



The use of plain abdominal x rays in the emergency department

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ABSTRACT

Abdominal x rays expose patients to significant doses of radiation and have limited use in emergency medicine. This review explores the evidence supporting the use of abdominal x rays in the emergency department, with particular reference to recent guidelines published by the Royal College of Radiologists. The authors' recommendations for the use of abdominal x rays in the emergency department are given.

Investigations are useful when the results affect clinical management by confirming or excluding a diagnosis, or when they aid risk stratification of a potentially serious condition. The plain abdominal x ray (AXR) is a commonly requested investigation in the emergency department (ED). The average AXR exposes the patient to 35 times the radiation dose of a chest x ray (0.7 mSv).¹ Anecdotally, the AXR is overused and unhelpful in the majority of conditions presenting to the ED. In the past, surgeons have requested an AXR as part of the routine work-up of patients with undifferentiated abdominal pain. There are also more specific reasons for requesting this investigation, for example in the case of an ingested foreign body, intestinal obstruction, renal colic, pancreatitis and suspected appendicitis. The Royal College of Radiologists (RCR) have recently updated guidelines for the use of plain abdominal radiography in the hospital setting (see box 1), although they do not specify whether this is applicable to ED patients in most cases and many of the recommendations are made on the basis of poor quality evidence or expert opinion.²

This review aims to unearth the evidence supporting the use of the plain AXR as a diagnostic test in the ED by performing a structured literature review.

METHODS

A comprehensive search of the literature was carried out, using Medline and Pre-Medline (OVID platform) 1966 to June 2007, Embase, evidence-based medicine reviews and the BestBETS database. Search terms included "plain abdominal radiograph", "abdominal x rays", "abdominal films", "abdominal roentgenogram", "abdominal imaging" and "abdominal pain". The MeSH heading searched was "radiography, abdominal".

The bibliographies of relevant papers were examined and cross-referenced. Papers were critically appraised for the quality of evidence presented. Studies were preferred in accordance with the usual hierarchy of evidence, namely controlled

clinical trials, prospective studies (including case-control studies) and case reports. Review articles were examined for their reference lists.

RESULTS

A total of 38 original papers was found that were relevant to the research question and these have been examined in detail (see table 1 available online only). A recurring problem throughout the studies was the lack of a consistent gold standard with which to compare the plain AXR as a diagnostic test. Some recent studies have used computed tomography (CT) as the gold standard. Many of the retrospective chart reviews had no methodological control and were simply the authors' subjective interpretation of the results. No evidence was found to support the use of plain AXR in patients with pancreatitis, inflammatory bowel disease, renal failure or haematuria.

DISCUSSION

Undifferentiated abdominal pain

Most papers focus on the use of AXR in undifferentiated abdominal pain. As early as the 1960s, it was appreciated that the diagnostic yield in this group of patients is low, with Rosenbaum *et al*³ finding that 7% of AXR were diagnostic, with 10.4% showing sufficient evidence of pathology to require additional investigation. A later study included 1000 patients presenting with abdominal pain, in whom 38% had an AXR, of which 58 out of 427 were abnormal, but in no case was the clinical diagnosis changed by the AXR.⁴

A larger study looked prospectively at 1780 referrals for AXR in patients with abdominal pain,⁵ and found that 10% of studies showed an abnormality. The authors suggest that the adoption of defined referral criteria would result in a minimal loss of clinically useful information, large financial savings and a reduction in radiation exposure, to the effect of 53.7% fewer AXR being performed.

Another large series had 5080 patients presenting with abdominal pain over a 4-year period, of whom 45% had a plain AXR performed.⁶ From 1366 patients with an initial diagnosis of non-specific abdominal pain, 508 underwent AXR, of which 75% were normal and 25% showed some abnormality, but over half of these abnormalities were felt to be unrelated to the final diagnosis. This chart review had the potential for considerable bias, as one of the authors was essentially responsible for making the final clinical diagnosis.

