The appropriateness of abdominal X-ray requests in the acute medical initial admissions unit

Abstract

Background/Aims Abdominal X-rays are frequently requested by clinicians in the Aberdeen Royal Infirmary acute medical initial assessment unit.

Method The proportion of indicated abdominal X-rays requested within 24 hours of admission was retrospectively examined. This process was repeated after displaying an educational poster with the Royal College of Radiologists guidelines (cycle 2) and a graded assertive communication poster (cycles 3 and 4); a tool to enable junior doctors to challenge inappropriate requests for abdominal X-rays from seniors.

Results Only 47.2% of abdominal X-ray requests were deemed appropriate in cycle 1. A 1.54% reduction in abdominal X-ray requests and an 11.5% increase in indicated abdominal X-rays were noted after cycle 2. Cycle 3 led to a statistically significant improvement with 2.6% fewer patients undergoing an abdominal X-ray and a 24.6% increase in indicated abdominal X-rays. This improvement was sustained in cycle 4.

Conclusions Promoting graded assertive communication is an effective means of helping junior doctors to challenge seniors requesting non-indicated abdominal X-rays.

Key words: Abdominal X-rays; Acute medicine; Education; Graded assertive communication; Guidelines

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Background

The Royal College of Radiologists iRefer guidelines (Remedios et al, 2017) outline specific indications for abdominal X-rays (Table 1). Inappropriate abdominal X-rays delay more appropriate investigations, lead to unnecessary radiation exposure for patients and add to the workload of the radiology department. Abdominal X-rays are frequently requested at the Aberdeen Royal Infirmary acute medical initial admissions unit with roughly 60 abdominal X-rays requested each month. Anecdotally, the authors observed that in most cases abdominal X-rays were normal or revealed non-specific inflammatory changes, were often falsely negative or had little influence on subsequent management. The primary indication where they were helpful were in patients with bowel obstruction but in these cases they were always followed by computed tomography imaging. Further to this, the use of a computerised request system at the Aberdeen Royal Infirmary worsens the inappropriate use of this investigation by avoiding vetting by the radiology department.

The inappropriate use and limited diagnostic utility of abdominal X-rays is well documented in the literature. Commonly cited reasons for inappropriate abdominal X-ray requests included diagnostic uncertainty in atypical presentations, pressure from senior

Table 1. Indications for an abdominal X-ray

Clinical suspicion of obstruction	
Toxic megacolon in patients with inflammatory bowel disease	
In specific circumstances with the following:	Palpable mass or foreign body
	Blunt or stab abdominal injury

From Remedios et al (2017)

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colleagues (Anyanwu and Moalypour, 1998), lack of knowledge regarding imaging guidelines (Khanzada et al, 2007) and abdominal X-rays being used as a defensive screening investigation (Stower et al, 1985). The aim of this project was to identify the proportion of abdominal X-ray requests over a period of 30 days which met the indications described by the Royal College of Radiologists guidelines (Remedios et al, 2017) (cycle 1). The aim was a target of 70% of requested abdominal X-rays being deemed as appropriate, as determined by a literature review conducted by the authors.

The authors then strategised ways to increase concordance with these guidelines. Educational posters are a widely-used and effective means of raising awareness of guidelines regarding current practice. Senior clinician request is another primary reason noted in the literature for inappropriate abdominal X-ray requests. Traditional hierarchical structures in clinical teams and disparity in clinical experience can hinder discussions between junior and more senior colleagues on important decisions influencing patient management. The 'concern uncertain safety stop' (CUSS) model for graded assertive communication is a tool that can overcome these barriers and be used to challenge decisions made by senior colleagues without it being considered to be insubordination (Figure 1) (Coggins, 2014).

Methods

Cycle 1

A retrospective cohort study was carried out including all patients over 18 years of age who were admitted to the acute medical initial admissions unit at the Aberdeen Royal Infirmary from 1–30 April 2021. The number of plain abdominal X-rays requested within 24 hours of admission was noted. The clinical signs or symptoms detailed on each computerised abdominal X-ray request and patient immediate discharge letter were recorded, as well as the patient's age and gender. Abdominal X-rays were considered to be indicated only if they met the indications outlined in the Royal College of Radiologists guidelines (Table 1). Genuine suspicion of bowel obstruction was defined as two or more of the following: a distended abdomen, increased bowel sounds, a history of constipation, vomiting and age over 50 years. The presence of a mass lesion, foreign body or evidence of toxic megacolon were considered significant, while faecal loading and non-specific inflammatory changes were considered insignificant findings.

