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碩士論文

腹部 X 光攝影對急診室非創傷性腹部急症病患的角色評估-以中台灣某區域醫院為對象之回溯性研究

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The Role of Abdominal Radiography in the Evaluation of Non-Traumatic Acute Abdomen Emergency Patients: Retrospective Study in a Regional General Hospital in Mid-Taiwan

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ABSTRACT

Objective: To investigate the diagnostic value of abdominal radiography (AR) in Non-Traumatic Acute Abdomen (NTAA) patients and to understand the differences of its diagnostic value among individual diseases of NTAA. Furthermore, the causes influencing the value are discussed.

Materials and Methods: A retrospective study of chart review focused on the patients with NTAA visiting the ER of a Regional General Hospital in Mid-Taiwan between Jan. 1st and June 30th, 2008 who underwent AR examination. 2912 patients were included in this study totally. Chi-Square test was used to study the overall diagnostic value of abdominal radiography in NTAA. Logistic regression analysis was used to study the relation between separating AR results, AR positive results, AR negative results and the individual disease. Odds ratios were reported with 95% confidence intervals. P-values of less than 0.05 were considered to indicate a significant difference.

Results: Fifty-three percent (1550 of 2912) of the study subjects were male and forty-seven percent (1362 of 2912) were female; the age-distribution was between 1 and 90 Y/O (mean: 45.88 Y/O ± 20.13, median age: 43 Y/O). In 2912 patients, abdominal radiographic interpretation was normal in 55.8% (n=1625), non-specific in 29.4% (n=856) and abnormal in 14.8% (n=431); 29% (n=845) of patients have taken further follow-up imaging in which 85.3% (721 of 845) showed abnormal results. Based on ICD-9-CM, the total disease items of AR ordering were 37 disease categories and the items of final diagnosis were 112 disease categories. The overall diagnostic value of abdominal radiography showed that the true negative rate was 10.5% (260 of 2481), false negative rate was 89.5% (2221 of 2481), true positive rate was 90.5% (390 of 431), false positive rate was 9.5% (41 of 431), PPV: 90.5%, NPV: 10.5%, sensitivity: 14.9%, specificity: 86.4%, efficiency: 22.3%. In Logistic regression analyses between AR (+) results and individual diseases, the p-value was less than 0.05 in five diseases, among them, the odds ratio was greater than one (2.14) in urolithiasis, odds ratios less than one in the other four diseases included non-specific diffuse abdominal pain, epigastric pain, diarrhea and dysuria. There were six cases of "intra-abdominal radiopque foreign body retention" included in these 37 clinical impressions, the final results of AR for this disease were TP：100% (4 of 4) and TN：100% (2 of 2) noted.

Conclusions: (1). Based on the study of 2912 NTAA patients, we thought the AR examination was abused. (2). If the emergency physicians would like to prove that urolithiasis caused NTAA, AR test had the diagnostic value. (3). If the emergency physicians would like to prove that the abdominal pain was caused by one of the four diseases: non-specific diffuse abdominal pain, epigastric pain, diarrhea, or dysuria, AR test had no value for diagnosis. (4). For the 37 clinical impressions listed in this study, if the emergency physicians

would like to exclude these diseases, AR test had no diagnostic value. (5). For disease of "intra-abdominal radiopaque foreign body retention", although the sample size in this study was small, we believed that AR tests had diagnostic value.

Keywords: Non-Traumatic Acute Abdomen, Abdominal Radiography, Sonography, Computed Tomography

腹部 X 光攝影對急診室非創傷性腹部急症病患的角色評估
-以中台灣某區域醫院為對象之回溯性研究

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摘要

研究目的：本文目的在探討“腹部 X 光攝影”對於整體“非創傷性腹部急症”的診斷價值，同時進一步了解“腹部 X 光攝影”對於引起“非創傷性腹部急症”的各個疾病的診斷價值以及其中的差異性。最後根據過去文獻以及臨床實務，分析影響“腹部 X 光攝影”診斷價值的因素，希望透過以上研究，有效提昇“腹部 X 光攝影”對於“非創傷性腹部急症”的診斷價值，減少不必要的“腹部 X 光攝影”檢查，降低醫療支出，減少因輻射線曝露所帶來的傷害。

材料與方式：本研究是以中台灣某區域教學醫院為對象，透過病歷回顧所作的回溯性研究，針對 2008 年 1 月 1 日至 2008 年 6 月 30 日期間，因“非創傷性腹部急症”前來急診室求診同時接受“腹部 X 光攝影”檢查的 2912 位病患進行研究，我們透過卡方檢定來了解“腹部 X 光攝影”對“非創傷性腹部急症”的整體診斷價值，另外我們運用羅吉斯迴歸分析(Logistic Regression Analysis)進一步了解不同的腹部 X 光攝影報告結果(如整體結果，不正常結果，正常結果)和各疾病之間的關係，我們將“顯著性差異”定義為 P 值小於 0.05，勝算比(odds ratio)是以 95%的信賴區間為計算基礎。

研究結果：本研究中，男性佔 53%(1550/2912)，女性為 47%(1362/2912)，年齡分佈從 1 歲到 90 歲(平均年齡：45.88 歲，中間值：43 歲)。針對 2912 位病患，腹部 X 光攝影報告結果為“正常(normal)”的有 55.8%(1625 人)，“非特異性(non-specific)”的有 29.4%(856 人)，“不正常(abnormal)”的有 29.4%(431 人)，29%(845 人)的病患曾經接受進一步的其它影像學檢查，在這 845 位病人中有 85.3%(721/845)的檢查結果屬於“不正常”。另外我們以“國際疾病分類第 9 版(ICD-9-CM)”為基礎，共計整理出 37 種開立腹部 X 光攝影的疾病，以及 112 項最後診斷確立的疾病。針對“非創傷性腹部急症”，“腹部 X 光攝影”的整體診斷價值如下：真陰性：10.5%(260/2481)、偽陰性：89.5%(2221/2481)、真陽性 90.5%(390/431)、偽陽性 9.5%(41/431)、陽性預測值：90.5%、陰性預測值：10.5%、敏感度：14.9%、特異性：86.4%、效率(efficiency)：22.3%。根據羅吉斯迴歸分析的結果，在本研究中有五項疾病和腹部 X 光攝影“不正常的報告”有顯著性相關(P 值小於 0.05)，其中“尿路結石”的勝算比大於 1(2.14)，其它四項疾病勝算比小於 1，包括：非特異性廣泛性腹部疼痛、中上腹部疼痛、腹瀉以及排尿困難。在我們 37 類開單原因中，有關“腹腔內非透射性異物置留”的疾病共有 6 例個案，腹部 X 光攝影對此疾病的診斷價值為：直陽性：100%(4/4)，真陰性：100%(2/2)。

結論：(1)腹部 X 光攝影檢查在本研究中明顯的被過度使用。(2)如果急診醫師想要使用腹部 X 光攝影去証實病患“腹部急症”的原因是因“尿路結石”引起時，腹部 X 光攝

影檢查對於這個目的具有診斷價值。(3)相反的，如果急診醫師想要使用腹部 X 光攝影去証實病患“腹部急症”的原因是因為“非特異性廣泛性腹部疼痛”、 “中上腹部疼痛”、“腹瀉”、 “排尿困難”四項中任何一種原因引起時，腹部 X 光攝影檢查對於這項目的，不具有診斷價值。(4)針對本文 37 項開立腹部 X 光攝影檢查的病因，如果急診醫師想要利用腹部 X 光攝影檢查去“排除”這些病因的可能性時，針對這個評估目的，腹部 X 光攝影檢查不具備診斷價值。(5)針對本文 37 項開立腹部 X 光攝影檢查的病因中有關“腹腔內非透射性異物置留”的病因，雖然本研究所收集的病例數不多，但是根據統計分析，我們相信腹部 X 光攝影對於証實該項病因具有診斷價值。

關鍵字詞：非創傷性腹部急症、腹部 X 光攝影、腹部超音波、腹部電腦斷層

誌謝

研究所即將畢業，回首過去七百多個日子，白天工作，晚上上課，有時候還要熬夜或是利用假日完成報告，尤其在最後半年裡的論文寫作，更是日以繼夜，不能取巧，所幸過程雖然辛苦，最後終於順利完成學業，為階段性人生劃下圓滿句點。

兩年的時間裡，很幸運的有同班同學相伴，彼此鼓勵，讓學習的過程不覺寂寞。另外也要感謝東海工工系老師的熱心教導，讓我在從事醫療工作二十五年後，有幸一窺”管理”廟堂。在這段時間裡，我特別要感謝黃欽印主任，黃老師學養豐富，教學認真，細心照顧專班同學，令人欽佩，尤其在擔任我的論文共同指導教授期間，百忙之餘，仍能耐著性子，細心指導，在這裡，我要致上最誠摯的感謝。另外，我還要謝謝蔡禎騰副校長---我的論文指導教授，在校期間，副座亦師亦友的教誨，無論在專業或是為人處事上，個人受益良多，而在論文部份，更是畫龍點睛，言簡易賅，多所包容，讓我有更多揮灑的空間，再一次獻上感謝。

我同時還要感謝我的家人，尤其是內人，我常說：如果我算聰明，那麼我的太太就是充滿智慧，其實此刻我的感謝還包括對她的歉意。回想十四年前，她在就讀陽明大學社區護理研究所時，一面工作，一面上課，同時還要照顧家中兩個小孩（４歲，８歲），而我當時忙於工作，幾乎很少分擔家務，如今身歷其境，對照過去她的難處，以及現在她對我的體諒、鼓勵，所以我必須說，我是帶著歉意來表達我最深的感激。

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吳新華　于 2010 年 7 月

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CHAPTER 1: INTRODUCTION

The medical services are different from the other industries, which possess some specific characteristics of invisibility, intolerance of mistake, inseparability, unequal information and unmemorable activities. However, they also share some common features, including the model combining input, process and output. In brief, the medical services accept input of diseases and patients, undergo the process of examinations, tests and treatment, and then finally generate the output of discharging recovered patients. Since the medical services apply the similar model that the other industries exercise, their efficacy should be emphasized to create the best output through the efficient procedures. When the input includes patient and disease, as well as the output is general health, what is the best process? The answer is the most effective diagnostic investigation and treatment that impacting patients least and being cost-effective. The most excellent investigation must provide accurate diagnoses and solutions of patients' problems.

The radiological diagnostic equipment has been improved for the recent half century, which accompanied with the progression of medical technologies and assisted patients in recovery of their health. However, most imaging modalities are radioactive and require the investment, including manpower and inventory, to operate it. Therefore, its process has to balance harm and the cost.

Acute abdominal pain, developing within several hours as a result of various etiologies and requiring instant medical or surgical treatment, is the most common symptom in the emergency room (ER), which accounts for 5-10% of the emergency patients (Kamin, et al., 2003 Feb; Lameris, et al., 2009). Clinically, it can be classified into two groups, traumatic and non-traumatic acute abdomen. Though the current medical image modalities, such as CT, MRI, Sonography and so on, provide valuable information, abdominal radiography (AR) is still the major tool to evaluate the condition of patients with acute abdomen at ER. Lee et al.(1976) reported that AR was the routine investigation for all patients with acute abdomen. However, more specialists considered that AR was abused in those patients at ER. Eisenberg et al.(1983) studied 1780 patients with acute abdomen and found that only 10%, 199 of 1780 patients, was reported abnormal AR. Additionally, 53.7% of AR examination was inappropriate on restrict criteria and only 3.5% of abnormal AR would be omitted without the examination. Anyanwu et al.(1998) studied 125 patients and

confirmed that only 10.4% of AR was valuable for making diagnoses of acute abdomen. Feyer et al.(2002) evaluated 131 patients in 2002 and concluded that only 7% of AR was helpful in clinical practice. Kellow et al.(2008) discovered that only 2-8% of AR was important among the 874 subjects. In summarized, the authors concluded that 'indiscriminate use of films is likely to be wasteful in terms of normal results and possibly misleading in showing abnormalities that are coincidental.

Despite being a relatively cheap investigation, the exclusion of a large volume of unnecessary AR on an annual basis could lead to large financial savings. Previous literatures concluded that the cost could be reduced by 12.8 million dollars each year (Johnson & Abernacy, 1983), the radiation exposure could be decreased significantly (a gonadal dose of 207 mR/film for men and 437 mR/film for women) (Rockville, 1976), examination duration may be arranged efficiently, and the diagnostic value may be reserved (Mirvis, Young, Keramati, McCrea, & Tarr, 1986) when reducing one erect abdominal AR.

Reviewing the related literature in Taiwan, especially in emergency medicine and radiological medicine, the issue of "the diagnostic value of AR for non-traumatic acute abdomen at ER" has never been studied and discussed thoroughly. Therefore, this research focused on the patients with non-traumatic acute abdomen visiting the ER of a Regional General Hospital in Mid-Taiwan between Jan. 1st and June 30th, 2008 who underwent AR examination. After excluding those cases with incomplete medical records or without achieving the criteria of non-traumatic acute abdomen, 2912 patients were included in this study to investigate the diagnostic value of abdominal radiography (AR) in non-traumatic acute abdomen patients and to understand the differences of its diagnostic value among individual diseases through analyzing the etiologies of non-traumatic acute abdomen. Furthermore, the causes influencing the value were investigated through statistical analyses. The purpose of the study was to reduce unnecessary abdominal radiography examination, to increase the diagnostic value of AR for non-traumatic acute abdomen, to decrease medical costs, and to diminish radiation exposure.