Rothrock *et al*⁷ undertook a prospective observational study looking at children who had an AXR during a period of one year, in an attempt to define

Box 1 RCR guidelines for the use of plain abdominal radiography

- ▶ Acute abdominal pain warranting hospital admission and surgical consideration
- ▶ Acute abdominal pain: if perforation or obstruction suspected
- ▶ Acute small or large bowel obstruction
- ▶ Inflammatory bowel disease of the colon: acute exacerbation
- ▶ Palpable mass (indicated in specific circumstances)
- ▶ Constipation (indicated in specific circumstances)
- ▶ Acute and chronic pancreatitis
- ▶ Suspected ureteric colic/stones (indicated in specific circumstances)
- ▶ Renal failure
- ▶ Haematuria
- ▶ Foreign body in pharynx/upper oesophagus (indicated in specific circumstances)
- ▶ Smooth and small foreign body, eg, coin (indicated in specific circumstances)
- ▶ Sharp/poisonous foreign body
- ▶ Blunt or stab abdominal injury

a clinical decision rule for ordering AXR. They concluded that limiting radiographs to children with a history of abdominal surgery, suspicion of foreign body ingestion, abnormal bowel sounds, abdominal distension, or peritoneal signs would have detected 93% of diagnostic radiographs in patients with major disease while eliminating 38% of films.

Anyanwu and Moalypour⁸ looked further into diagnostic yield in 224 patients presenting with abdominal pain; 10.4% were diagnostic, showing obstruction, perforation or renal calculus. The authors suggested that some radiographs are requested to avoid criticism from senior members of staff or simply for completeness of assessment. Feyler *et al*⁹ conducted a prospective observational study of AXR in acute medical emergencies. Of 1309 admissions, 131 had an AXR, of which only 12% were deemed appropriate according to the RCR guidelines and 7% influenced the management.

Gerhardt *et al*¹⁰ undertook a complex prospective study in order to identify a clinical guideline for the evaluation of non-specific abdominal pain using several clinical and radiological variables. Combined with clinical examination and laboratory analysis, AXR was found to have a sensitivity of 56% and specificity of 81% at predicting the need for urgent intervention in the first 24 h. Of note, the addition of CT to this diagnostic model increased the sensitivity to 92% and specificity to 90%.

Another recent paper looked at whether AXR requesting is influenced by the time of year, thus comparing the requesting habits of doctors at the beginning and end of their time in the ED.¹¹ The RCR guidelines were followed in 32% of the total requests and when guidelines were followed positive findings were found in 76.7%, as opposed to 8.9% when guidelines were not followed. This is comparable to two other studies auditing AXR use against RCR guidelines, one of which found that AXR are performed in 18.3% of patients presenting to the ED with abdominal pain, but 71% did not comply with the RCR guidelines.¹² The other found that 70% of requests did not comply with the RCR guidelines.¹³

From the available evidence, it would appear that plain AXR should not be used as a routine investigation in patients with undifferentiated abdominal pain, unless there is clinical suspicion of bowel obstruction (see next paragraph).

Bowel obstruction

A prospective study to determine the value of AXR in comparison with history and examination in acute abdominal pain (bowel obstruction in particular) found that from a study population of 1254 patients, 56.1% had AXR performed.¹⁴ A total of 15.8% showed findings leading to diagnosis or immediate treatment and 64.7% were negative. The sensitivity of AXR for detecting obstruction was 90.8% and the positive predictive value was 80.2%. The authors found several variables from the history and examination that related to the likelihood of having bowel obstruction. The six variables with highest sensitivity were a distended abdomen, increased bowel sounds, history of constipation, previous abdominal surgery, age over 50 years and vomiting. If only patients with any two of these symptoms had had radiographs taken, 42.6% could have been avoided without loss of diagnostic accuracy. These results enabled them to propose a simple clinical algorithm that would support decision making in patients with acute abdominal pain and help to avoid unnecessary AXR.

