



Brief Report

Implementing a guideline for the request of chest and abdominal x-rays in nontrauma pathologic conditions in an ED[☆]

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Abstract

Objective: The purpose of this study is to evaluate the impact of implementing a guideline for the request of chest and abdominal x-ray to reduce unnecessary examinations in nontraumatic pathologic conditions.

Methods: We selected most common chief complaints in nontrauma pathologic conditions at emergency department (ED) and reviewed the available literature to determine the effectiveness of chest and abdominal x-rays for each one. We developed a guideline for the request of x-rays according to the chief complaints, including modulating factors derived from initial clinical evaluation. Guideline implementation was achieved through a multifaceted educational intervention. To evaluate its impact, both in the absolute number and in the adequateness of x-ray requests, we compared data obtained from patients coming to the ED at 2 different time points, October 2004 (preimplementation) and October 2005 (postimplementation).

Results: In the preimplementation period, 52.7% of the patients underwent chest x-rays and 28.0% abdominal x-rays, whereas in the postimplementation period, the proportions decreased to 41.8% and 13.5%, respectively ($P < .001$ in both cases). The adequateness of x-ray requests improved, as shown by a reduction in the number of inappropriate x-ray examinations (absolute error reduction of 9.2%; 95% confidence interval, 7.7–10.8, and relative error reduction of 59.8%; 95% confidence interval, 49.7–69.8).

Conclusions: In our ED, implementing a specifically designed guideline for the request of chest and abdominal x-ray examinations in nontraumatic pathologic conditions reduced the absolute number of requests and the rate of inappropriate requests.

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1. Introduction

Chest and abdominal x-rays are frequently demanded procedures in emergency department (ED). More than half the patients seen in ED in the United Kingdom have a chest radiograph requested [1], and in the case of abdominal pain,

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up to 55% of patients undergo an abdominal x-ray [2]. However, the ability of these examinations to modify diagnostic or therapeutic decisions is limited.

Numerous studies have shown the overuse and limited effectiveness of chest x-rays [3-8] and abdominal x-rays [2,9-12] in a variety of clinical situations, as well as a tendency to request them although demonstration of relevant pathologic conditions is unlikely [13-15]. The main consequences of excessive and inappropriate x-ray requests are unnecessary patient exposure to radiation, delay in attending patients, overwork of health care staff, and increment in costs.

The English and American Colleges of Radiology have released guidelines [16,17] in which recommendations for radiologic studies are mainly related to established diagnoses and not to the setting in which the patient is initially evaluated at the ED (where a variety of final diagnoses may share the same presenting complaints).

Therefore, the objective of our study was to develop and implement a practical guideline for requesting chest and abdominal x-rays in nontraumatic pathologic conditions at the ED and to evaluate the impact of this implementation in reducing the x-ray requests and in improving their appropriateness.

2. Methods

The study was carried out in the ED of a tertiary teaching hospital that attends to 150 000 emergencies per year. Among these, approximately 100 000 belong to the medical and general surgery areas. We excluded patients seen by traumatology, ear, nose, and throat (ENT), ophthalmology, dermatology, psychiatry, and pediatrics, as well as critical patients attended in the emergency room. The study periods were October 2004 and October 2005 (before and after the guideline implementation, respectively). We selected all patients attended during these 2 periods with the most frequent chief complaints, 26 in total, for which chest and abdominal x-rays are usually performed (see Table 1 for a complete list of selected chief complaints).