The age and gender of patients with indicated abdominal X-rays were compared to those with inappropriate abdominal X-ray requests using univariate and multivariate analysis using odds ratios and associated 95% confidence intervals. SIMCA multivariate data analysis software, version 17 (Sartorius, Göttingen, Germany), was used to perform this analysis. The proportion of patients who had further imaging was also noted, including computed tomography imaging within 48 hours of admission. An abdominal X-ray was considered to be false negative if an abnormality was detected on computed tomography which was not apparent on the X-ray. An online qualitative survey was distributed among junior doctors in acute medical initial admissions to ask about the reasons for requesting non-indicated abdominal X-rays.

Concern	'I was just wondering what the reasons are for requesting this abdominal X-ray as I am a bit worried about whether it is indicated'
Uncertain	'I may be wrong, but I am uncertain of whether this abdominal X-ray is necessary as it does not meet the criteria outlined in the Royal College of Radiologists iRefer guidelines'
Safety	'I do not feel comfortable requesting this abdominal X-ray as it will lead to significant radiation exposure and is not indicated'
Stop	

Figure 1. The 'concern uncertain safety stop' model for graded assertive communication. From Remedios et al (2017)

Cycles 2 and 3

The above process was repeated after use of an educational poster (Appendix 1) as the first intervention (cycle 2: 1–30 May 2021) and a junior doctor-led abdominal X-ray vetting process as the second (cycle 3: 7 June–6 July 2021). The latter involved using a poster to promote the CUSS model for graded assertive communication (Appendix 2). This was intended as a tool to enable junior doctors to challenge inappropriate abdominal X-rays requested by seniors. Fisher's exact test was used to determine statistical significance using the Statistical Package for the Social Sciences (SPSS) Statistics 28 (IBM, Armonk, New York, USA).

Cycle 4

To demonstrate a sustainable improvement with the junior doctor-led abdominal X-ray vetting process, a delayed reaudit was carried out over a 60-day period (cycle 4: 19 September–14 November 2021).

Results

Cycle 1

From 1–30 April 2021, there were 665 admissions with abdominal X-rays being performed in 55 (8.3%) patients. The characteristics of patients who underwent abdominal X-ray imaging are shown in Table 2. Abdominal pain, obstruction, faecal loading and constipation were the most frequently cited indications for an abdominal X-ray. Only 47.2% of abdominal X-ray requests were deemed appropriate (Figure 2). Indicated abdominal X-rays had a diagnostic yield of 26.9%, with bowel obstruction being the most common abnormality identified (Figure 3). Non-indicated abdominal X-rays revealed only faecal loading and non-specific inflammatory changes.

Of patients undergoing a plain abdominal X-ray within 24 hours of presentation, 60% required further imaging. This included 29.1% who underwent computed tomography imaging within 48 hours of admission (Table 3). Notably, the need for further computed tomography imaging was primarily guided by clinical presentation rather than abdominal X-ray findings, with 50% of computed tomography imaging being carried out in patients with normal abdominal X-rays.

Table 2. Characteristics of patients admitted to acute medical initial admissions who underwent an abdominal X-ray

Characteristic	
Age	Mean age: 61.2 years
	Median age: 58 years
Gender	Male: 43.4%
	Female: 56.6%
Presenting complaint	Non-specific abdominal pain 25.8%
	Diarrhoea 11.7%
	Constipation 24.7%
	Nausea and/or vomiting 27.8%
	Flank pain 6.5%
	Delirium 1.4%
	Other 2.1%
Cited indications	Abdominal pain 35.7%
	Query obstruction 36.9%
	Faecal loading 17.1%
	Constipation 7.1%
	Other 3.2%

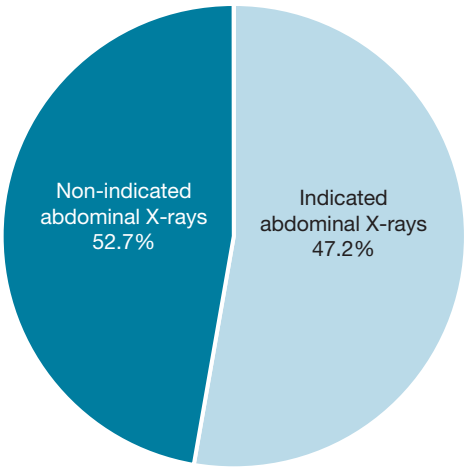

Figure 2. The relative proportion of indicated and non-indicated abdominal X-rays of all those requested within 24 hours of admission.