Suri *et al*¹⁵ conducted a (small) prospective study comparing AXR with ultrasound and CT in their ability to diagnose obstruction, including the level and cause of the obstruction. The authors found that AXR had a sensitivity of 77% and specificity of 50%. They were able to diagnose the level of obstruction in 60% but the aetiology in only 7%. Their results highlight CT as the most sensitive (93%) and specific (100%) investigation in the diagnosis of obstruction.

Maglinte *et al*¹⁶ looked at the respective values of CT and AXR in suspected small bowel obstruction. They found AXR had 69% sensitivity and 57% specificity. The main advantage of CT is its ability to diagnose the cause of the obstruction, which it did in 95% of true positives.

It is suggested from this evidence that plain AXR should remain the initial method of radiological evaluation in the work-up of patients with suspected small bowel obstruction, with the addition of CT in patients with a high clinical suspicion of obstruction.^{17 18}

Hollow viscus perforation

No evidence was found to support AXR in the investigation of suspected intra-abdominal hollow viscus perforation, which would be supported by current ED practice of performing an erect chest film as the first-line radiological investigation. One study did compare the values of plain x ray (erect chest film) and ultrasound in the detection of pneumoperitoneum in patients with suspected perforation.¹⁹ Ultrasound had a sensitivity of 92% (versus 78%), a negative predictive value of 39% (versus 20%) and specificity of 53% (versus 53%). The authors concluded that ultrasound is more sensitive than plain radiography in the diagnosis of pneumoperitoneum, and this may play a larger role in the future as more emergency physicians use ultrasound as a bedside diagnostic tool.

Appendicitis

Most emergency physicians would agree that appendicitis is a clinical diagnosis in which plain AXR plays no role. This is supported by the available evidence. In a retrospective chart review of 821 consecutive patients with suspected appendicitis, Rao *et al*²⁰ found that 78% underwent AXR, but no individual radiographic finding was statistically more likely to occur in patients with appendicitis. In another large study of 5080 patients, 19% of appendicitis patients were imaged, with 79% being normal, and of the remaining 21%, 21 out of the 28 AXR

findings were inconsistent or incidental.⁶ In a prospective series of 104 patients presenting with right lower quadrant pain, the treatment plan was altered by an AXR in 6% of cases, including renal calculus in two cases (with blood on urinalysis) and ileus in three cases.²¹

Another recent study from Turkey looked at patients who had undergone appendectomy, and found that AXR was “helpful” in diagnosis in less than 10% of cases and these were when the appendix had perforated.²² The authors make the point that these patients would all have gone to surgery on clinical grounds alone. Another Turkish group performed a retrospective analysis looking at the value of 13 signs on AXR in the diagnosis of appendicitis in children.²³ They quote a sensitivity of 84% of AXR in diagnosing appendicitis, although the presence of lumbar scoliosis made up half of the detected abnormalities and the usefulness of the investigation is betrayed by a low specificity (44%) and negative predictive value.

From the available evidence, plain AXR should not be used as a routine investigation in patients with clinically suspected appendicitis.

Renal or ureteric colic

In most UK ED, the first-line radiological investigation of a patient with suspected renal colic would be an intravenous urogram or a CT kidney, ureter, bladder examination. The addition of a plain AXR prior to this would seem to add no benefit. A retrospective case review looked at the role of CT and AXR in diagnosing ureteric calculi.²⁴ Using CT as the gold standard in a population of 835 patients with suspected renal colic, plain AXR had a sensitivity of 45% and a specificity of 77% of picking up ureteric calculus. This supports the use of CT as the initial investigation without the need to perform an AXR beforehand. Monitoring and follow-up of patients with renal calculi may involve plain AXR but this is outwith the scope of ED practice.

Acute and chronic pancreatitis

Recognised abnormalities on plain AXR in acute pancreatitis are the presence of a sentinel loop and the colon cut-off sign.²⁵ However, the recommendations of the RCR seem at odds with current practice in ED in the UK, and no evidence could be found to support the use of plain AXR in the diagnosis of pancreatitis.