We used several sources of information to develop the guideline. We conducted a comprehensive electronic search (Medline, EMBASE, ISI Web) using terms (and their synonyms) for the selected chief complaints, together with those terms referring to chest or abdominal x-rays. The search was limited to studies evaluating the accuracy of diagnostic tests in an ED setting. The results were compared and combined with information obtained from the American College of Radiology (ACR) and the Royal College of Radiology (RCR) of the UK guidelines [16,17]. Finally, we assembled an expert panel including 2 radiologists and 2 staff members of the ED. We discussed the first version of the guideline with all staff members of the ED and with a selected group of representative physicians from those hospital medical and surgical departments most often involved in

Table 1 Number and percentage of patients coming to the ED during the 2 study periods, according to the selected chief complaints

Chief complaint	Patients (October 2004)	%	Patients (October 2005)	%
Abdominal pathologic conditions				
Ascites	31	0.8	12	0.3
Diarrhea	163	4.0	114	2.8
Abdominal pain	846	20.8	779	19.2
Constipation	23	0.6	23	0.6
Gastrointestinal bleeding	153	3.8	104	2.6
Jaundice	4	0.1	5	0.1
Vomit	177	4.4	168	4.1
Urologic pathologic conditions				
Renal colic	141	3.5	136	3.3
Hematuria	84	2.1	83	2.0
Urinary symptoms	110	2.7	89	2.2
Lung and heart pathologic conditions				
Shortness of breath	432	10.6	556	13.7
Chest pain	489	12.0	510	12.5
Edema	13	0.3	15	0.4
Hemoptysis	16	0.4	22	0.5
Hypertension	60	1.5	85	2.1
Respiratory tract infection	69	1.7	104	2.6
Palpitations	65	1.6	66	1.6
Syncope	110	2.7	123	3.0
Tachycardia	55	1.3	35	0.9
Neurologic pathologic conditions				
Headache	157	3.9	165	4.06
Seizures	39	1.0	36	0.9
Stroke	63	1.5	82	2.0
Intoxication	73	1.8	45	1.1
Dizziness/Vertigo	252	6.2	293	7.2
Confusional state	39	1.0	20	0.5
Other pathologic conditions				
Low back pain	166	4.1	151	3.7
Fever	232	5.7	245	6.0
Total	4062	100	4066	100

the care of the selected population. All suggestions were considered, and most were included in the guideline design.

We designed an implementation strategy based on a multifaceted intervention. This strategy included creation of educational material and meetings to inform all medical and surgical physicians working in the ED. The educational material included a small 21 × 10-cm plastic card, with the recommendations printed on both sides. We grouped chief complaints into abdominal, urological, heart and lung, neurologic, and other pathologic conditions to facilitate card reading (Fig. 1).

We placed a poster-sized version of the card at strategic locations around the ED. A computer application was also available in all ED computers. An automatic pop-up reminder appeared whenever an x-ray was requested electronically.

Finally, we organized several 45-minute educational meetings for all medical and surgical residents working in



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**PRACTICAL GUIDELINE FOR THE REQUEST
OF CHEST AND ABDOMINAL X-RAY IN NON
TRAUMATIC PATHOLOGY**

ABDOMINAL PATHOLOGIC CONDITION		
Reason for consultation	Modulating factor	X-ray
Ascites		No
Diarrhea		No
	Inflammatory bowel disease is suspected	Supine abdominal x-ray
Abdominal pain		No
	Peptic pain is suspected/normal abdominal examination	No
	Not specific, chronic, normal abdominal examination	No
Acute abdominal pain		PA thorax x-ray + Supine abdominal x-ray
	Intestinal obstruction o perforated viscus is suspected	PA thorax x-ray + supine abdominal x-ray + Abdominal upright x-ray (if standing is not feasible, change to tumble lateral position abdominal x-ray)
	Apendicitis or biliary tract pathology is suspected	No
Constipation		No
	-Dementia -Psychiatric drug treatment -Vomiting	Supine abdominal x-ray
Gastrointestinal Bleeding		No
	Upper tract bleeding	PA or AP thorax x-ray
	- Abdominal pain and /or - Abnormal abdominal examination	PA thorax x-ray + Supine abdominal x-ray
Jaundice		No
Vomit		No
	Gastric or intestinal obstruction is suspected	PA thorax x-ray + supine abdominal x-ray+ Abdominal upright x-ray
UROLOGIC PATHOLOGIC CONDITION		
Reason for Consultation	Modulating factor	X-ray
Renal colic		Supine abdominal x-ray
	Not calculus seen in previous x-ray	No
Hematuria		Supine abdominal x-ray
	Not calculus seen in previous x-ray	No
Urinary bladder obstruction		No
Urinary symptoms		No
OTHER PATHOLOGIC CONDITION		
Reason for Consultation	Modulating factor	x-ray
Low back pain		No
fever		PA and L thorax x-ray
	- < 40 y + - No comorbidity + - Normal cardiopulmonary examination	No
	Viral disease is suspected	No