CHAPTER 2: LITERATURE REVIEW

2.1: Review of Acute Abdomen

2.1.1: Definition of Acute Abdomen

Acute abdomen is defined as any clinical condition characterized by severe abdominal pain that develops over a period of hours requiring emergent medial or surgical treatment.(Silen, 1996)

In generally, It may be a life-threatening situation includes an enormous spectrum of disorders ranging from benign self-limited diseases to conditions that require emergent surgery which may involve biliary tree, solid viscera, intestine, genitourinary system, or the pelvic organs in females in the reproductive age group. (Berry, Chowdahury, & Suri, 2004)

In a review of 30,000 patients with acute abdominal pain reported in the Debombal's study(1991), acute appendicitis has been shown to be the commonest cause of acute abdominal pain accounting for nearly 28 percent of all cases, followed by acute cholecystitis (9.7%), bowel obstruction (4.1%), acute gynaecologic infection (4%), acute pancreatitis (2.9%), acute renal colic (2.9%), gastrointestinal perforation (2.5%), diverticulitis (1.5%), ischemic bowel disease (1%). Additionally, nearly one-third of cases, the cause should be determined.

2.1.2: Pathophysiology of Acute Abdomen

According to Porter's (2003) description, the pathophysiology of Acute Abdomen may be caused as follow:

Visceral pain comes from the abdominal viscera, which are innervated by autonomic contraction—not to cutting, tearing, or local irritation. Visceral pain is typically vague, dull, and nauseating. It is poorly localized and tends to be referred to areas corresponding to the embryonic origin of the affected structure. Foregut structures (stomach, duodenum, liver, and pancreas) cause upper abdominal pain. Midgut structures (small bowel, proximal colon, and appendix) cause periumbilical pain. Hindgut structures (distal colon and GU tract) cause lower abdominal pain.

Somatic pain comes from the parietal peritoneum, which is innervated by somatic nerves, which respond to irritation from infectious, chemical, or

other inflammatory processes. Somatic pain is sharp and well localized.

Referred pain is pain perceived distant from its source and results from convergence of nerve fibers at the spinal cord. Common examples of referred pain are scapular pain due to biliary colic, groin pain due to renal colic, and shoulder pain due to blood or infection irritating the diaphragm.

2.1.3: Etiology of Acute Abdomen

Porter (2003) classified the locations of pain as right or left upper quadrant pain (RUQ or LUQ), right or left lower quadrant pain (RLQ or LLQ), RUQ pain, LUQ pain, RLQ pain, LLQ pain, and diffuse abdominal pain in Merck Manual of Medical Information. Different locations of the pain indicate different potential diseases. (Figure 2.1)

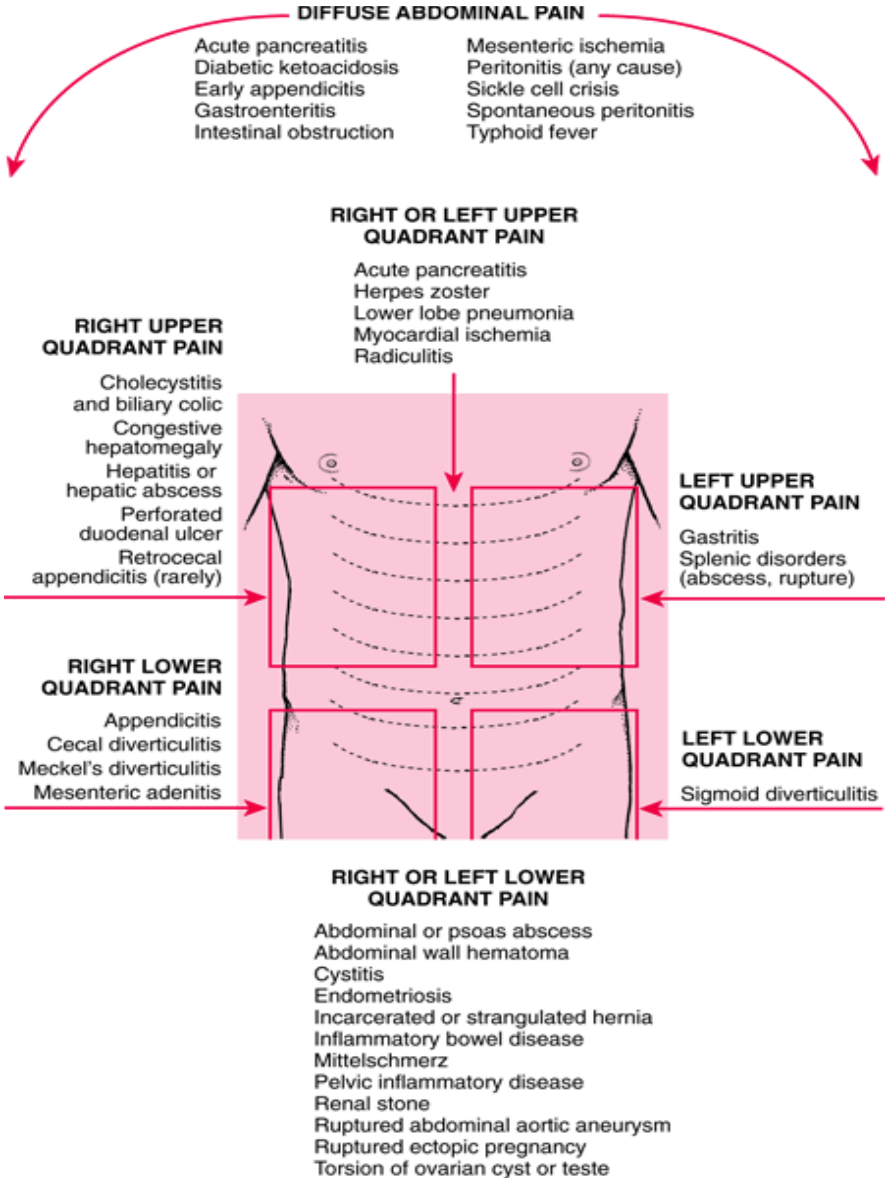

Fig. 2.1: Location of Abdominal Pain and Possible Cause (Porter, 2003)

2.1.4: Evaluation of Acute Abdomen

An acute abdomen requires immediate evaluation and diagnosis because it may indicate a condition that calls for surgical intervention. Following procedures for evaluation of acute abdomen are critical:

History Taking: A thorough history usually suggests the diagnosis (Table 2.1). Information about the onset, duration, character, location, and symptoms associated with the pain is critical in making an accurate diagnosis. The patient is asked what decreases or increases the pain; constant, increasing pain is generally associated with appendicitis and diverticulitis, whereas intermittent pain more likely indicates an intestinal obstruction, ureteral calculi, or biliary calculi. Appendicitis may often be differentiated from a perforating ulcer by the slower onset or development of pain.

Although the patient's report of the location of the pain is sometimes misleading because of referral, radiation, or reflection of pain, it may serve to identify a specific organ or system. Factors in the patient's history that are useful in the diagnosis and management of an acute abdomen include changes in bowel habits, weight loss, bloody stool, diarrhea, menses, vomiting, clay-colored stool, and previous abdominal surgery. (Mosby, 2008)

Table 2.1: History in Patients with Acute Abdominal Pain(Porter, 2003)

Question	Potential Responses and Indications
Where is the pain?	See Fig. 2.1
What is the pain like	Acute waves of sharp constricting pain that "take the breath away" (renal or biliary colic), Waves of dull pain with vomiting (intestinal obstruction) Colicky pain that becomes steady (appendicitis, strangulating intestinal obstruction, mesenteric ischemia) Sharp, constant pain, worsened by movement (peritonitis) Tearing pain (dissecting aneurysm) Dull ache (appendicitis, diverticulitis, pyelonephritis)
Have you had it before?	Yes suggests recurrent problems such as ulcer disease, gallstone colic, diverticulitis, or mittelschmerz
Was the onset sudden?	Sudden: "like a light switching on" (perforated ulcer, renal stone, ruptured ectopic pregnancy, torsion of ovary or testis, some ruptured aneurysms) Less sudden: most other causes
How severe is the pain?	Severe pain (perforated viscus, kidney stone, peritonitis, pancreatitis) Pain out of proportion to physical findings (mesenteric ischemia)
Does the pain travel to any other part of the body?	Right scapula (gallbladder pain) Left shoulder region (ruptured spleen, pancreatitis) Pubis or vagina (renal pain) Back (ruptured aortic aneurysm)
What relieves the pain?	Antacids (peptic ulcer disease) Lying as quietly as possible (peritonitis)
What other symptoms occur with the pain?	Vomiting precedes pain and is followed by diarrhea (gastroenteritis) Delayed vomiting, absent bowel movement and flatus (acute intestinal obstruction; the delay increases with a lower site of obstruction) Severe vomiting precedes intense epigastric, left chest, or shoulder pain (emetic perforation of the intra-abdominal esophagus)

Physical Examination:(Kavanagh, 2004)

Inspection:

Look for evidence of anaemia/jaundice

Look for visible peristalsis or abdominal distension

Look for signs of bruising around the umbilicus (Cullen's sign - can be present in haemorrhagic pancreatitis and ectopic pregnancy) or flanks (Grey Turner's sign - can be present in retroperitoneal haematoma).

Assess whether patient is dehydrated (skin turgor/dry mucous membranes).

Auscultation:

Auscultate abdomen all four quadrants

Absent bowel sounds suggest paralytic ileus, generalised peritonitis or intestinal obstruction. High-pitched and tinkling bowel sounds suggest sub-acute intestinal obstruction

Intestinal obstruction can also present with normal bowel sounds

If there is reason to suspect aortic aneurysm, listen carefully for abdominal and iliac bruits

Percussion:

Percuss the abdomen to assess whether swelling/distension might be due to bowel gas or ascites

Patients who display tenderness to percussion are likely to have generalised peritonitis and this should act as a red flag for serious pathology

Assess for shifting dullness and fluid thrill

Percussion can also be used to determine size of an abdominal mass extent of organomegaly

Palpation:

Palpate the abdomen gently, then more deeply, starting away from the pain and moving towards it

Feel for masses, tenderness, involuntary guarding and organomegaly (including the bladder)

Test for rebound tenderness

Examine the groins for evidence of herniae

Always examine the scrotum in men as pain may be referred from unrecognised testicular pathology

Check supraclavicular and groin lymph nodes

Testing: Tests are selected based on clinical suspicion.

Standard tests (e.g. CBC, Biochemistries, Urinalysis) are often done but are of little value due to poor specificity; patients with significant disease may have normal results. Abnormal results do not provide a specific diagnosis.(Porter, 2003)

Imaging tests: based on suspected diagnosis.

An abdominal series, consisting of plain and erect abdominal X rays and upright chest X ray, may be done in Acute Abdomen. However, these conventional X-ray studies are seldom diagnostic and need not be routinely performed. Sonography may be done for some diseases such as suspected biliary tract disease. Unenhanced helical CT is the choice for suspected renal stones. CT with intravenous and oral contrast is diagnostic for patients with significant abdominal pain. However, when patients were with definitive symptoms and signs of Acute Abdomen, the advanced imaging should not be performed to avoid delaying surgery in.

On account of considerable overlap of symptoms and signs of various diseases causing acute abdomen, the clinical accuracy is low and range from 50-65 percent. (Balthazar & Chako, 1990; Staniland, 1972)

2.2 Current Imaging Modalities for Acute Abdomen in Emergency Department

Various imaging modalities available for investigation of acute abdomen in ED include plain X ray, ultrasound (US), computed tomography (CT). The earlier study about plain abdominal radiographs (AR) contribute to five acute abdominal conditions (acute appendicitis, acute cholecytitis, acute pancreatitis, perforated duodenal ulcer, intestinal obstruction) suggested that plain abdominal radiographs should become a routine investigation in the acute abdomen.(Lee, 1976) But in recent thirty years, the diagnostic value of abdominal radiography has been questioned, many other articles were published for discussing the indiscriminate use of abdominal radiographs in acute abdomen and suggested the investigation for non-specific acute abdominal pain should be limited.

Because the plain film of the abdomen has certain inherent limitations in abdominal diagnoses, any cross-sectional imaging technique, such as sonography or computed tomography (CT), is likely to provide more and different information about acute abdominal pathology. Many studies have compared the use of CT and plain AR in patients with abdominal pain and universally support the early use of CT in patients presenting with abdominal pain requiring admission. In Gerhardt's study (2005) to "identify a clinical guideline for the evaluation of nonspecific abdominal pain (NSAP) using history, physical examination, laboratory analysis, acute abdominal series (AAS) radiographs, and nonenhanced helical computed tomography (NHCT) clinical

predictor variables (CPVs)" shows that NHCT is a rational choice for decision support in the evaluation of NSAP and is likely the single most useful diagnostic adjunct available to augment the clinical evaluation. MacKersie, et al.(2005) evaluated and compared the diagnostic accuracy of unenhanced helical computed tomography (CT) prospectively for non-traumatic acute abdominal pain patients with traditional abdominal radiography which showed unenhanced helical CT yielded an overall sensitivity, specificity, and accuracy of 96.0%, 95.1%, and 95.6%, respectively. The AAS interpretations yielded an overall sensitivity, specificity, and accuracy of 30.0%, 87.8%, and 56.0%, respectively. They concluded that the accuracy of unenhanced helical CT was significantly greater than the accuracy of AAS ($P < .05$)". Another study also revealed that early abdominal CT in patients with acute abdominal pain improves diagnostic certainty (Sala, 2007).

In patients with abdominal pain presenting to the emergency ward, the abdominal plain film (accompanied by a standing chest radiograph) has been the first diagnostic radiographic examination after the physical examination. Sonography is inexpensive and portable and residents' knowledge of sonographic interpretation and scanning is becoming more sophisticated. Therefore, it is feasible to use sonography as an adjunct to the plain abdominal film, The role of ultrasound in emergency department management of patients with acute abdominal pain may well increase as it becomes more common-place and ultrasound expertise in the specialty grows. Laing showed "in one-third of patients, pain in the right upper quadrant is not related solely to the gallbladder, and diagnosis of the hepatic, renal, and other sources of this pain was possible with sonography but not with a plain film only" (Laing, 1981).

Choice of an imaging modality should be guided by the disease most suspected (Berry, et al., 2004). The emergency physician should be aware of the sensitivity and specificity of any radiological study being considered.