Ingested foreign body

Ingested foreign bodies are a common presentation to the ED, particularly in children, when the main concern (in the case of non-hazardous foreign body) is impaction in the oesophagus. Normally, the first-line investigation is either chest x ray or the use of a hand-held metal detector. A discussion of the merits of hand-held metal detectors over plain x rays, and algorithms for management, can be found in two recent papers in this journal.^{26 27} In cases of potentially hazardous foreign bodies, such as sharp objects, button batteries or large non-metallic foreign bodies (such as large glass beads), plain x ray is recommended to identify position but again this would normally start with a chest film. Plain AXR should be reserved for those patients who have a negative chest film but who have a foreign body detected by metal detector and in those who have a potentially harmful foreign body as above.

The use of plain AXR in the detection of packages in suspected body packers has been the subject of a short cut review.²⁸ Although diagnostic if positive, the plain AXR is not sufficiently sensitive to exclude a foreign body in this group of patients.

Trauma—blunt trauma and stab wounds

The use of plain AXR in trauma is certainly not commonplace in the UK, but there is some literature suggesting it may play a role in certain circumstances, particularly in environments where there is no capacity to perform CT. In a prospective study from India, where CT was not available, plain AXR was used in conjunction with ultrasound and paracentesis (diagnostic peritoneal lavage) to investigate 72 patients with abdominal trauma and was diagnostic in three cases of intestinal injury, although the authors do not use a gold standard, and indeed do not mention whether the bowel injury could have been diagnosed from the diagnostic peritoneal lavage result.²⁹ It would appear that if CT is to be performed, the addition of plain AXR beforehand will add no benefit.

In penetrating trauma, some centres have advocated the use of plain AXR to look for evidence of extraluminal air in the peritoneal cavity,^{30 31} although there seems to be reasonable evidence that this is neither useful nor cost-effective.³² Many centres now follow an approach that involves either emergency surgery (if haemodynamically unstable), or local wound exploration progressing to laparoscopy and laparotomy depending on the findings.³³

GENERAL COMMENTS

This review has found limited evidence to support the use of AXR in patients presenting to the ED. The indiscriminate use of the AXR as a routine investigation in the general work-up of patients presenting with undifferentiated abdominal pain is costly, exposes the patient to unnecessary radiation and is not indicated in the majority of cases.

If for a moment we turn history on its head and suppose that a new investigation, the AXR, has been suggested as a diagnostic test in the investigation of patients with various abdominal pathologies, we would subject it to rigorous investigation and control before suggesting it should be used in everyday practice. From the available evidence it would be dismissed as a poor test and not recommended for use in the ED.

Several studies have compared the use of CT and plain AXR in patients with abdominal pain and universally support the early use of CT in patients presenting with abdominal pain requiring admission.^{10 17 34 35}

The role of ultrasound in ED management of patients with abdominal pain may well increase as it becomes more commonplace and ultrasound expertise in the specialty grows, but further work is needed in this area before recommendations regarding its use can be made.

During this search several papers were found that explored related aspects of the use of AXR in the ED worth mention, such as the different types of AXR, image interpretation, requesting habits of staff and the influence of the AXR on patient management plans.

The three-film abdominal series has been compared with standard views and found to be superfluous to requirements.^{36 37} Both studies concluded that the upright abdominal radiograph can be eliminated from the standard series without loss of diagnostic information. Numerous articles comment on the problems with the accurate interpretation of AXR,^{13 25} and several authors have challenged the request process for AXR.^{38 39} Consistently, studies have shown that the AXR rarely changes the management plan and is often used as a defensive screening investigation.^{9 38 40} Despite the available evidence, there has been a continuing failure to act to alter practice and reduce the burden of abdominal radiographs being performed in the ED.

It would seem that the RCR guidelines for the use of plain AXR are not supported by either current evidence or established practice and should be reviewed in the context of ED use of this investigation (box 2).

Box 2 Suggested use of plain abdominal radiography in the ED

- Acute abdominal pain: if bowel obstruction suspected
- Oesophageal foreign body suspected (depending on local protocol for metal detector)
- Sharp/poisonous foreign body suspected

CONCLUSION

The plain AXR has limited use in the ED for specific conditions, but should not be used indiscriminately as a routine investigation in undifferentiated patients presenting with abdominal symptoms.