Fig. 1 Plastic card (21×10 cm) containing the guideline for the requests of chest and abdominal X-ray.

HEART AND LUNG PATHOLOGIC CONDITION		
Reason for consultation	Modulating factor	X-ray
Shortness of breath		PA and L thorax x-ray
	Exacerbated heart failure or COPD -Not fever + -Not localized findings in chest examination + -Not chest pain	PA thorax x-ray
	Mild/moderate asthma -Not fever + -Not localized findings in chest examination + -Not chest pain	No
Chest pain		PA and L thorax x-ray
	- Skeletal/muscular pain is suspected + - No other symptoms + - Normal cardiopulmonary examination	No
Lower limb edema		No
	- Heart failure is suspected	PA and L thorax x-ray
Hemoptysis		PA and L thorax x-ray
Arterial hipertensión		No
	Not complicated (not chest pain, dyspnea, heart failure,neurologic dysfunction) Hypertensive Emergency	No PA and L thorax x-ray
Respiratory tract infection (cough, chest pain, dyspnea ± - fever)		PA and L thorax x-ray
	- upper respirations tract symptoms + - < 40 y + - Not other previous disease + - Normal cardiopulmonary examination	No
Palpitations		No
	-ECG: arrhythmia -Known heart disease -Abnormal cardiopulmonary examination	PA and L thorax x-ray
Syncope		No
	-Cardiogenic etiology or pulmonary embolism is suspected - Abnormal cardiopulmonary examination	PA and L thorax x-ray
NEUROLOGIC PATHOLOGIC CONDITION		
Reason for consultation	Modulating factor	X-ray
Headache		No
Seizure		No
	- Not known epileptic and > 30y - Heart / lung symptoms - Abnormal cardiopulmonary examination	PA and L thorax x-ray
Stroke		PA and L thorax x-ray
	Recurrent stroke (not first consultation)	No
Intoxication		No
	-Actual or prior Glasgow Scale score <10 -Vomiting or suspected bronchial aspiration -Heart/lung symptoms - Abnormal cardiopulmonary examination	PA and L thorax x-ray
Dizziness/ vertigo		No
	- Heart/lung symptoms - Abnormal cardiopulmonary examination	PA and L thorax x-ray
Confusional state		No
	-Elderly -Alcohol deprivation -Heart/lung symptoms -Abnormal cardiopulmonary examination	PA and L thorax x-Ray

Fig. 1 (continued)

the ED. The objectives of these meetings were (1) to explain the reasons for guideline implementation, (2) to explain the rationale for the recommendations to clarify possible controversies, and (3) to explain card use and the computerized application. At the end of the talk, we provided all participants with the cards.

We designed a “before and after” study to evaluate the impact of the guideline implementation on the number of

chest and abdominal x-ray requests and on the rate of inappropriate requests. From the computer records of the ED, we extracted all episodes for patients coming to the ED with one of the selected chief complaints during the 2 study periods. We developed a specific database that included demographic data, chief complaint, chest or abdominal x-ray request and view, and any ultrasound or computed tomography (CT) requests. The exact times for x-ray request and performance were also analyzed for each patient. We considered only first x-ray requests and any additional x-rays requested within the first hour after the first one. In this way, we excluded from subsequent analysis any other requests based on test results or made to assess patient progress.