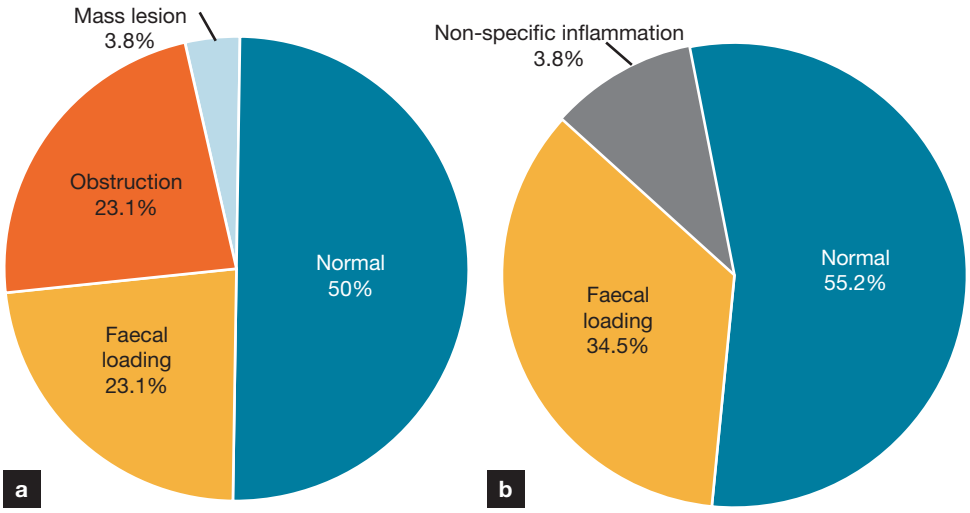

Figure 3. a. Indicated abdominal X-rays and (b) non-indicated abdominal X-rays.

Abdominal X-rays also had a high false negative rate of 43.8% which included patients with diverticulitis, pancreatitis, ischaemic colitis, cholecystitis and pyelonephritis (Table 4).

Abdominal X-rays had 100% sensitivity at detecting bowel obstruction, but all eight patients with evidence of obstruction on plain abdominal X-ray required subsequent computed tomography imaging to establish the aetiology and site of obstruction. There were four cases of small bowel obstruction, including one case of high-grade mechanical obstruction secondary to malignancy. There was also one case of large bowel obstruction and a patient with a gastric volvulus. On multivariate analysis, women (odds ratio 2.78, 95% confidence interval 1.64–7.38) over the age of 65 years (odds ratio 2.32, 95% confidence interval 1.62–3.69) were most likely to have a plain abdominal X-ray inappropriately requested.

A qualitative survey was sent to 35 people, of whom 28 responded. This revealed that senior clinician request and ignorance regarding the Royal College of Radiologists guidelines were the primary reasons why non-indicated abdominal X-rays were requested (Figure 4). Respect for seniority and fear of embarrassment if wrong were cited by junior doctors as barriers to raising a concern when asked to request a non-indicated abdominal X-ray by a senior (Figure 5).

Cycle 2 and 3

After displaying the first educational poster, there was a 1.54% reduction in the proportion of patients undergoing an abdominal X-ray, coinciding with an 11.5% increase in the proportion of indicated abdominal X-rays (Table 5). A statistically significant improvement was seen with the graded assertive communication poster, with a further 2.56% reduction in the

Table 3. The proportion of patients who underwent subsequent imaging after an initial plain abdominal X-ray in acute medical initial admissions at the Aberdeen Royal Infirmary