Documental and legal concerns are equally invalid reasons, as is the feeling that "it's what we always order for patients with this abdominal complaint." (Billittier, Abrams, & Brunetto, 1996)

Radiographic examinations should be used to answer specific questions raised by the history and physical examination. The need to obtain a given radiological evaluation should be based on the potential information it may reveal and the likelihood that this information will alter patient care. This cost-

effective approach minimizes unnecessary radiation exposure and has been advocated by many authorities.

2.2.1: Radiation Doses in Current Medial Imaging.

Medical imaging technology has evolved rapidly over the recent thirty years, the effective dose range from a few microsieverts (teeth, limbs, chest) to tense of millisieverts.(prolonged fluoroscopic procedures or CT scan)(Hart & Wall, 2002).

As Hart, et al. Report (2002), a total of about 4.1 million medical and dental X-ray examinations are now conducted each year in the UK (0.7 examination per head of population) resulting in an annual per caput effective dose of 330 mSv, this is not significantly different from the previous rough estimate of 350 mSv for 1991 (Table 2.2). However, over the last ten years, CT has more than doubles its contribution and is now responsible for 40% of the total dose to the population from medial X-rays. In contrast, the conventional radiography radiation doses have gradually come down.

Table 2.2: UK Annual Frequencies and Collective Does by Examination Category (Hart & Wall, 2002)

Examination category	Number of examinations	Percentage frequency	Collective dose (man Sv)	Percentage collective dose
Conventional radiology				
Skull and facial bones	1,046,830	2.52	39.9	0.21
Head – soft tissue	70,784	0.17	2.2	0.01
Teeth – intraoral (hospital)	177,086	0.43	0.9	0.00
Teeth – panoramic (hospital)	392,853	0.95	3.9	0.02
Teeth – intraoral (dentists)	9,562,500	23.02	47.8	0.25
Teeth – panoramic (dentists)	2,937,500	7.07	29.4	0.15
Neck – soft tissue	40,319	0.10	0.2	0.00
Cervical spine	858,547	2.07	60.1	0.31
Thoracic spine	281,215	0.68	196.9	1.02
Lumbar spine	824,763	1.99	824.8	4.27
Lumbo-sacral joint	338,901	0.82	92.2	0.48
Whole spine/scoliosis	33,614	0.08	3.4	0.02

Table 2.2: UK Annual Frequencies and Collective Does by Examination Category (Hart & Wall, 2002)

Examination category	Number of examinations	Percentage frequency	Collective dose (man Sv)	Percentage collective dose
Myelography	4,826	0.01	9.8	0.05
Shoulder girdle	775,553	1.87	8.3	0.04
Upper arm	138,912	0.33	0.1	0.00
Elbow	435,202	1.05	0.4	0.00
Forearm, wrist and hand	2,960,214	7.13	1.6	0.01
Pelvis	919,740	2.21	643.8	3.34
Hip	885,489	2.13	321.2	1.66
Femur	191,294	0.46	0.5	0.00
Leg length	16,844	0.04	3.1	0.02
Knee, lower leg, ankle and foot	4,123,461	9.93	7.2	0.04
Arthrography	8,752	0.02	1.5	0.01
Skeletal survey	12,032	0.03	21.7	0.11
Chest	8,286,520	19.95	165.8	0.86
Mammography	1,726,303	4.16	466.3	2.42
Abdomen (plain film)	1,217,192	2.93	852.0	4.42
Oesophagus	123,751	0.30	185.6	0.96
Stomach and duodenum	98,581	0.24	256.3	1.33
Small intestine	41,089	0.10	154.2	0.80
Colon	359,436	0.87	2,587.9	13.41
Other abdominal investigations	11,753	0.03	35.7	0.19
Biliary system	67,627	0.16	270.3	1.40
Kidneys and ureters	14,731	0.04	29.0	0.15
IVU	162,502	0.39	390.0	2.02
Bladder and urethra	82,941	0.20	102.5	0.53
Gynaecology	27,627	0.07	29.9	0.15
Lymphangiography	128	0.00	0.0	0.00
Tomography other than of teeth	2,722	0.01	0.4	0.00
Bone mineral densitometry	27,265	0.07	0.1	0.00
Sub-total (conventional radiology)	**39,287,402**	**94.6**	**7,847**	**40.7**
Angiography				
Cerebral angiography	11,999	0.03	48.0	0.25
Pulmonary angiography	5,529	0.01	29.9	0.16
Abdominal angiography	12,711	0.03	285.0	1.48
Aortography	11,161	0.03	122.6	0.64
Angiocardiography	162,871	0.39	1076.4	5.58
Peripheral angiography	116,903	0.28	361.5	1.87
Sub-total (angiography)	**321,174**	**0.8**	**1,923**	**10.0**
Computed tomography				
CT head	618,391	1.49	1236.8	6.41
CT neck	24,332	0.06	60.8	0.32
CT abdomen	297,244	0.72	2972.4	15.40
CT chest	192,885	0.46	1543.1	8.00
CT pelvis	139,722	0.34	1397.2	7.24

Table 2.2 UK annual frequencies and collective does by examination category (Hart & Wall, 2002)

Examination category	Number of examinations	Percentage frequency	Collective dose (man Sv)	Percentage collective dose
CT extremity	18,401	0.04	9.2	0.05
CT spine	63,183	0.15	252.7	1.31
CT pelvimetry	8,200	0.02	1.6	0.01
CT interventional	13,184	0.03	131.8	0.68
CT bone mineral densitometry	1,594	0.00	1.6	0.01
CT angiography	5,129	0.01	30.8	0.16
CT other	4,771	0.01	23.9	0.12
Sub-total (CT)	**1,387,036**	**3.3**	**7,662**	**39.7**
Interventional radiology				
Biopsy	28,202	0.07	43.6	0.23
Biliary and urinary systems	47,968	0.12	235.1	1.22
Cardiovascular	121,810	0.29	903.9	4.68
Gastrointestinal	46,121	0.11	28.3	0.15
Other interventional	3,173	0.01	28.6	0.15
Sub-total (interventional radiology)	**247,274**	**0.6**	**1,239**	**6.4**
Unassignable examinations	**298,113**	**0.7**	**626.0**	**3.2**
Overall total	**41,541,000**	**100**	**19,298**	**100**

NG, et al. (1998) described that the average radiation dose of AR exposes the patient to 35 times than the radiation dose of a chest x ray (0.7 mSv) (Table 2.3). The data was compatible with international established reference dose values (in mGy) (Table 2.4).

Table 2.3: Distribution of Individual Entrance Surface Dose (ESD) and Median Effective Dose for Seven Routine X ray Examinations (12 projections) from a Random Sample of 12 hospitals in Malaysia (Ng, et al., 1998)

Radiograph	Projection	Number	Entrance surface dose (mGy)					
			Min.	First quartile	Median	Mean	Third quartile	Max.
Chest	PA	131	0.05	0.16	0.26	0.28	0.35	0.74
	LAT	62	0.27	0.70	1.17	1.40	2.00	3.80
Abdomen	AP	99	1.67	5.98	9.22	10.00	13.82	24.45
Pelvis/hip	AP	70	1.14	3.81	5.33	8.41	11.08	30.91
Skull	AP/PA	103	0.72	3.11	4.74	4.78	6.85	8.27
	LAT	78	0.42	1.91	3.03	3.34	4.81	7.66
Cervical spine	AP	48	0.37	0.55	0.70	1.02	1.06	3.07
	LAT	46	0.23	0.60	1.49	1.60	2.28	3.96
Thoracic spine	AP/PA	22	2.21	4.79	6.39	7.03	8.72	12.87
	LAT	23	2.66	8.77	15.92	16.54	21.90	39.24
Lumbar spine	AP	88	2.24	5.34	9.06	10.56	14.71	30.68
	LAT	97	4.96	8.99	13.97	18.60	25.12	56.92

Table 2.4: Compared ESD with International Established Reference Dose Values (in mGy) (Ng, et al., 1998)

Radiograph	Projection	Present study (1998): median values	USA (1992) CRCPD/CDRH [19]: median values	NRPB (1986) [4]: median values	NRPB (1992) [15]	IAEA Basic Safety Standard (1996) [20]
Chest	PA	0.3	0.17	0.18	0.3	0.4
	LAT	1.2	—	0.99	1.5	1.5
Abdomen	AP	9.2	5.6	6.68	10	10
Pelvis/hip	AP	5.3	—	5.67	10	10
Skull	AP/PA	4.7	—	4.20	5	5
	LAT	3.0	1.6	2.19	3	3
Cervical spine	AP	0.7	1.5	—	—	—
	LAT	1.5	—	—	—	—
Thoracic spine	AP	6.4	—	—	7	7
	LAT	15.9	—	—	20	20
Lumbar spine	AP	9.1	6.4	7.68	10	10
	LAT	14.0	—	19.7	30	30

2.2.2: The Diagnostic Value of Abdominal Radiography in Evaluation of Acute Abdomen

The Abdominal Radiography (AR) was defined spanning from the diaphragm to the symphysis pubis. Acute Abdominal Series (AAS), which includes an upright chest X ray and upright and supine radiographs of the abdomen are used frequently by clinical physician in emergency department, Supine abdominal film alone usually contribute a large proportion of radiographic findings compared with erect views. There is ample evidence to

suggest that supine films have a higher proportion of useful information than erect views and that the contribution of erect films can be dismissed. Ukrisana (2002) found restricting of the upright abdominal view from the routine plain-film abdominal series in the screening of surgical cases from medical cases could result in cost-saving and a decrease in radiation exposure without significant loss of diagnostic information.

Despite the proliferation and the availability of newer imaging modalities including ultra-sonogram (US) and computed tomography (CT), abdominal radiography remain the first and frequent films ordered in a significant number of emergency department patients, however, these plain x rays are seldom diagnostic, often non-specific and are usually normal.

The issues about the evaluation of acute abdomen with Abdominal Radiography are reviewed and summarized as following: (1). Are they overusing? (2). Problem of overuse was associated with inappropriate request? (3). Which are the poor clinical indications for AR ordering? (4). In contrast, which are the good candidates for AR ordering?

1. **Indiscriminate use of AR in evaluation of emergent acute abdomen patients**

   Eisenberg, et al.(1983) described only 10% (179/1780) of the acute abdomen cases who had abnormal abdominal radiographs in their study, restricting to some referral criteria, 53.7% of the abdominal radiographs would be avoided and only 3.5% abnormal radiographs missed. Anyanwu et al. (1998) mentioned that only 10.4% (13/125 patients) of AR for acute abdomen at emergency department were diagnostic. Tasu, et al. (2001) described the diagnostic value of abdominal radiographs (175 cases) in there study and were considered to be contributive to final diagnosis in 13% of the cases, non-contributive in 87%.They concluded that plain abdominal radiographs are neither sensitive nor specific and frequently misleading diagnosis.

   In Ahn's study (2002), a total of 871 patients underwent abdominal radiography, interpretation of these abdominal radiographs was nonspecific in 588 (68%) of 871 patients, normal in 200 (23%), and abnormal in 83 (10%), they concluded that abdominal radiographs are not sensitive in the evaluation of adult patients presenting to the emergency department with non-traumatic acute abdominal pain. Feyer et al. (2002)

analyzed 131 plain abdominal radiographs performed with non-specific abdominal symptoms and signs prospectively and found that the clinical management was influenced by plain abdominal radiographs in only nine cases (7%). The majority of plain abdominal radiographs requested on acute medical emergencies are inappropriate.

MacKersie (2005) evaluated the non-traumatic acute abdominal pain patients with abdominal radiography prospectively. Ninety-one patients underwent a three-view acute abdominal series (AAS), The AAS interpretations yielded an overall sensitivity, specificity, and accuracy of 30.0%, 87.8%, and 56.0% respectively and concluded that AAS is an insensitive technique in the evaluation of non-traumatic acute abdominal pain in adults. Kellow et al. (2008) described abdominal radiographs helped confirm the suspected diagnosis in 2%-8% of 874 cases with non-traumatic acute abdomen, normal or nonspecific result of AR were about 81% of the total studies. Its results contribute to patient treatment were in a small percentage of cases.

2. Inappropriate requests (unclear indication, no follow-up guideline, wrong film's ordering) of abdominal radiology in evaluation of emergent acute abdomen patients.

Eisenberg, et al. (1983) described the likelihood ratios for abnormal abdominal radiographs (Table 2.5)、 Percentage of Abnormal abdominal Radiographs Related to Degree of pain and Tenderness (Table 2.6)、Frequency of specific radiographic abnormalities with respect pre-radiographic clinical diagnoses (Fig 2.2) and develop criteria for the ordering of plain abdominal radiographs that maximize the yield of abnormal radiographs. They concluded that the procedure should be done in patients with moderate or severe abdominal tenderness, and in patients without moderate or severe tenderness who have a high clinical suspicion of bowel obstruction, renal-ureteral calculi, trauma, ischemia, or gallstones (if ultrasound is unavailable). Had these referral criteria been used for the patients in this study, 53.7% of the 1780 examinations would have been avoided, with only 3.5% abnormal radiographs missed (similar to the false-positve rate of many diagnostic tests).

Table 2.5: Statistically Significant Likelihood Ratios for Abnormal Abdominal Radiography.(Eisenberg, et al., 1983)

	Likelihood Ratios†
Likelihood predictive of abnormality (>1)	
Increased, high-pitched bowel sounds	57.5
Penetrating trauma	38.0
Distention	9.5
History of abdominal surgery	7.4
Blood in the urine	6.3
History of renal-ureteral calculi	5.8
Flank pain/tenderness	5.0
History of abdominal tumor	4.7
History of gallbladder disease	4.2
Severe abdominal pain and tenderness	3.0
Generalized abdominal pain and tenderness	3.0
Abdominal pain for less than 1 day	1.8†
Vomiting	1.8†
Likelihood predictive of normality (<1)	
History of ulcer disease	0.3
Mild abdominal pain	0.3
Abdominal pain for more than 1 week	0.5†

* Likelihood ratio is defined as the prevalence of each clinical variable in patients with abnormal abdominal radiographs divided by the frequency in patients with normal abdominal radiographs.