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REFERENCES

- Hart D, Wall BF. *Radiation exposure of the UK population from medical and dental X-ray examinations*. Didcot: National Radiological Protection Board, 2002.
- The Royal College of Radiologists. *Making the best use of clinical radiology services: referral guidelines*. London: The Royal College of Radiologists, 2007.
- Rosenbaum HD, Lieber A, Hanson DJ, et al. Routine survey roentgenogram of abdomen on 500 consecutive patients over 40 years of age. *Am J Roentgenol* 1964;**91**:903–9.
- Brewer BJ, Golden GT, Hitch DC, et al. Abdominal pain. An analysis of 1,000 consecutive cases in a university hospital emergency room. *Am J Surg* 1976;**131**:219–23.
- Eisenberg RL, Heineken P, Hedgcock MW, et al. Evaluation of plain abdominal radiographs in the diagnosis of abdominal pain. *Ann Intern Med* 1982;**97**:257–61.
- Campbell JP, Gunn AA. Plain abdominal radiographs and acute abdominal pain. *Br J Surg* 1988;**75**:554–6.
- Rothrock SG, Green SM, Hummel CB. Plain abdominal radiography in the detection of major disease in children: a prospective analysis. *Ann Emerg Med* 1992;**21**:1423–9.
- Anyanwu AC, Moalypour SM. Are abdominal radiographs still overutilized in the assessment of acute abdominal pain? A district general hospital audit. *J R Coll Surg Edinb* 1998;**43**:267–70.
- Feyler S, Williamson V, King D. Plain abdominal radiographs in acute medical emergencies: an abused investigation? *Postgrad Med J* 2002;**78**:94–6.
- Gerhardt RT, Nelson BK, Keenan S, et al. Derivation of a clinical guideline for the assessment of nonspecific abdominal pain: the Guideline for Abdominal Pain in the ED Setting (GAPEDS) phase 1 study. *Am J Emerg Med* 2005;**23**:709–17.
- Morris-Stiff G, Stiff RE, Morris-Stiff H. Abdominal radiograph requesting in the setting of acute abdominal pain: temporal trends and appropriateness of requesting. *Ann R Coll Surg Engl* 2006;**88**:270–4.
- Bell DJ, Woo EK. Re: AC Anyanwu, SM Moalypour. Are abdominal radiographs still overutilized in the assessment of acute abdominal pain? A district general hospital audit. *J R Coll Surg Edinb Irel* 1998;**43**:267–70. [Letter] *Surgeon* 2006; **4**:61.
- Kahnzada TW, Samad A, Zulficar I. Abuse of plain abdominal radiographs in abdominal pain. *Rawal Med J* 2007;**32**:48–50.
- Bohner H, Yang Q, Franke C, et al. Simple data from history and physical examination help to exclude bowel obstruction and to avoid radiographic studies in patients with acute abdominal pain. *Eur J Surg* 1998;**164**:777–84.
- Suri S, Gupta S, Sudhakar PJ, et al. Comparative evaluation of plain films, ultrasound and CT in the diagnosis of intestinal obstruction. *Acta Radiol* 1999;**40**:422–8.
- Maglinte DD, Reyes BL, Harmon BH, et al. Reliability and role of plain film radiography and CT in the diagnosis of small-bowel obstruction. *AJR Am J Roentgenol* 1996;**167**:1451–5.
- Ahn SH, Mayo-Smith WW, Murphy BL, et al. Acute nontraumatic abdominal pain in adult patients: abdominal radiography compared with CT evaluation. *Radiology* 2002;**225**:159–64.
- Thompson WM, Kilani RK, Smith BB, et al. Accuracy of abdominal radiography in acute small-bowel obstruction: does reviewer experience matter? *AJR Am J Roentgenol* 2007;**188**:W233–8.
- Chen SC, Yen ZS, Wang HP, et al. Ultrasonography is superior to plain radiography in the diagnosis of pneumoperitoneum. *Br J Surg* 2002;**89**:351–4.