Number of acute medical initial admissions 1–30 April 2021	665
Abdominal X-ray within 24 hours of admission	55 (8.3%)
Requiring further imaging (of all abdominal X-ray requests)	33 (60.0%)
Requiring computed tomography imaging within 48 hours (of all abdominal X-ray requests)	16 (29.1%)
Requiring oesophagogastroduodenoscopy or flexible sigmoidoscopy (of all abdominal X-ray requests)	7 (12.7%)
Requiring magnetic resonance imaging small bowel (of all abdominal X-ray requests)	2 (3.6%)
Requiring abdominal ultrasound (of all abdominal X-ray requests)	9 (16.4%)

Table 4. Computed tomography findings in patients with normal abdominal X-rays

Condition	Prevalence
Diverticulitis	27.3%
Pancreatitis	27.3%
Ischaemic colitis	18.2%
Cholecystitis	9.1%
Pyelonephritis	9.1%
Normal	9.1%

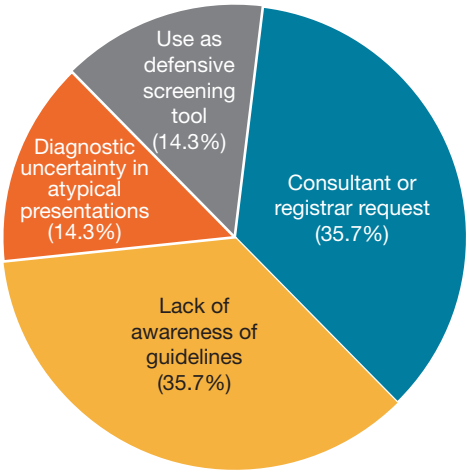

Figure 4. Reasons for inappropriate abdominal X-rays request based on a qualitative survey distributed among junior doctors in acute medical initial admissions unit.

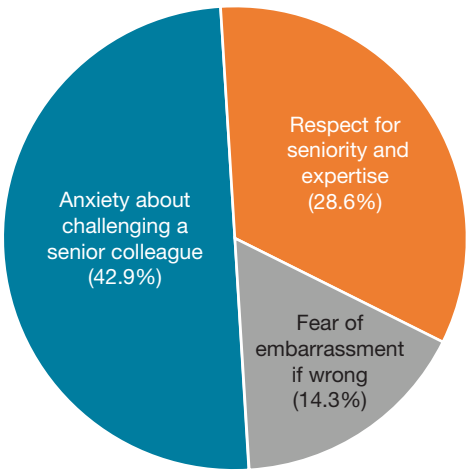

Figure 5. Reasons preventing junior doctors from challenging senior colleagues regarding non-indicated abdominal X-rays.

number of patients undergoing abdominal X-rays (P=0.03; Fisher's exact test) and 24.6% increase in those which are clinically indicated (P=0.029; Fisher's exact test).

Cycle 4

Reauditing over a 60-day period showed that the junior doctor-led vetting process resulted in a sustained improvement with no significant change in the proportion of patients undergoing an abdominal X-ray (4.17 vs 4.36; P=0.92) or % indicated abdominal X-rays (83.3 vs 81.0; P=0.95) from cycle 3.

Table 5. Proportion of patients undergoing abdominal X-rays within 24 hours of admission, proportion of abdominal X-rays followed by computed tomography imaging within 48 hours of admission and proportion of indicated abdominal X-rays across four cycles

Cycle	Cycle 1 (1–30 April)	Cycle 2 (1–30 May)	Cycle 3 (7 June–6 July)	Cycle 4 (19 Sept–14 Nov)
Number of patients admitted	665	683	863	1927
% of admissions abdominal X-ray within 24 hours	8.3	6.7	4.2	4.4
% of indicated abdominal X-ray (of all abdominal X-rays)	47.2	58.7	83.3	81.0
Diagnostic yield (% of all abdominal X-rays)	12.6	15.2	16.3	11.2
% requiring further computed tomography imaging (% of all abdominal X-rays)	29.1	30.8	28.5	32.1
% straight to computed tomography imaging (of all admissions)	0.3	0.2	0.1	0.1
No of missed cases of bowel obstruction, toxic megacolon or foreign body	0	0	0	0

Minimal change was noted in the proportion of patients undergoing initial computed tomography imaging in either cycle two (P=0.623; Fisher's exact test) or three (P=0.981) or four (P=0.746) and there were no missed cases of bowel obstruction, foreign body or toxic megacolon in any cycle.