* $p < 0.001$ unless otherwise noted.

† $p < 0.05$.

Table 2.6: Percentage of Abnormal Abdominal Radiographs Related to Degree of Pain and Tenderness.(Eisenberg, et al., 1983)

Degree	Patients with Pain	Patients with Tenderness
	← n (%) →	
Severe	73/308 (23.7)	24/78 (30.8)
Moderate	90/958 (9.4)	110/617 (17.8)
Mild	17/462 (3.7)	34/538 (6.3)
None	2/52 (3.8)	14/547 (2.6)

* Patients with abnormal radiographs/patients examined (%).
Significance: $p < 0.001$ (using Kendall Tc test for an ordered series).

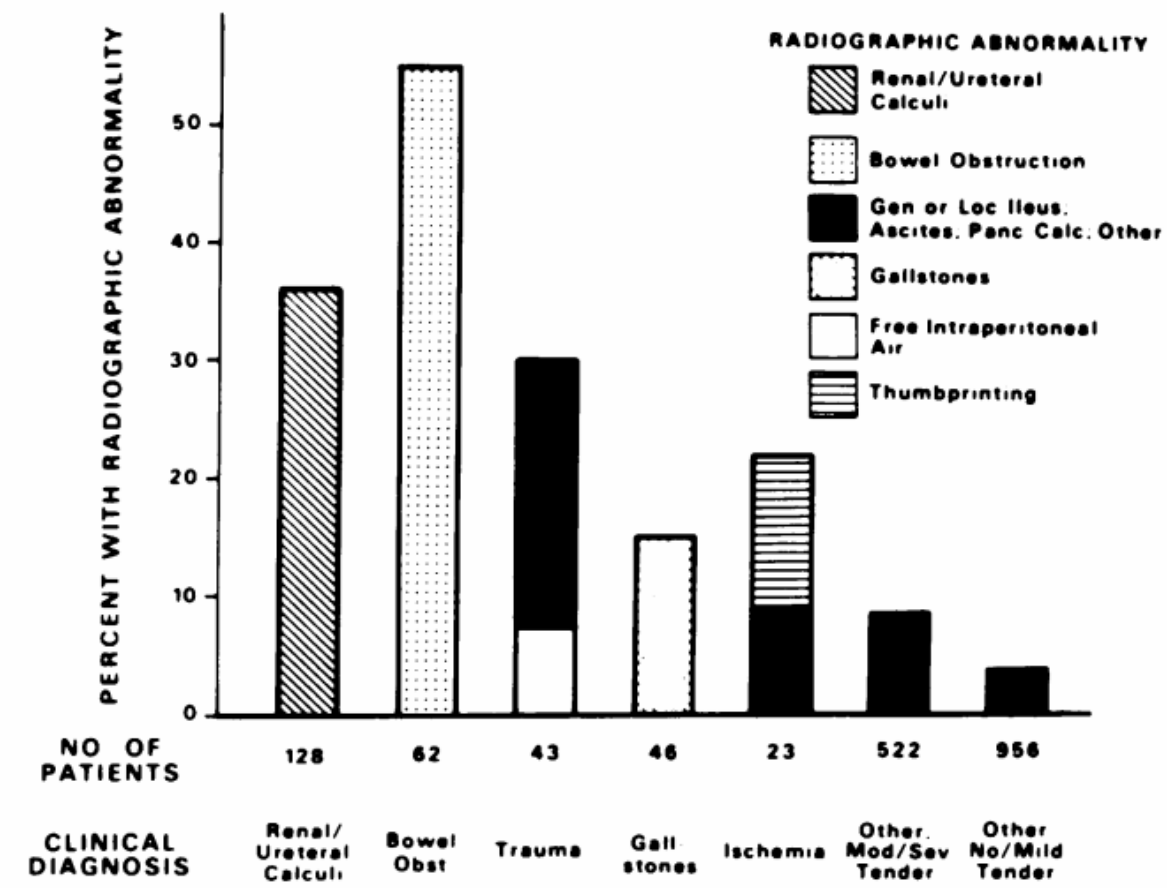

Fig 2.2: Frequency of specific radiographic abnormalities with respect to pre-radiographic clinical diagnoses (Eisenberg, et al., 1983)

Greene (1986) reviewed the literature for guidelines in ordering the abdominal view(s) with the highest diagnostic yield and offered the following recommendations:

(1). Avoiding radiography for conditions without radiologic signs.

(2). Avoid radiography in women of reproductive potential unless there are strong clinical indications.

(3). Avoid radiography if no change in clinical management well result.

(4). If radiography is indicated, order either a supine abdomen and erect CXR or a supine abdomen only.

The authors in previous literatures mentioned that the cost could be reduced by 12.8 million dollars each year (Johnson & Abernacy, 1983), the radiation exposure could be decreased significantly (a gonadal dose of 207 mR/film for men and 437 mR/film for women) (Rockville, 1976), examination duration may be arranged efficiently, and the diagnostic value

may be reserved (Mirvis, et al., 1986) when reducing one erect abdominal AR.

Ukrisana, et al. (2002) evaluated the diagnostic yield of abdominal series (erect and supine abdominal radiograph, standing CXR) in 246 cases with acute abdomen at emergency department and concluded that the elimination of the upright abdominal view from the routine plain-film abdominal series in the screening of surgical cases from medical cases could result in cost-saving and a decrease in radiation exposure without significant loss of diagnostic information.

Tasu, et al. (2001) evaluated the prescription, impact and diagnostic utility of plain abdominal radiography, the prescription was in agreement with standard guidelines in 28% of the cases and not in agreement in 72% found in this study, the author commended that better physician awareness is required to limit the number of unnecessary examinations. In Feyler's study (2002), 131 acute abdominal pain patients received abdominal radiograph, only 16 cases (12%) for requests conformed to the recommended guidelines by the Royal College of Radiologists. In 62 cases (47%), there was no comment made on the film by the requesting clinician. The majority of plain abdominal radiographs requested on acute medical emergencies was inappropriate. The author concluded that there is a need to ensure guidelines are followed to prevent unnecessary exposure of patients to radiation as well as preventing expenditure on irrelevant investigations.

Morris et al. (2006) demonstrated of 225 abdominal radiographic reported films with acute abdomen cases. In this study, RCR guidelines were followed in only 73 (32%) of 225 cases. When guidelines were adhered to, positive findings were identified in 56 (76.7%) of 73 cases whereas when guidelines were not followed positive findings were seen in only 13/139 (8.9%) of AR. They concluded that a program of education is proposed to emphasize the RCR guidelines (Table 2.7) with re-audit to assess adherence to the guidelines.

Table 2.7: Royal College of Radiologists (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

3、Poor candidate of clinical impression with acute abdomen for abdominal radiography ordering.

McCook, et al. (1982) presented a prospective analysis of 100 consecutive abdominal radiographs of 96 emergency patients with a variety of abdominal complaints and concluded that in patients with diffuse, nonspecific abdominal pain, nausea, vomiting, or gastrointestinal bleeding, 98% of the radiographs were negative or had positive findings which were unrelated to the current clinical problem. In Campbell's study (1988), if the initial diagnosis is suspected appendicitis, urinary tract infection, or non-specific abdominal pain, there is little value in the routine use of abdominal radiographs. Ahn et al. (2002) mentioned that the abdominal radiographs was 0% sensitivity for appendicitis, pyelonephritis, pancreatitis, and diverticulitis.

4、Good candidate of clinical impression with acute abdomen for abdominal radiography ordering.

Previous literature described Ninety-three percent of the positive radiographs related to the acute problem occurred in patients with renal colic; hematuria; ingestion of foreign bodies; previously known surgical conditions, such as incarcerated hernias; intra-abdominal metastatic carcinoma; fecal impaction; or true acute abdominal syndromes.(McCook, et al., 1982) In Rothrock's study (1992), restricting abdominal radiographs to patients with at least one of these five high-yield clinical features (prior abdominal surgery, foreign body ingestion, abdominal bowel sounds, abdominal distention, peritoneal signs) will detect most diagnostic and suggestive radiographs in children with major abdominal diseases(93% sensitive and 40% specific, Positive and negative predictive values were 11% and 99%).

Anyanwu, et al. (1998) suggested confining abdominal radiography to patients with suspected gastrointestinal obstruction, perforation or ischemia, unexplained peritonitis, or renal colic would have included all these diagnostic films and reduced the utilization of AR to 20.5%. Ahn, et al. (2002) mentioned that the highest sensitivity of abdominal radiography was 90% for intra-abdominal foreign body and 49% for bowel obstruction. Kellow, et al. (2008) described if a patient requires abdominal radiography beyond clinical history, physical examination, and lab. results, the emergency physician should be encouraged to request more definitive imaging with the exception of catheter placement.

CHAPTER 3: MATERIALS AND METHODS

3.1 Data Source

This was a retrospective cross-sectional study of chart review including radiological interpretation and medical record for patients presenting with non-traumatic acute abdomen admitted to the emergency department of the institution (a Regional General Hospital in Mid-Taiwan encompassing 700 sickbeds) who underwent abdominal radiography (KUB, plain abdomen, standing abdomen) from Jan. 1st to June 30th , 2008.

The non-traumatic acute abdominal pain was defined as sudden onset of abdominal pain present for less than 24 hours before admitting to our ER with exclusion from traumatic cause.

Medical records and radiological request included cause and interpretation were reviewed by two authors (Ms. TSAI-HUNG CHANG and Miss SHU-HUI KE), who are senior nurses with clinical experience about 23 years.

An abdominal radiographic study was defined spanning from the diaphragm to the symphysis pubis may have consisted of erect or supine abdominal radiograph or KUB (Kidneys, Ureters, Bladder) (Fig. 3.1). Study which was at the discretion of the ordering emergency physician, but no distinction of value between these films was made for the purpose of this study. In addition, for those who underwent more than one radiographic examination in this study period, only the indication and interpretation for the first imaging study were included.

The review of medical record and radiological request included: (1). demographics (gender, age, sex, the state of discharge). (2). sort of abdominal radiography (AR) and results of AR. (3). kind of follow-up imaging and its result. (4).the initial clinical impression for AR request. (5).the final diagnosis was selected from the main five diagnoses list in discharge note (either discharged from ED or from admission room, or transfer to other hospital or death).

On base of ICD-9-CM, we defined the "disease positive" as if clinical impression equal to final diagnosis, in contrast, the disease was defined as "disease negative" if clinical impression was different from final diagnosis.

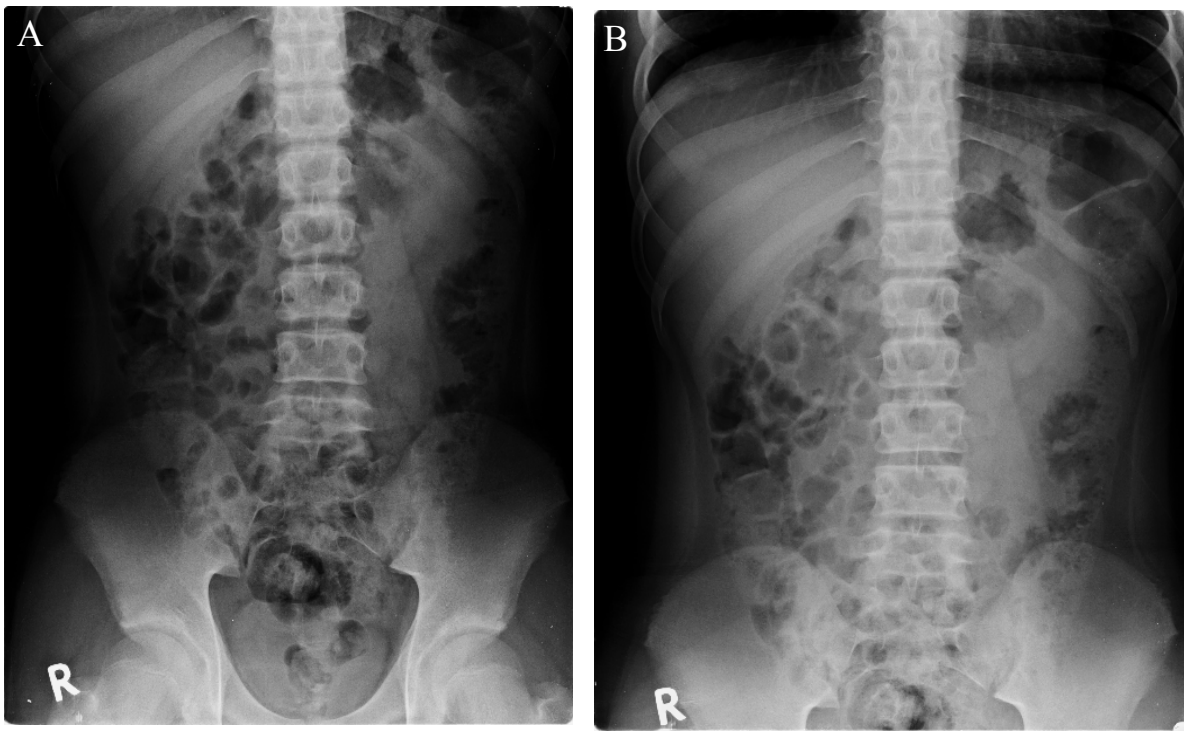

Fig. 3.1(A).KUB (kidney, Ureter, bladder) (B). Plain Abdomen.

3.2 Patient Selection

Patients called for our institution's emergency department who had received the Abdominal Radiography were screened and collected first from Jan.1st to June.30th 2008. Finally, retrospective review of radiographic request and medical record were conducted and patients were included if the symptoms or signs or ordering descriptions matched the acute abdominal pain criteria.

Patients who were excluded if the initial clinical impression of AR request was not specified or the AR interpretation was not available. In addition, patients with acute abdomen due to traumatic cause were also excluded from this study.