To assess the adequateness of every x-ray request, we defined *inappropriateness* according to our expertise criteria. Thus, we considered “inappropriate” a given x-ray or view when it was not recommended in the guideline for a particular chief complaint, even after taking into account all possible modulating factors (Table 2 and Fig. 1).

As a secondary outcome, we recorded the time delay between x-ray request and x-ray performance during the 2 study periods.

Given the characteristics of this study in which patients were not directly involved and because only data regarding current practice was collected, the study did not require ethical approval.

2.1. Statistical methods

For each study period, we calculated the proportion of patients who underwent chest or abdominal x-rays and the proportion of inappropriate requests for each chief complaint. To estimate the effect of guideline implementation, we compared the proportion of patients with x-rays and the proportion of inappropriate requests during the preimplementation and postimplementation periods using a χ^2 test. We estimated the magnitude of the effect by calculating the absolute and relative reductions along with 95% confidence intervals (CIs). We compared the mean time delay until x-rays were performed during the 2 study periods using the Student *t* test. A $P < .05$ was considered statistically significant.

3. Results

Fig. 1 shows the card with the recommended x-ray for each chief complaint that may change according to possible modulating factors.

Table 1 shows the number and percentage of patients coming to the ED during the 2 study periods according to the selected chief complaints.

During the preimplementation period, 2144 (52.7%) chest x-rays were requested for 4062 patients. In the postimplementation period, 1698 (41.8%) were requested for 4066

Table 2 Defined “erroneous x-ray requests” for each chief complaint

Chief complaint	Erroneous request
Abdominal pathologic conditions	
Ascites	Any abdominal x-ray or chest x-ray
Diarrhea	Standing abdominal x-ray or any chest x-ray
Abdominal pain	*
Constipation	Standing abdominal x-ray or any chest x-ray
Gastrointestinal bleeding	Standing abdominal x-ray
Jaundice	Any abdominal x-ray or chest x-ray
Vomit	*
Urologic pathologic conditions	
Renal colic	Standing abdominal x-ray or any chest x-ray
Hematuria	Standing abdominal x-ray or any chest x-ray
Urinary symptoms	Any abdominal x-ray or any chest x-ray
Lung and heart pathologic conditions	
Shortness of breath	Any abdominal x-ray
Chest pain	Any abdominal x-ray
Edema	Any abdominal x-ray
Hemoptysis	No chest x-ray and any abdominal x-ray
Hypertension	Any abdominal x-ray
Respiratory tract infection	Any abdominal x-ray
Palpitations	Any abdominal x-ray
Syncope	Any abdominal x-ray
Tachycardia	**
Neurologic pathologic conditions	
Headache	Any abdominal x-ray or chest x-ray
Seizure	Any abdominal x-ray
Stroke	Any abdominal x-ray
Intoxication	Any abdominal x-ray
Dizziness/vertigo	Any abdominal x-ray
Confusional state	Any abdominal x-ray
Other pathologic conditions	
Low back pain	Any abdominal x-ray or chest x-ray
Fever	Any abdominal x-ray

* In the case of abdominal pain and vomit as chief complaint, according to the guideline, both to request and not to request chest and/or abdominal x-ray could be appropriate, taking into account all possible modulating factors.

** Tachycardia as chief complaint was not included on the guideline.

patients. This represented a decrease of 10.9% (95% CI, 8.9-13.2). Regarding abdominal x-rays, requests decreased from 1139 (28.0%) for 4062 patients to 551 (13.5%) for 4066 patients, representing a 14.5% reduction (95% CI, 12.8-16.2). Both reductions were statistically significant ($P < .001$). These reductions were not associated with an increase in the use of other diagnostic imaging tests (CT or ultrasonographic scan [USS]). In the preimplementation period, 63 CT scans and 271 US scans (1.6% and 6.7%,

respectively) were performed, as compared to 66 CT and 198 US scans (1.6% and 4.9%, respectively) in the postimplementation period.