Discussion

This study revealed that abdominal X-rays are an overused investigation, with 52.7% being inappropriate according to the Royal College of Radiologists guidelines (Remedios et al, 2017). Non-indicated abdominal X-rays had limited clinical utility, did not reveal any significant findings and did not influence patient management. Compliance with guidelines and diagnostic yield have been reported to be as low as 30% and 10.4% respectively in previous studies (Singh-Ranger, 2002). Equally, in a large prospective cohort study Eisenberg et al (1983) demonstrated that abdominal X-rays only influenced patient management in 13% of patients. This study used a questionnaire to determine an initial provisional diagnosis based purely on clinical findings and compared this to a final diagnosis following a plain abdominal X-ray. The most commonly cited indications for inappropriate abdominal X-ray requests in this study were undifferentiated abdominal pain and query obstruction, often in patients with little in the way of clinical findings to suggest genuine suspicion of obstruction. Similar to the observations in the current study, in the literature abdominal X-rays in patients with non-specific abdominal pain were associated with a low diagnostic yield, ranging from 7–10% (Eisenberg et al, 1983).

Bowel obstruction was the most common abnormality identified on plain abdominal X-ray in this study. A clinical algorithm to guide decision making would help avoid unnecessary abdominal X-rays in patients suspected of this presentation. Böhner et al (2003) used this approach and found that the clinical variables listed in Table 6 were associated with the highest positive predictive value in determining the likelihood of bowel obstruction. Moreover, if abdominal X-rays were only requested for patients who had two or more of these clinical variables, 42.6% of abdominal X-rays could have been avoided without any loss of diagnostic accuracy.

Multivariate regression analysis revealed that abdominal X-rays are most likely to be inappropriately requested for women aged over 65 years. The reasons for this are not immediately clear but may be because they are more likely to present with constipation secondary to polypharmacy. Similar findings were obtained in a previous study (Bhangu et al, 2010).

The diagnostic utility of abdominal X-rays as an imaging modality is questionable. Across the three cycles, there was a false negative rate of 43.8% for all abdominal X-rays. The limited diagnostic value of abdominal X-rays is noted in cases of pancreatitis, appendicitis and diverticulitis (Bertin et al, 2019). Abdominal X-rays were also noted by Levine et al (1997)

Table 6. Clinical variables associated with the highest positive predictive value in determining the likelihood of obstruction

Clinical variable	Positive predictive value (%)
Distended abdomen	18.8
Increased bowel sounds	12.1
History of constipation	10.5
Previous abdominal surgery	9.5
Age over 50 years	8.2
Vomiting	7.9

From Böhner et al (2003)

to be inferior to the gold standard computed tomography kidney ureter bladder at detecting renal or ureteric stones, with a sensitivity of 45% and a specificity of 77% respectively.

Although all cases of bowel obstruction were identified on plain abdominal X-ray in this study, all patients nonetheless required computed tomography of the abdomen and pelvis to confirm the level and aetiology of obstruction. Suri et al (1999) demonstrated that abdominal X-rays had a sensitivity of 77% and specificity of 50% at diagnosing obstruction, compared to 93% and 100% respectively for computed tomography. Further to this, the level of obstruction could be identified in 60% of cases and the cause was evident in 7% compared to 93 and 87% respectively for computed tomography. However, it should be noted that in all eight cases of obstruction in this study there was a strong clinical suspicion of obstruction at initial presentation. This raises the question of whether in such cases computed tomography imaging should have been requested as the initial investigation rather than plain abdominal X-ray.

Lack of awareness of the Royal College of Radiologists guidelines (Remedios et al, 2017) among junior doctors and senior clinician request were the most common reasons cited for inappropriate abdominal X-ray requests. Although a modest improvement was seen with the Royal College of Radiologists educational poster, a statistically significant improvement was observed only with the CUSS model for graded assertive communication poster, leading to 2.6% fewer abdominal X-rays and a 24.6% increase in the porportion of clinically indicated abdominal X-rays. This effect was demonstrated to be sustainable in cycle 4. The CUSS model is thus an effective tool to overcome the hierarchical barriers and challenges caused by disparity clinical experience necessary to raise concerns to seniors regarding decisions affecting patient safety.