3.3 Abdominal Radiography Collection

In our hospital's emergency department, the abdominal radiographs were interpreted initially by the ordering doctors, whose management decisions are made before a formal radiological interpretation is provided. An immediate radiological consultation by our radiologist may be possible during the day or occasionally at night, but this occurs infrequently for abdominal radiography.

The steps of data collection for abdominal radiography were performed according to the order as follows: (1). Reorganized the kind of abdominal

radiograph applied. (2). Summarized the results of abdominal radiographs. The abdominal radiographic results were classified as normal, nonspecific, or abnormal which were based on the official interpretations of the board-certified radiologists as a surrogate for the interpretations of the emergency physicians. *The normal results means "no abnormality identified" in the study. Non-specific interpretations were those that no definitive finding(s) could be correlated with initial clinical impression even there were some unrelated findings. Abnormal study interpretations cite a possible explanation for the patient's symptoms or initial clinical impression of X- ray request.*

3.4 Follow-up Imaging Collection

Medical records were reviewed to (1). Determine whether the patient had undergone any other radiological imaging for a similar indication (Named " Follow-up Imaging"). Follow-up images consisted of abdominal CT, abdominal US, or an IVU study performed within 48 hours of abdominal radiography. (2). Record the follow-up imaging results. The radiologists' interpretations of each follow-up study were categorized as normal or abnormal results. *The normal findings meant "no abnormality identified ", the "abnormal" defined as the findings that may be partial or absolute contribute to the initial diagnosis. The former represent the minor abnormal findings and the later means the major abnormality.*

3.5 Clinical Impressions for Abdominal Radiography

The clinical impressions for abdominal radiography ordering in this study will be organized (Table 4.2).

3.6 The Final Diagnosis of included patients in this study

The final diagnosis of patients included in this study was recorded from the discharge note and summarized. (Table 4.3)

3.7 Data Processing and Statistical Analysis

Software of Microsoft Excel 2003 and SPSS 13.0 version were used for data processing, including data selection, data merge, data aggregation and calculation.

1. Data analysis

(1). Demographics (Sex, Age, state of discharge).

(2). the relation between results of abdominal radiography and Follow-up images.

(3). the relation between abdominal radiographic results and F/U imaging's results.

(4). the relation between clinical impression associated and non-traumatic acute abdomen and abdominal radiography results.

(5). the consistency between clinical impression and final diagnosis.

2. Statistical Analysis

(1). Chi-Square test was used to study the significance of the difference of associations between variables, In this study, the test was applied for analysis of the relation between results of abdominal radiography and Follow-up images, the relation between abdominal radiographic result and F/U images, the consistency between clinical impression and final diagnosis.

(2). Odds ratios are reported with 95% confidence intervals.

(3). P-values of less than 0.05 were considered to indicate a significant difference.

(4). Logistic regression analysis was used to studies for the relation between separating AR results as positive and negative or analyzing the diagnostic value based on the AR results and the individual disease.

CHAPTER 4: RESULTS

4.1 Patient Collection and Demographics

From Jan. 1st to June 30th 2008, 3396 patients called for the institution's emergency department who had taken the abdominal radiography were collected. 437 cases were excluded from initial clinical impression of AR request due to ordering was not specified or the AR interpretation was not available. In addition, another 47 cases with acute abdomen were also excluded due to traumatic cause from this study. In summary, total 2912 patients were included in our study who had received abdominal radiography with any cause of non-traumatic acute abdominal pain. In these 2912 cases, 845 patients had received follow-up images subsequently and 2067 cases were no any additional images during the study period. (Fig. 4.1)

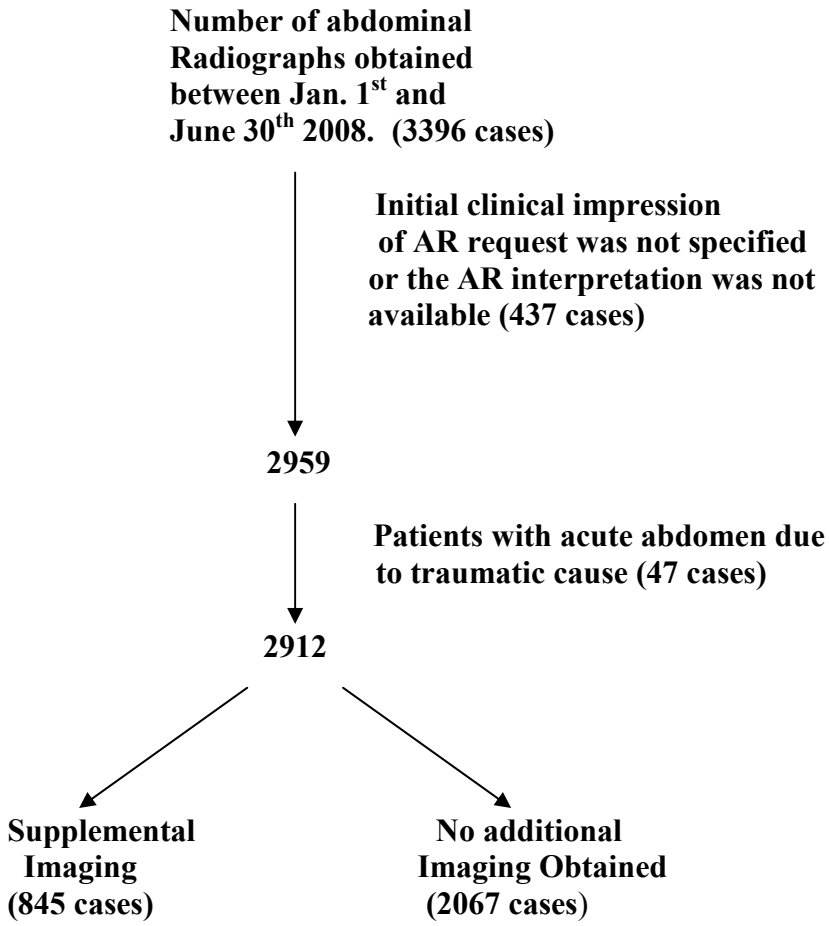

Fig. 4.1: Flowchart of patients present to emergency department and undergoing Abdominal Radiography.

Fifty-three percent (1550 of 2912) of the study subjects were male and forty-seven percent (1362 of 2912) were female, the age-distribution was between 1 and 90 Y/O (mean: 45.88 Y/O ± 20.13, median age: 43.00) in this study.(Table 4.1)

Table 4.1: Demographics (n=2912)

Gender		
Male	1550	(53.2%)
Female	1362	(46.8%)
Age		
1-10 yrs	7	(0.2%)
11-20 yrs	229	(7.9%)
21-30 yrs	579	(19.9%)
31-40 yrs	515	(17.7%)
41-50 yrs	497	(17.1%)
51-60 yrs	374	(12.8%)
61-70 yrs	242	(8.3%)
71-80 yrs	287	(9.9%)
81-90 yrs	157	(5.4%)
>90 yrs	25	(0.9%)
State of discharge		
A	938	(32.2%)
DA	1	(0.02%)
AAD	35	(1.2%)
H	1937	(66.5%)
T	1	(0.0%)

A: Admission. DA: dead. AAD: Against Advise Discharge. H: discharge from ED. T: Transfer.

4.2 Clinical Impression for Abdominal Radiography Ordering

Table 4.2 showed that the clinical impression for ordering the abdominal radiography included an enormous spectrum of disorders in this study which were summarized to 37 disease categories. urolithiasis, gastroenteritis, gastritis, non-specific diffuse abdominal pain and constipation revealed the top five causes in sequence and contribute about 61.3% in total number of requests.

Table 4.2: Clinical Impression for AR Ordering and list in sequence (N=2912)

Sequence	Clinical Impression	N	(%)	Sequence	Clinical Impression	N	(%)
1	Urolithiasis	456	(15.7%)	**21**	Colonic diverticulitis	14	(0.5%)
2	Gastroenteritis	419	(14.4%)	**22**	BPH	12	(0.4%)
3	Gastritis	380	(13.0%)	**23**	Dysmenorrhea	11	(0.4%)
4	Non-specific diffuse abdominal pain	345	(11.8%)	**24**	Urine retention	7	(0.2%)
				25	Foreign body retention	6	(0.2%)
5	Constipation	187	(6.4%)		Hernia	6	(0.2%)
6	abdominal Fullness	127	(4.4%)	**26**	Inguinal hernia	5	(0.2%)
7	GU infection	110	(3.8%)	**27**	Vaginal bleeding	2	(0.1%)
8	Acute appendicitis	97	(3.3%)	**28**	Anal bleeding	1	(0.0%)
9	Epigastric pain	91	(3.1%)		Dirty discharge and wound reddish via gastrostomy	1	(0.0%)
10	Acute pancreatitis	84	(2.9%)				
11	Peptic ulcer	80	(2.7%)		Feeding jejunostomy tube wound pain	1	(0.0%)
12	GI bleeding	77	(2.6%)				
13	Intestinal obstruction	75	(2.6%)		Inguinal pain	1	(0.0%)
14	Vomiting	73	(2.5%)		Liver cirrhosis	1	(0.0%)
15	Biliary tract stone	59	(2.0%)		R/O spleen rupture	1	(0.0%)
16	Hematuria	51	(1.8%)		UB rupture	1	(0.0%)
17	Diarrhea	37	(1.3%)		Vental hernia	1	(0.0%)
18	biliary tract infection	31	(1.1%)				
19	PID	24	(0.8%)				
20	Dysuria	19	(0.7%)				
	Peritonitis	19	(0.7%)				

4.3 Results of Final Diagnosis

The proven final diagnosis in this study was recorded from discharge note and list in sequence, which were reorganized to 112 disease categories (Table 4.3). Gastroenteritis, urolithiasis, gastritis, non-specific diffuse abdominal pain and constipation occupied the top five causes in sequence and contribute about 57% (1657 of 2912) in total number of requests.

Table 4.3: Final Diagnosis and list in sequence (N=2912)

Sequence	Clinical Impression	N	(%)	Sequeence	Clinical Impression	N	(%)
1	gastroenteritis	434	(14.9%)	**28**	DM	4	(0.1%)
2	urolisthesis	405	(13.9%)		foreign body retention	4	(0.1%)
3	Gastritis	388	(13.3%)	**29**	acute cystitis	3	(0.1%)

Table 4.3: Final Diagnosis and list in sequence (N=2912)

Sequence	Clinical Impression	N	(%)	Sequeence	Clinical Impression	N	(%)
4	Nonspecific diffuse abdominal pain	247	(8.5%)		anemia	3	(0.1%)
					cirrhosis of liver	3	(0.1%)
5	constipation	183	(6.3%)		disorder of muscle, ligament	3	(0.1%)
6	GU infection	133	(4.6%)		fever	3	(0.1%)
7	acute appendicitis	95	(3.3%)		hepatic coma	3	(0.1%)
8	abdominal. fullness	91	(3.1%)		inguinal hernia	3	(0.1%)
9	acute pancreatitis	85	(2.9%)	**30**	acute laryngopharyngitis	2	(0.1%)
	peptic ulcer	85	(2.9%)		acute renal failure	2	(0.1%)
10	GI bleeding	78	(2.7%)		acute respiratory failure	2	(0.1%)
11	intestinal obstruction	68	(2.3%)		anxiety state	2	(0.1%)
12	vomiting	67	(2.3%)		chronic hepatitis	2	(0.1%)
13	epigastric pain	66	(2.3%)		corpus luteum cyst or hematoma	2	(0.1%)
14	Billiary tract stone	58	(2.0%)				
15	hematuria	50	(1.7%)		CVA	2	(0.1%)
16	Billiary tract infection	33	(1.1%)		esophagitis	2	(0.1%)
17	myalgia and myositis	29	(1.0%)		follicular cyst of ovary	2	(0.1%)
18	diarrhea	27	(0.9%)		hemorrhoids	2	(0.1%)
19	PID	25	(0.9%)		jaundice	2	(0.1%)
20	peritonitis	19	(0.7%)		malignant neoplasm of ascending colon	2	(0.1%)
21	colonic diverticulitis	14	(0.5%)				
	dysuria	14	(0.5%)		malignant neoplasm of hepatic flexure co	2	(0.1%)
22	BPH	12	(0.4%)				
	dysmenorrhea	12	(0.4%)		malignant neoplasm of rectum	2	(0.1%)
23	chronic pancreatitis	9	(0.3%)		reticulosarcoma, intra-abdominal lymph n	2	(0.1%)
24	lumbago	8	(0.3%)				
	paralytic ileus	8	(0.3%)		vaginal bleeding	2	(0.1%)
25	functional disorder of intestine	7	(0.2%)	**31**	alcoholic cirrhosis of liver	1	(0.0%)
					alcoholic liver damage	1	(0.0%)
	hydronephrosis	7	(0.2%)		angina pectoris	1	(0.0%)
26	chronic renal failure	6	(0.2%)		asthma	1	(0.0%)

Table 4.3: Final Diagnosis and list in sequence (N=2912)