Overall, 15.5% of requests during the preimplementation period were inappropriate according to the criteria shown in Table 2. This percentage was reduced to 6.2% after we implemented the guideline (error reduction, 9.2%; 95% CI, 7.7-10.8). In relative terms, we observed a 59.8% error reduction (95% CI, 49.7-69.8) between before and after periods.

Regarding the various pathologic examinations (Table 3), abdominal pathologic examination had the highest reduction in the number of requests (38% compared to 20% for chest x-rays and 55% compared to 29% for abdominal x-rays) as well as in the proportion of inappropriate requests (from 35% to 16%). In urologic pathologic examination, erroneous requests were reduced from 21% to 12% reflecting a moderate decrease both in chest x-ray and abdominal x-ray requests. In heart and lung pathologic examination, a thoracic x-ray was already appropriately requested for a large number of patients in the preimplementation period, and the error rate was the lowest out of any pathologic examination (6.1%). Not surprisingly, the postimplementation request and error reductions were not large (from 81% to 73% and from 6.1% to 2%, respectively). The reduction in chest x-ray requests for neurologic pathologic examination was high. Before guideline use, chest x-rays were requested for 48% of patients with this type of pathologic condition, whereas afterward, the rate decreased to 27%. With regard to "other pathologic examinations," most striking was the decrease in the number of abdominal x-ray requests (from 29% to 15%), mostly because in cases of fever, the number of abdominal x-ray fell from 29% to 11% (data not shown). No reduction in requests was observed for low back pain (from 28% to 29%) (data not shown).

One month after the postimplementation evaluation (November 2005), the effects of the intervention continued to be apparent (data not shown).

Reductions in the number of x-rays led to an overall decrease in time delays between x-ray request and x-ray performance, which on average was only 5 minutes.

4. Discussion

In our ED, implementing a specifically designed guideline for the request of chest and abdominal x-rays in nontraumatic pathologic conditions reduced the absolute number of radiographic examinations and also the number of inappropriate requests. To our knowledge, with the exception of some nonvalidated decision rules/specific recommendations for more adequate x-ray ordering [18-21], there have been no systematic guidelines for x-ray requests based on patient symptoms that take into account the wide range of urgent pathologic conditions and, therefore, specifically adapted to ED practice.

Table 3 X-ray requests and erroneous requests in the preimplementation and postimplementation periods

	October 2004	October 2005
Abdominal pathologic examination		
Patients	1397	1205
Chest x-ray requests (%)	529 (38)	243 (20)
Abdominal x-ray requests (%)	773 (55)	351 (29)
Erroneous requests (%)*	131 (35)	42 (16)
Absolute error reduction (95% CI)*	0.19 (0.12-0.25)	
Relative error reduction (95% CI)*	0.53 (0.35-0.72)	
Urologic pathologic conditions		
Patients	335	308
Chest x-ray requests (%)	50 (15)	18 (5.8)
Abdominal x-ray requests (%)	140 (42)	108 (35)
Erroneous requests (%)	72 (21)	37 (12)
Absolute error reduction (95% CI)	0.09 (0.05-0.14)	
Relative error reduction (95% CI)	0.44 (0.23-0.65)	
Heart and lung pathologic conditions		
Patients	1309	1516
Chest x-ray requests (%)	1062 (81)	1109 (73)
Abdominal x-ray requests (%)	71 (5.4)	24 (1.6)
Erroneous requests (%)*	76 (6.1)	29 (2)
Absolute error reduction (95% CI)*	0.04 (0.03-0.06)	
Relative error reduction (95% CI)*	0.68 (0.43-0.70)	
Neurologic pathologic conditions		
Patients	623	641
Chest x-ray requests (%)	302 (48)	171 (27)
Abdominal x-ray requests (%)	41 (6.6)	9 (1.4)
Erroneous requests (%)	65 (10)	21 (3.3)
Absolute error reduction (95% CI)	0.07 (0.04-0.10)	
Relative error reduction (95% CI)	0.68 (0.42-0.95)	
Other pathologies		
Patients	398	308
Chest x-ray requests (%)	201 (50)	157 (40)
Abdominal x-ray requests (%)	114 (29)	59 (15)
Erroneous requests (%)	118 (30)	63 (16)
Absolute error reduction (95% CI)	0.14 (0.08-0.19)	
Relative error reduction (95% CI)	0.46 (0.27-0.66)	
Total		
Patients	4062	4066
Chest x-ray requests (%)	2144 (52.7)	1698 (41.8)
Abdominal x-ray requests (%)	1139 (28.0)	551 (13.5)
Erroneous requests (%)*	462 (15.5)	192 (6.2)
Absolute error reduction (95% CI)*	0.09 (0.07-0.10)	
Relative error reduction (95% CI)*	0.59 (0.49-0.69)	

