There has been little study of influences on clinicians’ behaviour and the process by which change is produced [31]. Work with focus groups involving junior doctors and others will contribute to this understanding. In addition, the discipline of ‘behaviour change theory’ may have much to offer, not only in the area of implementation but throughout the guideline development process [32].

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References

14. HealthInsight. Quality Health Information for Australians [Internet]. Canberra: Australian Government Department of Health and