Sequence	Clinical Impression	N	(%)	Sequeence	Clinical Impression	N	(%)
	dyspepsia	6	(0.2%)		benign neoplasm of other specified parts	1	(0.0%)
	pneumonia	6	(0.2%)				
	urine retention	6	(0.2%)		benign neoplasm of ovary	1	(0.0%)
27	hernia	5	(0.2%)		burn of trunk, unspecified site, blister	1	(0.0%)
	malignant neoplasm of liver	5	(0.2%)		cardiac dysrhythmia	1	(0.0%)
	URI	5	(0.2%)		chronic cholecystitis	1	(0.0%)
31	chronic ischemic heart disease	1	(0.0%)	**31**	noninflammatory disorder of ovary	1	(0.0%)
	congestive heart failure	1	(0.0%)		open wound of elbow	1	(0.0%)
	coronary atherosclerosis	1	(0.0%)		open wound to other and unspecified part	1	(0.0%)
	costipation	1	(0.0%)				
	disease of white blood cells	1	(0.0%)		orchitis and epididymitis	1	(0.0%)
	displacement of lumbar	1	(0.0%)		osteoarthrosis, localized, primary	1	(0.0%)
	dypnea	1	(0.0%)				
	dyspareunia	1	(0.0%)		ovarian cyst	1	(0.0%)
	endometriosis	1	(0.0%)		pancreatic head CA.	1	(0.0%)
	essential hypertension	1	(0.0%)		pelvic congestion syndrome	1	(0.0%)
	feeding jejunostomy tube wound pain	1	(0.0%)		polycystic ovaries	1	(0.0%)
	heart failure	1	(0.0%)		pulmonary tuberculosis	1	(0.0%)
	hepatitis	1	(0.0%)		secondary malignant neoplasm of lung	1	(0.0%)
	hypopotassemia	1	(0.0%)		septicemia	1	(0.0%)
	hypotassemia	1	(0.0%)		tension headache	1	(0.0%)
	inguina lhernia	1	(0.0%)		transient cerebral ischemia	1	(0.0%)
	lumbar intervertebral disc disorder	1	(0.0%)		uterovaginal prolapse, complete	1	(0.0%)
	lymphadenitis	1	(0.0%)		verntral hernia	1	(0.0%)
	malignant neoplasm of body of stomach	1	(0.0%)		vertigo of central origin	1	(0.0%)
					volume depletion	1	(0.0%)

Table 4.3: Final Diagnosis and list in sequence (N=2912)

Sequence	Clinical Impression	N	(%)	Sequeence	Clinical Impression	N	(%)
	malignant neoplasm of bronchus and lung,	1	(0.0%)				
	malignant neoplasm of female breast	1	(0.0%)				
	malignant neoplasm of lower lobe, bronch	1	(0.0%)				
	malignant neoplasm of upper lobe, bronch	1	(0.0%)				
	mittelschmerz	1	(0.0%)				
	neoplasm of uncertain behavior of pleura	1	(0.0%)				
	neoplasm of uncertain behavior of trache	1	(0.0%)				
	neoplasm of uncertain behavior of uterus	1	(0.0%)				

4.4 Abdominal Radiography Results

In 2912 patients, 99.6% (2899 of 2912) cases were examined with KUB study, none of patients in this study was examined with plain abdominal radiography. Abdominal radiographic interpretation was normal in 55.8% (n=1625), Non-specific in 29.4% (n=856) and Abnormal in 14.8% (n=431)

of patients; 29% (n=845) of patients have taken further abdominal imaging in which 85.3% (721 of 845) showed abnormal. (Table 4.4)

Table 4.4: List of AR and F/U image (n=2912)

Sort of AR		
Plain	0	(0.0%)
Standing	13	(0.4%)
KUB	2899	(99.6%)
Result of AR		
Normal	1625	(55.8%)
Non-specific	856	(29.4%)
Abnormal	431	(14.8%)
F/U image		
No	2067	(71.0%)
Yes	845	(29.0%)
Results of F/U Image		
Normal	124	(14.7%)
Abnormal	721	(85.3%)

4.5 Follow-up Imaging

Further imaging was requested for 25.9% (421 of 1625) of patients with normal radiography results, 29.3% (251 of 856) of patients with non-specific results had F/U imaging, and 40.1% (173 of 431) of patients with abnormal results of AR received subsequent other imaging, In total, 27.1% (672 of 2481) patients taken further imaging study even that the AR result showed “no abnormality (n=672)”. The more of the abnormal AR results found, the more of the F/U image done with a significant difference (P＜0.001).(Table 4.5)

Table 4.5: Relation between Abdominal Radiography Result & Follow-up Image (N=2912)

Radiography results	N	**Follow-up image**		Odds Ratio	95%CI	p value
		No (n=2067)	Yes (n=845)			
Normal	1625	1204 (74.1%)	421 (25.9%)	1.00	Reference	
Non-specific	856	605 (70.7%)	251 (29.3%)	1.19	(0.99 , 1.43)	0.076
Abnormal	431	258 (59.9%)	173 (40.1%)	1.92	(1.54 , 2.40)	<0.001*

In follow-up imaging patients (n=845), 81.9% (345 of 421) of cases have abnormal F/U imaging results but the previous abdominal radiography interpretation were normal (n=421), 88 % (221 of 251) of non-specific AR results cases were found to have abnormal findings at follow-up imaging, This number increased to 89.6% (155 of 173) for abnormal abdominal radiography results respectively. The more of abnormal AR results found, the more of the abnormal F/U imaging results noted with a significant difference ($P < 0.05$). (Table 4.6)

Table 4.6: Relation between Abdominal Radiography Result & Follow-up Image result (N=845)

Abd. Radiography results	N (n=845)	**Imaging Results** Normal (n=124)	Abnormal (n=721)	Odds Ratio	95%CI	p value
Normal	421	76 (18.1%)	345 (81.9%)	1.00	reference	
Non-specific	251	30 (12.0%)	221 (88.0%)	1.62	(1.03 , 2.56)	0.046*
Abnormal	173	18 (10.4%)	155 (89.6%)	1.90	(1.10 , 3.28)	0.028*

Major abnormalities on the abnormal follow-up images (n=721) were found in 55.7% (192 of 345), 62.4% (138 of 221), and 88.4% (137 of 155) of the abdominal radiographs read as normal, nonspecific, and abnormal with significant difference ($P < 0.001$) respectively. (Table 4.7)

Table 4.7: Relation between Abdominal Radiography Results & Abnormal Follow-up Imaging Results (N=721)

Abd. Radiography results	N (n=721)	**Imaging Abnormal** minor (n=254)	major (n=467)	Odds Ratio	95%CI	p value
Normal	345	153 (44.3%)	192 (55.7%)	1.00	reference	
Non-specific	221	83 (37.6%)	138 (62.4%)	1.32	(0.94 , 1.87)	0.130
Abnormal	155	18 (11.6%)	137 (88.4%)	6.07	(3.55 , 10.36)	<0.001*

4.6 Overall Results

In this 2912 cases study with various associated diseases of non-traumatic acute abdomen , The overall diagnostic value of abdominal radiograph showed that the true negative rate is 10.5% (260 of 2481), false negative rate is 89.5% (2221 of 2481), true positive rate is 90.5% (390 of 431), false positive rate is 9.5% (41 of 431), there is no significant difference for AR use in evaluation of non-traumatic acute abdominal disease (P Value > 0.05) (Table 4.8).

Overall, Abnormal AR results is 14.8% (431 of 2912) and only 13.4% (390 of 2912) positive diagnostic yield of AR result found (Table 4.8). There was limited diagnostic value of AR in evaluation of non-traumatic acute abdomen patients in this study noted.

Table 4.8: Abdominal Radiography -- Sensitivity, Specificity, Efficiency

	Test Outcome					
	Abd. Radiography result					
	(-)		(+)		p value	
Non-specific cases not included					0.528	PPV = 90.5% NPV= 10.5% Sensitivity = 21.1% Specificity = 80.6% Efficiency = 27.2%
disease (-)	170	(10.5%)	41	(9.5%)		
disease (+)	1455	(89.5%)	390	(90.5%)		
Non-specific cases included					0.502	PPV = 90.5% NPV= 10.5% Sensitivity = 14.9% Specificity = 86.4% Efficiency = 22.3%
disease (-)	260	(10.5%)	41	(9.5%)		
disease (+)	2221	(89.5%)	390	(90.5%)		

4.7 Subanalysis

In table 4.9, most patients with various clinical impression tended to follow up the images no matter what the AR results were (p-value >0.05), with the exception of "abdominal fullness" which showed the abnormal AR results tend to have more F/U images with a significant difference.(appendix 1) The phenomenon represented that the clinical physicians lacked confidence of the AR results. The discovery was similar to the observed results in Table 4.5.

On evaluating "abdominal fullness", the proportion of follow-up images was significantly higher in the patients with abnormal AR than those with

normal results (Odds Ratio 3.35 and p<0.001) (see in appendix 1). The condition showed the clinical doctors arranged AR for abdominal fullness expect to exclude the problem, so the more abnormal the results were, the more distrust of the clinical physicians were; therefore, the proportion of arranging "follow-up images" increased significantly.

Table 4.9: Relation between AR Results & Follow-up Image by Clinical Impression (N=2912)

		F/U Image	Abd. Radiography results											
			Normal			Non-specific				Abnormal				
				FU image			FU image		Odds			FU image		
Clinical impression	Total	Total	N	n	(%)	N	n	(%)	ratio	95%CI	N	n	(%)	ratio	95%CI
Urolithiasis	456	**227(50%)**	203	101	(49.8)	67	30	(44.8)	0.82	(0.47,1.43)	186	96	(51.6)	1.08	(0.72,1.60)
gastroenteritis	419	**62(15%)**	269	39	(14.5)	124	18	(14.5)	1.00	(0.55,1.83)	26	5	(19.2)	1.40	(0.50,3.94)
Gastritis	380	**31(8.2%)**	256	22	(8.6)	122	9	(7.4)	0.85	(0.38,1.90)	2	0	(0.0)		
Non-specific diffuse abdominal pain	345	**111(32.2%)**	189	57	(30.2)	112	38	(33.9)	1.19	(0.72,1.96)	44	16	(36.4)	1.32	(0.66,2.63)
constipation	187	**6(3%)**	96	1	(1.0)	39	1	(2.6)	2.50	(0.15,41.0)	52	4	(7.7)	7.92	(0.86,72.7)
abdominal. fullness	127	**33(26%)**	74	17	(23.0)	33	6	(18.2)	0.75	(0.26,2.10)	20	10	(50.0)	3.35	(1.20,9.40)
GU infection	110	**19(17.3%)**	61	8	(13.1)	32	8	(25.0)	2.21	(0.74,6.58)	17	3	(17.6)	1.42	(0.33,6.06)
Acute appendicitis	97	**62(63.9%)**	59	37	(62.7)	37	24	(64.9)	1.10	(0.47,2.59)	1	1	(100)		
epigastric pain	91	**22(24.2%)**	55	13	(23.6)	33	7	(21.2)	0.87	(0.31,2.46)	3	2	(66.7)	6.46	(0.54,77.1)
Acute pancreatitis	84	**50(59.5%)**	46	23	(50.0)	35	24	(68.6)	2.18	(0.87,5.47)	3	3	(100)		
peptic ulcer	80	**25(31.3%)**	40	12	(30.0)	36	12	(33.3)	1.17	(0.44,3.07)	4	1	(25.0)	0.78	(0.07,8.25)
GI bleeding	77	**18(23.4%)**	45	6	(13.3)	30	10	(33.3)	3.25	(1.03,10.2)	2	2	(100)		
Intestinal obstruction	75	**35(46.7%)**	19	8	(42.1)	41	17	(41.5)	0.97	(0.32,2.93)	15	10	(66.7)	2.75	(0.67,11.2)
vomiting	73	**13(17.8%)**	47	7	(14.9)	6	1	(16.7)	1.14	(0.12,11.3)	20	5	(25.0)	1.90	(0.52,6.93)
biliary tract stone	59	**33(55.9%)**	34	17	(50.0)	20	12	(60.0)	1.50	(0.49,4.59)	5	4	(80.0)	4.00	(0.40,39.5)
hematuria	51	**21(41.2%)**	29	13	(44.8)	14	6	(42.9)	0.92	(0.25,3.34)	8	2	(25.0)	0.41	(0.07,2.38)
diarrhea	37	**6(6.2%**	21	4	(19.0)	11	2	(18.2)	0.94	(0.14,6.19)	5	0	(0.0)		
biliary tract infection	31	**23(74.2%)**	19	15	(78.9)	9	6	(66.7)	0.53	(0.09,3.14)	3	2	(66.7)	0.53	(0.04,7.49)
PID	24	**5(20.8%)**	14	4	(28.6)	10	1	(10.0)	0.28	(0.03,2.97)	0				
dysuria	19	**7(36.8%)**	8	2	(25.0)	8	3	(37.5)	1.80	(0.21,15.4)	3	2	(66.7)	6.00	(0.34,107.3)
Peritonitis	19	**11(57.9%)**	9	5	(55.6)	4	2	(50.0)	0.80	(0.08,8.47)	6	4	(66.7)	1.60	(0.19,13.7)
Colonic diverticulitis	14	**11(78.6%)**	7	5	(71.4)	6	5	(83.3)	2.00	(0.13,29.8)	1	1	(100)		
BPH	12	**6(50%)**	7	3	(42.9)	5	3	(60.0)	2.00	(0.19,20.6)	0				
dysmenorrhea	11	**2(18.2%)**	4	0	(0.0)	7	2	(28.6)			0				
Urine retention	7	**0**	4	0	(0.0)	2	0	(0.0)			1	0	(0.0)		
Foreign body	6	**0**	1	0	(0.0)	1	0	(0.0)			4	0	(0.0)		

Table 4.9: Relation between AR Results & Follow-up Image by Clinical Impression (N=2912)

		F/U Image	Abd. Radiography results									
			Normal			Non-specific				Abnormal				
				FU image			FU image		Odds			FU image		Odds	
Clinical impression	Total	Total	N	n	(%)	N	n	(%)	ratio	95%CI	N	n	(%)	ratio	95%CI
retention															
hernia	6	**1(16.7%)**	3	1	(33.3)	3	1	(33.3)	1.00	(0.03,29.8)	0				
inguinal hernia	5	**1(20%)**	2	0	(0.0)	3	1	(33.3)			0				
vaginal bleeding	2	**0**	1	0	(0.0)	1	0	(0.0)			0				
anal bleeding	1	**0**	0			1	0	(0.0)			0				
dirty discharge & wound reddish via gastrostomy	1	**0**	1	0	(0.0)	0					0				
feeding jejunostomy tube wound pain	1	**0**	0			1	0	(0.0)			0				
inguinal pain	1	**1(100%)**	1	1	(100)	0					0				
liver cirrhosis	1	**1(100%)**	0			1	1	(100)			0				
r/o spleen rupture	1	**1(100%)**	0			1	1	(100)			0				
UB rupture	1	**0**	0			1	0	(0.0)			0				
vental hernia	1	**0**	1	0	(0.0)	0					0				

In table 4.10, no matter what the AR results were, the follow-up images of the studied diseases were reported abnormal in the significant amount of cases ($P > 0.05$), with the exception of urolithiasis, In which the abnormal F/U images results were proportional to abnormal AR results in a significant difference ($P = 0.009$)(appendix 2). The very high proportion of the normal or non-specific AR results turned out to be positive reports in the follow-up images found in this study. Taking urolisthiasis as an example, 108 of 131 patients, 81.7%, with normal or non-specific AR results were reported abnormal in the follow-up images. The condition indicated that the doctors' suspicion to the AR results was reasonable.