* Abdominal pain, vomit, and tachycardia as chief complaint were excluded from the analyses of error reduction.

Clinical practice guidelines are becoming increasingly important elements of clinical care. However, widespread use and adherence to these guidelines may face multiple barriers [22,23]. To the limiting factors that may affect implementation of any kind of guideline, we must add the specific factors of an ED, such as the high volume of patients and the presence of nonspecific symptoms corresponding to a wide variety of final diagnoses. In addition, overworked doctors in training with an irregular work schedule may request an excess of routine tests. These factors may all explain the low adherence to the established RCR and ACR recommendations [2,3,9,10,13].

We followed a multifaceted implementation strategy by distributing educational material, holding meetings, and creating electronic reminders. This method has proved to be effective in the implementation process of Guidelines for Clinical Practice (GCP) [24,25].

The impact of the implementation of our guideline was similar to the average impact of other GCPs, which ranged from 6% to 14% [24]. However, the impact was not homogeneous for all pathologic examination. In abdominal pathologic study, introduction of the guideline importantly reduced both the number of abdominal x-ray requests and the number of erroneous requests. Similarly, in neurologic pathologic examination, we observed a reduction in chest x-ray requests, which was undoubtedly because of the guideline that did not recommend routine chest x-rays. In heart and lung pathologic conditions, despite the elevated number of chest x-ray requests, most were appropriate, so there were small margins for improvement. Probably because of the possible barriers that may be faced during the implementation of any guideline, we have not been able to reduce the inappropriate requests for certain pathologic conditions. This was the case for low back pain, in which the number of abdominal x-ray remained as high in preimplementation and postimplementation of the guideline.

The reduction in the number of x-ray requests was not associated with an increase in the number of CT or US scans performed.

The effect of the intervention was still observed 1 month after the implementation although this fact would not necessarily guarantee its long-term success [26]. The inclusion of this kind of guidelines in the residents' training program would undoubtedly help maintain a longer lasting effect.

The observed reduction in requests did not lead to a significant parallel reduction in the time delay between x-ray request and performance. This could be because in our ED, chest and abdominal x-ray examinations comprise only 30% of all plain radiologic studies and also that the time delay may be affected by many other factors such as the area where patients are attended, the degree of overcrowding, and personnel shifts.

Our study has limitations. Our definition of *erroneous request* only considered as inappropriate those requests that should never have been indicated regardless of any possible

modulating factor linked to a particular chief complaint. This might have affected and most probably undervalued the absolute number of estimated errors. However, our criteria for inappropriateness remained the same before and after the implementation of the guideline and, therefore, had no impact on our main finding of reducing the rate of erroneous requests. Only a prospectively designed study collecting data on modulating factors from clinical charts would allow us to use another definition of *inappropriate request*.

In conclusion, our study demonstrates the feasibility of implementing a specific guideline for chest and abdominal x-ray requests in the ED, its clinical use, and its role in reducing the amount of unnecessary radiation received by patients. We also showed our guideline was a useful tool for training doctors in their everyday clinical practice.

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