- Rao PM, Rhea JT, Rao JA, et al. Plain abdominal radiography in clinically suspected appendicitis: diagnostic yield, resource use, and comparison with CT. *Am J Emerg Med* 1999;**17**:325–8.
- Boleslawski E, Panis Y, Benoist S, et al. Plain abdominal radiography as a routine procedure for acute abdominal pain of the right lower quadrant: prospective evaluation. *World J Surg* 1999;**23**:262–4.
- Oncel M, Degirmenci B, Demirhan N, et al. Is the use of plain abdominal radiographs (PAR) a necessity for all patients with suspected acute appendicitis in emergency services? *Curr Surg* 2003;**60**:296–300.
- Turkylmaz Z, Sonmez K, Konus O, et al. Diagnostic value of plain abdominal radiographs in acute appendicitis in children. *East Afr Med J* 2004;**81**:104–7.
- Levine JA, Neitlich J, Verga M, et al. Ureteral calculi in patients with flank pain: correlation of plain radiography with unenhanced helical CT. *Radiology* 1997;**204**:27–31.
- Lee PW. The plain X-ray in the acute abdomen: a surgeon's evaluation. *Br J Surg* 1976;**63**:763–6.
- Ramlakhan SL, Burke DP, Gilchrist J. Things that go beep: experience with an ED guideline for use of a handheld metal detector in the management of ingested non-hazardous metallic foreign bodies. *Emerg Med J* 2006;**23**:456–60.
- Lee JB, Ahmad S, Gale CP. Detection of coins ingested by children using a handheld metal detector: a systematic review. *Emerg Med J* 2005;**22**:839–44.
- Costello J, Townend W. Abdominal radiography in "body packers". *Emerg Med J* 2004;**21**:498.
- Mohapatra S, Pattanayak SP, Rao KRRM, et al. Options in the management of solid visceral injuries from blunt abdominal trauma. *Indian J Surg* 2003;**65**:263–8.
- Robin A, Andrews J, Lange D, et al. Selective management of anterior abdominal stab wounds. *J Trauma* 1989;**29**:1684–9.
- Taviloglu K, Gunau K, Ertekin C, et al. Abdominal stab wounds. The role of selective management. *Eur J Surg* 1998;**164**:17–21.
- Kester D, Andrassy R, Aust J. The value and cost-effectiveness of abdominal roentgenograms in the evaluation of stab wounds to the abdomen. *Surg Gynecol Obstet* 1986;**162**:337–9.
- Cameron P, Civil I. The management of anterior abdominal stab wounds in Australasia. *Aust NZ J Surg* 1998;**68**:510–13.
- Nagurney JT, Brown DF, Novelline RA, et al. Plain abdominal radiographs and abdominal CT scans for nontraumatic abdominal pain—added value? *Am J Emerg Med* 1999;**17**:668–71.
- MacKersie AB, Lane MJ, Gerhardt RT, et al. Nontraumatic acute abdominal pain: unenhanced helical CT compared with three-view acute abdominal series. *Radiology* 2005;**237**:114–22.
- Mirvis SE, Young JW, Keramati B, et al. Plain film evaluation of patients with abdominal pain: are three radiographs necessary? *AJR Am J Roentgenol* 1986;**147**:501–3.
- Ukrisana P, Yenarkarn P. Evaluation of the necessity of the three-film abdominal series in the diagnosis of abdominal pain. *J Med Assoc Thai* 2002;**85**:998–1002.
- Stower MJ, Amar SS, Mikulin T, et al. Evaluation of the plain abdominal X-ray in the acute abdomen. *J R Soc Med* 1985;**78**:630–3.
- Field S, Guy PJ, Upsdell SM, et al. The erect abdominal radiograph in the acute abdomen: should its routine use be abandoned? *BMJ (Clin Res Ed)* 1985;**290**:1934–6.
- McCook TA, Ravin CE, Rice RP. Abdominal radiography in the emergency department: a prospective analysis. *Ann Emerg Med* 1982;**11**:7–8.