The AR abnormal results of some diseases were highly compatible with the follow-up images; interestingly, the clinical doctors still arranged follow-up images in these patients. The phenomenon indicated their distrust of the AR abnormal results in these diseases. Taking urolisthiasis as an example, 90 of 96 patients, 93.8%, with AR abnormal results also had abnormal follow-up images, but they finally accepted the management of follow-up images. (Fig. 4.2) (Fig. 4.3)

Table 4.10: Relation between AR Result & F/U Image Result (N=845)

Clinical impression	FU Imaging Total	Abdominal Radiography results: Normal N	Normal Image (+) n (%)	Non-specific N	Non-specific Image (+) n (%)	Non-specific Odds ratio	Non-specific 95%CI	Abnormal N	Abnormal Image (+) n (%)	Abnormal Odds ratio	Abnormal 95%CI
Urolithiasis	227	101	81 (80.2)	30	27 (90.0)	2.22	(0.61,8.07)	96	90 (93.8)	3.70	(1.42,9.68)
nonspecific diffuse abdominal Pain	111	57	41 (71.9)	38	36 (94.7)	7.02	(1.51,32.6)	16	15 (93.8)	5.85	(0.71,48.0)
Acute appendicitis	62	37	33 (89.2)	24	22 (91.7)	1.33	(0.22,7.91)	1	1 (100)		
gastroenteritis	62	39	25 (64.1)	18	13 (72.2)	1.46	(0.43,4.94)	5	3 (60.0)	0.84	(0.12,5.64)
Acute pancreatitis	50	23	22 (95.7)	24	24 (100)			3	3 (100)		
Intestinal obstruction	35	8	7 (87.5)	17	14 (82.4)	0.67	(0.06,7.64)	10	8 (80.0)	0.57	(0.04,7.74)
abdominal fullness	33	17	16 (94.1)	6	6 (100)			10	8 (80.0)	0.25	(0.02,3.19)
biliary tract stone	33	17	17 (100)	12	12 (100)			4	4 (100)		
Gastritis	31	22	19 (86.4)	9	5 (55.6)	0.20	(0.03,1.18)	0			
peptic ulcer	25	12	10 (83.3)	12	11 (91.7)	2.20	(0.17,28.1)	1	1 (100)		
biliary tract infection	23	15	15 (100)	6	6 (100)			2	2 (100)		
epigastric pain	22	13	12 (92.3)	7	6 (85.7)	0.50	(0.03,9.46)	2	2 (100)		
hematuria	21	13	10 (76.9)	6	3 (50.0)	0.30	(0.04,2.34)	2	0 (0.0)		
GU infection	19	8	6 (75.0)	8	5 (62.5)	0.56	(0.06,4.76)	3	3 (100)		
GI bleeding	18	6	3 (50.0)	10	9 (90.0)	9.00	(0.66,122.8)	2	2 (100)		
vomiting	13	7	5 (71.4)	1	1 (100)			5	5 (100)		
Colonic diverticulitis	11	5	5 (100)	5	5 (100)			1	1 (100)		
Peritonitis	11	5	5 (100)	2	2 (100)			4	4 (100)		
dysuria	7	2	2 (100)	3	3 (100)			2	2 (100)		
BPH	6	3	3 (100)	3	3 (100)			0			
constipation	6	1	1 (100)	1	1 (100)			4	1 (25.0)		
diarrhea	6	4	4 (100)	2	2 (100)			0			
PID	5	4	2 (50.0)	1	0 (0.0)			0			
dysmenorrhea	2	0		2	1 (50.0)			0			
hernia	2	1	1 (100)	1	1 (100)			0			
inguinal hernia	1	0	0 (0.0)	1	1 (100)			0			
inguinal pain	1	1	0 (0.0)	0				0			
liver cirrhosis	1	0		1	1 (100)			0			
r/o spleen rupture	1	0	0 (0.0)	1	1 (100)			0			
anal bleeding	0										
dirty discharge & wound reddish via gastrostomy	0										
feeding jejunostomy tube wound pain	0										
Foreign body retention	0										
UB rupture	0										
Urine retention	0										
vaginal bleeding	0										
Vental hernia	0										

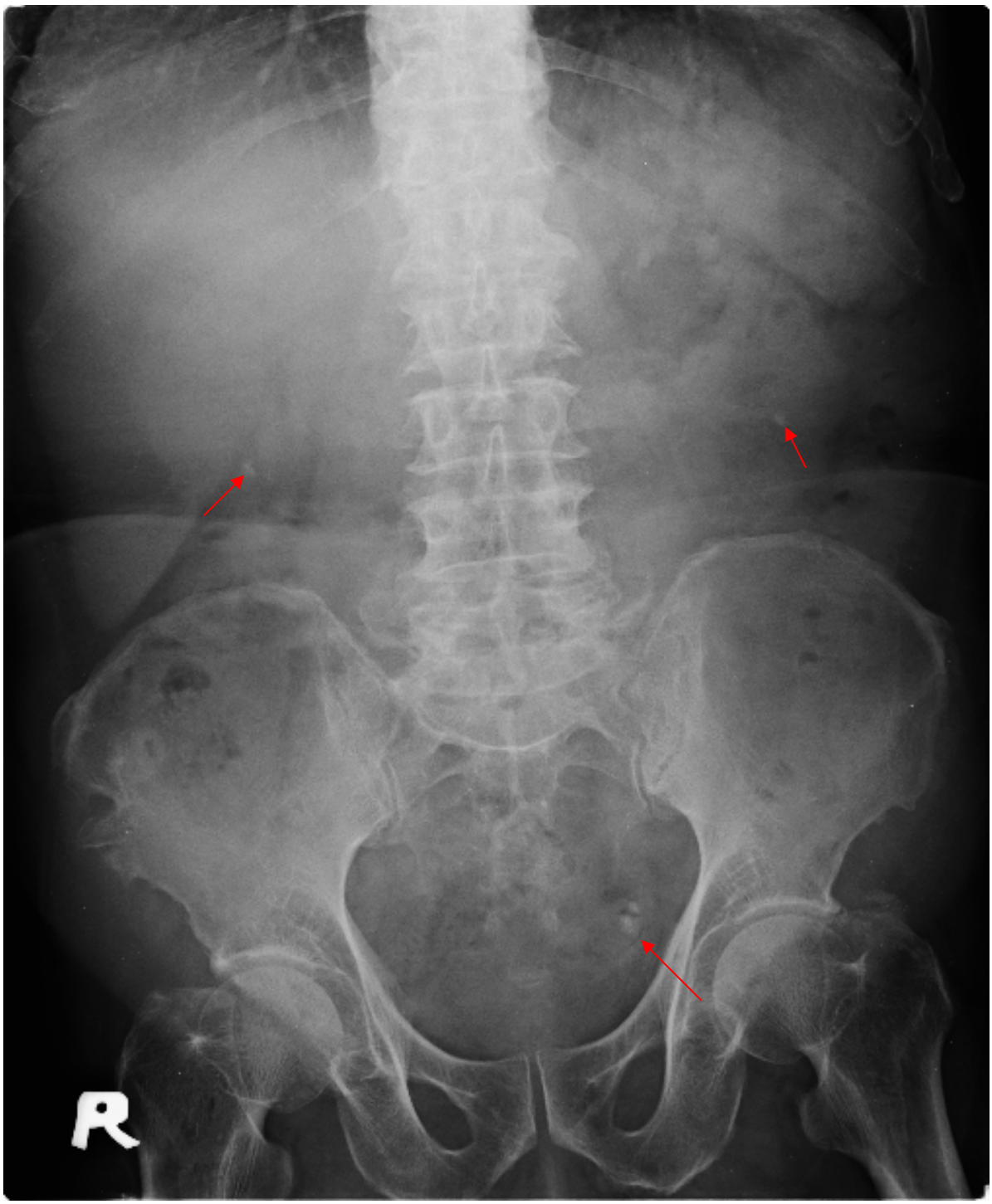

Fig.4.2 KUB showed that bil.Renal stones and Lt side distalthird ureteral stones.

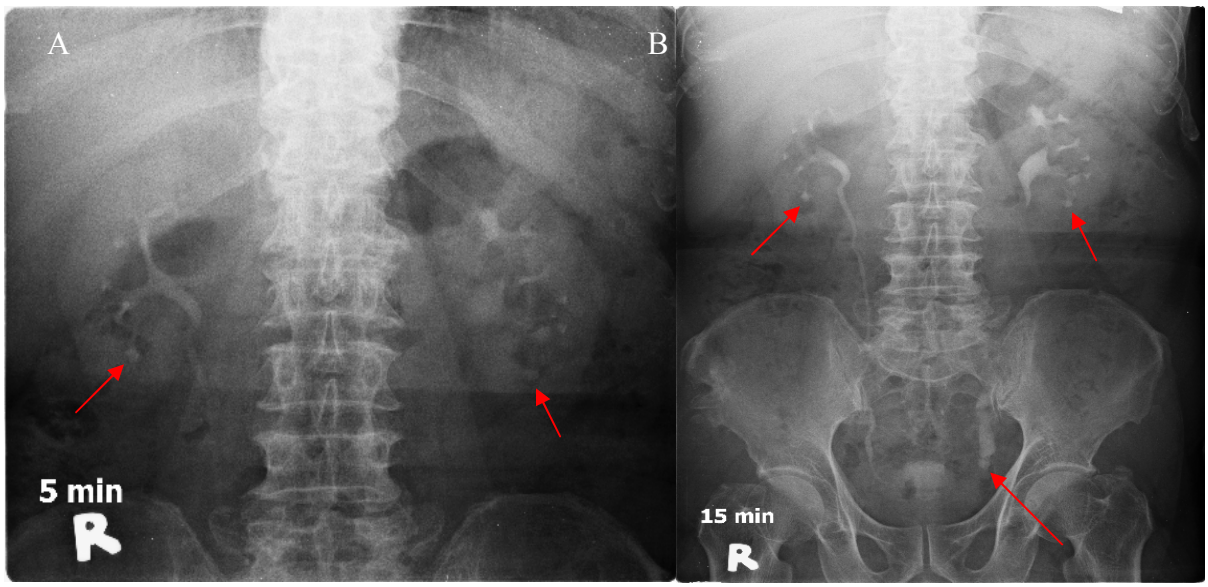

Fig.4.3 IVP (F/U Imaging) showed that bil. Lower pole renal stones (A) and Lt side distal third ureteral stone (B).

Table 4.11 displayed the AR results related to TN, FN, FP and TP in each disease. Almost all diseases had far more patients with normal AR results rather than those with abnormal ones. Additionally, FN rate of AR results was significantly higher in each disease, which was the same as the result of table 4.8.

Table 4.11: Relation between Abdominal Radiography Results and Diagnosis by Clinical Indication (N=2912)

		Abd. Radiography (–)		Abd. Radiography (+)	
		Diagnosis (–)	Diagnosis (+)	Diagnosis (–)	Diagnosis (+)
Clinical impression	n	TN	FN	FP	TP
Urolithiasis	456	50 (11.0%)	220 (48.2%)	11 (2.4%)	175 (38.4%)
gastroenteritis	419	5 (1.2%)	388 (92.6%)	0 (0.0%)	26 (6.2%)
Gastritis	380	6 (1.6%)	372 (97.9%)	0 (0.0%)	2 (0.5%)
nonspecific diffuse abdominal pain	345	88 (25.5%)	213 (61.7%)	13 (3.8%)	31 (9.0%)
constipation	187	8 (4.3%)	127 (67.9%)	1 (0.5%)	51 (27.3%)
abdominal fullness	127	32 (25.2%)	75 (59.1%)	4 (3.1%)	16 (12.6%)
GU infection	110	0 (0.0%)	93 (84.5%)	0 (0.0%)	17 (15.5%)
Acute appendicitis	97	2 (2.1%)	94 (96.9%)	0 (0.0%)	1 (1.0%)
epigastric pain	91	24 (26.4%)	64 (70.3%)	2 (2.2%)	1 (1.1%)
Acute pancreatitis	84	2 (2.4%)	79 (94.0%)	0 (0.0%)	3 (3.6%)
peptic ulcer	80	0 (0.0%)	76 (95.0%)	0 (0.0%)	4 (5.0%)
GI bleeding	77	1 (1.3%)	74 (96.1%)	0 (0.0%)	2 (2.6%)

Table 4.11: Relation between Abdominal Radiography Results and Diagnosis by Clinical Indication (N=2912)

		Abd. Radiography (–)		Abd. Radiography (+)	
		Diagnosis (–)	Diagnosis (+)	Diagnosis (–)	Diagnosis (+)
Clinical impression	n	TN	FN	FP	TP
Intestinal obstruction	75	7 (9.3%)	53 (70.7%)	2 (2.7%)	13 (17.3%)
vomiting	73	5 (6.8%)	48 (65.8%)	1 (1.4%)	19 (26.0%)
biliary tract stone	59	2 (3.4%)	52 (88.1%)	0 (0.0%)	5 (8.5%)
hematuria	51	4 (7.8%)	39 (76.5%)	1 (2.0%)	7 (13.7%)
diarrhea	37	7 (18.9%)	25 (67.6%)	3 (8.1%)	2 (5.4%)
biliary tract infection	31	0 (0.0%)	28 (90.3%)	0 (0.0%)	3 (9.7%)
PID	24	0 (0.0%)	24 (100.0%)	0 (0.0%)	0 (0.0%)
dysuria	19	3 (15.8%)	13 (68.4%)	2 (10.5%)	1 (5.3%)
Peritonitis	19	0 (0.0%)	13 (68.4%)	0 (0.0%)	6 (31.6%)
Colonic diverticulitis	14	0 (0.0%)	13 (92.9%)	0 (0.0%)	1 (7.1%)
BPH	12	0 (0.0%)	12 (100.0%)	0 (0.0%)	0 (0.0%)
dysmenorrhea	11	0 (0.0%)	11 (100.0%)	0 (0.0%)	0 (0.0%)
Urine retention	7	2 (28.6%)	4 (57.1%)	0 (0.0%)	1 (14.3%)
Foreign body retention	6	2 (33.3%)	0 (0.0%)	0 (0.0%)	4 (66.7%)
hernia	6	1 (16.7%)	5 (83.3%)	0 (0.0%)	0 (0.0%)
inguinal hernia	5	2 (40.0%)	3 (60.0%)	0 (0.0%)	0 (0.0%)
vaginal bleeding	2	0 (0.0%)	2 (100.0%)	0 (0.0%)	0 (0.0%)
anal bleeding	1	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
dirty discharge and wound reddish via gastrostomy	1	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
feeding jejunostomy tube wound pain	1	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)
inguinal pain	1	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
liver cirrhosis	1	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
r/o spleen rupture	1	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
UB rupture	1	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
vental hernia	1	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)

Table 4.12 described the diagnostic values, including PPV, NPV, sensitivity, specificity and efficiency of AR in the individual diseases. There was a common feature of AR performance, which showed high PPV and specificity whereas low NPV and sensitivity in the diseases. The efficiency of

urolisthiasis was highest (49.3%) after excluding the diseases with fewer than or equal to 10 cases in this study.