A larger sample would have increased confidence in these results. Owing to the retrospective nature of this study, the authors relied on clear documentation of the clinical signs or symptoms of obstruction. Poor documentation may have contributed the large proportion of non-indicated abdominal X-rays. In terms of future direction, it would be interesting to examine the proportion of non-indicated abdominal X-rays requested by junior doctors at the beginning and end of a rotation to examine the influence of clinical experience in acute medicine on awareness of guidelines and confidence in challenging inappropriate requests by seniors. Introducing a radiology-led vetting process, whereby abdominal X-ray requests not fulfilling Böhner et al's (2003) clinical algorithm would need to be discussed with a radiologist, could further improve concordance with the Royal College of Radiologists iRefer guidelines.

Conclusions

Abdominal X-rays have limited diagnostic value. Encouraging graded assertive communication among junior doctors is an effective and sustainable means of challenging inappropriate abdominal X-rays requested by seniors and ultimately improving concordance with guidelines. This is particularly significant given the large proportion of non-indicated abdominal X-rays observed at the beginning of this study and the accompanying unnecessary radiation exposure, cost and demand on the radiology department associated with this.

Key points

- Only 47.2% of abdominal X-ray requests were deemed appropriate.
- Indicated abdominal X-rays had a diagnostic yield of 26.9%, with bowel obstruction being the most common abnormality identified.
- Non-indicated abdominal X-rays revealed no significant findings.
- In this study, 52.7% of abdominal X-rays could have been avoided without loss of diagnostic accuracy had the Royal College of Radiologists guidelines been adhered to.
- Abdominal X-rays had a high false-negative rate of 43.8%.
- Older women were most likely to have an abdominal X-ray requested inappropriately.
- Encouraging graded assertive communication among junior doctors is an effective means of challenging inappropriate abdominal X-rays requested by seniors.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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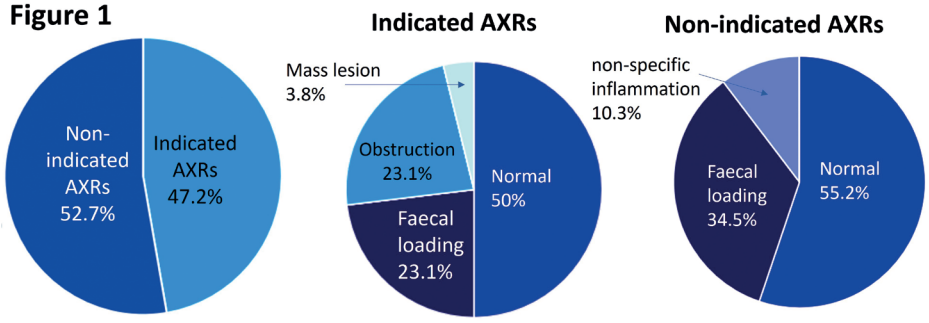
Appendix 1. Educational poster aimed at increasing awareness of the Royal College of Radiologists guidelines. AMIA = acute medical initial admissions unit; AXR = abdominal X-ray; CXR = chest X-ray; RCR = Royal College of Radiologists.

Requesting an AXR?

Is it really necessary?

- An AXR has **35X** the radiation dose of a CXR.
- A recent audit carried out locally in AMIA revealed that AXRs are an **overused** and often **unhelpful** investigation.
- In fact, **52.7% of AXRs** were **inappropriate** and could have been avoided **without loss of diagnostic accuracy** had the **RCR iRefer guidelines** been adhered to *(figure 1).*
- **AXRs** also had a **high false-negative rate** of **43.8%**.

Figure 1



iRefer RCR The Royal College of Radiologists

Appropriate indications for AXRs (as per RCR guidelines):

- clinical suspicion of ***obstruction***
- ***toxic megacolon*** in patients with inflammatory bowel disease
- In **specific circumstances** with the following:

1. palpable mass/foreign body
2. blunt or stab abdominal injury

Examples of common *inappropriate* indications:

- Constipation
- faecal loading alone
- abdominal pain

without genuine suspicion of obstruction: (i.e. a distended abdomen, increased bowel sounds, nausea/vomiting)

Appendix 2. A 'concern uncertain safety stop' model for graded assertive communication used to promote a junior doctor-led abdominal X-ray (AXR) vetting process. From Coggins (2014).