Table 4.12: Abdominal Radiography – PPV, NPV, Sensitivity, Specificity, Efficiency by Clinical Indication (N=2912)

		Abd. Radiography				
Clinical impression	n	PPV	NPV	Sensitivity	Specificity	Efficiency
Urolithiasis	456	94.1%	18.5%	44.3%	82.6%	49.3%
gastroenteritis	419	100.0%	1.3%	6.3%	100.0%	7.4%
Gastritis	380	100.0%	1.6%	0.5%	100.0%	2.1%
nonspecific diffuse abdominal. pain	345	70.5%	29.2%	12.7%	87.1%	34.5%
constipation	187	98.1%	5.9%	28.7%	88.9%	31.6%
abdominal fullness	127	80.0%	29.9%	17.6%	88.9%	37.8%
GU infection	110	100.0%	0.0%	15.5%		15.5%
Acute appendicitis	97	100.0%	2.1%	1.1%	100.0%	3.1%
epigastric pain	91	33.3%	27.3%	1.5%	92.3%	27.5%
Acute pancreatitis	84	100.0%	2.5%	3.7%	100.0%	6.0%
peptic ulcer	80	100.0%	0.0%	5.0%		5.0%
GI bleeding	77	100.0%	1.3%	2.6%	100.0%	3.9%
Intestinal obstruction	75	86.7%	11.7%	19.7%	77.8%	26.7%
vomiting	73	95.0%	9.4%	28.4%	83.3%	32.9%
biliary tract stone	59	100.0%	3.7%	8.8%	100.0%	11.9%
hematuria	51	87.5%	9.3%	15.2%	80.0%	21.6%
diarrhea	37	40.0%	21.9%	7.4%	70.0%	24.3%
biliary tract infection	31	100.0%	0.0%	9.7%		9.7%
PID	24		0.0%	0.0%		0.0%
dysuria	19	33.3%	18.8%	7.1%	60.0%	21.1%
Peritonitis	19	100.0%	0.0%	31.6%		31.6%
Colonic diverticulitis	14	100.0%	0.0%	7.1%		7.1%
BPH	12		0.0%	0.0%		0.0%
dysmenorrhea	11		0.0%	0.0%		0.0%
Urine retention	7	100.0%	33.3%	20.0%	100.0%	42.9%
Foreign body retention	6	100.0%	100.0%	100.0%	100.0%	100.0%
hernia	6		16.7%	0.0%	100.0%	16.7%
inguinal hernia	5		40.0%	0.0%	100.0%	40.0%
vaginal bleeding	2		0.0%	0.0%		0.0%
anal bleeding	1		100.0%		100.0%	100.0%
dirty discharge and wound reddish via gastrostomy	1		100.0%		100.0%	100.0%
feeding jejunostomy tube wound pain	1		0.0%	0.0%		0.0%
inguinal pain	1		100.0%		100.0%	100.0%
liver cirrhosis	1		100.0%		100.0%	100.0%
r/o spleen rupture	1		100.0%		100.0%	100.0%
UB rupture	1		100.0%		100.0%	100.0%
vental hernia	1		100.0%		100.0%	100.0%

Univariate logistic regression analyses were applied to evaluate the relationship between AR results (positive, negative and efficiency) and individual diseases of 37 disease categories in 2912 patients. The results were shown in table 4.13 and 4.14. Table 4.13 displayed dependent variables of AR result positive in the left column and AR result negative in the right column, respectively. AR efficiency was taken as a dependent variable in table 4.14.

The left column of table 4.13 showed that p-value was less than 0.05 and odds ratio of AR (+) result equaled to 2.14 in urolithiasis, so AR was valuable in confirming the diagnosis of urolisthiasis.

The p-value was less than 0.05 and Odds Ratio of AR result (+) results was less than 1 in the other non-specific diffuse abdominal pain, epigastric pain, diarrhea and dysuria, so its application to prove these medical conditions was inappropriate.

The right column of table 4.13 described the relationship between AR normal results and individual diseases. Among them, eleven diseases (urolithiasis, gastroenteritis, gastritis, non-specific diffuse abdominal pain, abdominal fullness, acute appendicitis, epigastric pain, acute pancreatitis, GI bleeding, diarrhea, foreign body retention) showed p-value less than 0.05, Five of these eleven diseases (urolithiasis, non-specific abdominal pain, abdominal fullness, epigastric pain, diarrhea) show Odds ratio great than 1 and another five diseases (gastroenteritis, gastritis, acute appendicitis, acute pancreatitis, GI bleeding) show less than 1, but the NPV showed very low in all of these 37 clinical impressions.

Table 4.13: Logistic Regression for Abdominal Radiography Results

		Univariate				Univariate			
Clinical impression	Total	n / N	**AR(+)**	OR	p	n /N	**AR(-)**	OR	p
Urolithiasis	456	175 / 186	94.1%	2.14	0.039*	50 / 270	18.5%	2.17	<0.001*
gastroenteritis	419	26 / 26	100.0%			5 / 393	1.3%	0.09	<0.001*
Gastritis	380	2 / 2	100.0%			6 / 378	1.6%	0.12	<0.001*
Non-specific diffuse abdominal pain	345	31 / 44	70.5%	0.18	<0.001*	88 / 301	29.2%	4.82	<0.001*
constipation	187	51 / 52	98.1%	5.85	0.084	8 / 135	5.9%	0.52	0.080
abdominal fullness	127	16 / 20	80.0%	0.38	0.102	32 / 107	29.9%	4.02	0.000*
GU infection	110	17 / 17	100.0%			0 / 93	0.0%		
Acute appendicitis	97	1 / 1	100.0%			2 / 96	2.1%	0.18	0.015*
epigastric pain	91	1 / 3	33.3%	0.05	0.014*	24 / 88	27.3%	3.43	<0.001*

Table 4.13: Logistic Regression for Abdominal Radiography Results

		Univariate				Univariate			
Clinical impression	Total	n / N	**AR(+)**	OR	p	n /N	**AR(-)**	OR	p
Acute pancreatitis	84	3 / 3	100.0%			2 / 81	2.5%	0.21	0.030*
peptic ulcer	80	4 / 4	100.0%			0 / 76	0.0%		
GI bleeding	77	2 / 2	100.0%			1 / 75	1.3%	0.11	0.030*
Intestinal obstruction	75	13 / 15	86.7%	0.65	0.584	7 / 60	11.7%	1.13	0.761
vomiting	73	19 / 20	95.0%	1.99	0.507	5 / 53	9.4%	0.89	0.801
biliary tract stone	59	5 /5	100.0%			2 / 54	3.7%	0.32	0.118
hematuria	51	7 / 8	87.5%	0.71	0.752	4 / 43	9.3%	0.87	0.799
diarrhea	37	2 / 5	40.0%	0.06	0.003*	7 / 32	21.9%	2.43	0.040*
biliary tract infection	31	3 / 3	100.0%			0 / 28	0.0%		
PID	24					0 / 24	0.0%		
dysuria	19	1 / 3	33.3%	0.05	0.014*	3 / 16	18.8%	1.98	0.287
Peritonitis	19	6 / 6	100.0%			0 / 13	0.0%		
Colonic diverticulitis	14	1 / 1	100.0%			0 / 13	0.0%		
BPH	12					0 / 12	0.0%		
dysmenorrhea	11					0 / 11	0.0%		
Urine retention	7	1 / 1	100.0%			2 / 6	33.3%	4.30	0.093
Foreign body retention	6	4 / 4	100.0%			2 / 2	100.0%		<0.001*
hernia	6					1 / 6	16.7%	1.71	0.624
inguinal hernia	5					2 / 5	40.0%	5.73	0.056
vaginal bleeding	2					0 / 2	0.0%		
anal bleeding	1					1 / 1	100.0%		
dirty discharge and wound reddish via gastrostomy	1					1 / 1	100.0%		
feeding jejunostomy tube wound pain	1					0 / 1	0.0%		<0.001*
inguinal pain	1					1 / 1	100.0%		
liver cirrhosis	1					1 / 1	100.0%		
r/o spleen rupture	1					1 / 1	100.0%		
UB rupture	1					1 / 1	100.0%		
vental hernia	1					1 / 1	100.0%		

Table 4.14 described the relationship between efficiency of AR results and individual diseases. It revealed that eleven diseases (urolisthiasis, gastroenteritis, gastritis, non-specific diffuse abdominal pain, constipation, abdominal fullness, acute appendicitis, acute pancreatitis, peptic ulcer, G-I bleeding, vomiting) were with p-value less than 0.05. Five of them were with Odds Ratio greater than 1, including urolithiasis (4.64), nonspecific diffuse abdominal pain (2.01), constipation (1.66), abdominal fullness (2.2) and vomiting (1.73). The results

indicated that AR offered better efficiency in these five diseases comparing to the other ones. Additionally, AR was not recommended in the rest six diseases (gastroenteritis, gastritis, acute appendicitis, acute pancreatitis, peptic ulcer, G-I bleeding) due to the lower efficiency.

Table 4.14: Logistic Regression for Abdominal Radiography Results

		AR result		Univariate		
Clinical impression	N	n	%	OR	95%CI	p
Urolithiasis	456	225	49.3%	4.64	(3.76 , 5.73)	<0.001*
gastroenteritis	419	31	7.4%	0.24	(0.17 , 0.35)	<0.001*
Gastritis	380	8	2.1%	0.06	(0.03 , 0.13)	<0.001*
nonspecific diffuse abdominal Pain	345	119	34.5%	2.01	(1.58 , 2.56)	<0.001*
Constipation	187	59	31.6%	1.66	(1.20 , 2.29)	0.002*
abdominal Fullness	127	48	37.8%	2.20	(1.52 , 3.18)	<0.001*
GU infection	110	17	15.5%	0.63	(0.37 , 1.06)	0.079
Acute appendicitis	97	3	3.1%	0.11	(0.03 , 0.34)	<0.001*
epigastric pain	91	25	27.5%	1.33	(0.83 , 2.12)	0.235
Acute pancreatitis	84	5	6.0%	0.21	(0.09 , 0.53)	<0.001*
peptic ulcer	80	4	5.0%	0.18	(0.06 , 0.49)	<0.001*
GI bleeding	77	3	3.9%	0.14	(0.04 , 0.44)	<0.001*
Intestinal obstruction	75	20	26.7%	1.27	(0.76 , 2.14)	0.365
vomiting	73	24	32.9%	1.73	(1.05 , 2.84)	0.030*
biliary tract stone	59	7	11.9%	0.46	(0.21 , 1.02)	0.056
hematuria	51	11	21.6%	0.95	(0.49 , 1.87)	0.891
Diarrhea	37	9	24.3%	1.12	(0.52 , 2.38)	0.772
biliary tract infection	31	3	9.7%	0.37	(0.11 , 1.22)	0.101
PID	24	0	0.0%	0.00		0.998
Dysuria	19	4	21.1%	0.93	(0.31 , 2.80)	0.891
Peritonitis	19	6	31.6%	1.61	(0.61 , 4.25)	0.337
Colonic diverticulitis	14	1	7.1%	0.27	(0.03 , 2.04)	0.202
BPH	12	0	0.0%	0.00		0.998
Dysmenorrheal	11	0	0.0%	0.00		0.998
Urine retention	7	3	42.9%	2.61	(0.58 , 1.70)	0.209
Foreign body retention	6	6	100.0%			
hernia	6	1	16.7%	0.69	(0.08 , 5.95)	0.739
inguinal hernia	5	2	40.0%	2.32	(0.39 , 3.91)	0.357
vaginal bleeding	2	0	0.0%			
anal bleeding	1	1	100.0%			
dirty discharge and wound reddish via gastrostomy	1	1	100.0%			

Table 4.14: Logistic Regression for Abdominal Radiography Results

		AR result		Univariate		
Clinical impression	N	n	%	OR	95%CI	p
feeding jejunostomy tube wound pain	1	0	0.0%			
inguinal pain	1	1	100.0%			
liver cirrhosis	1	1	100.0%			
r/o spleen rupture	1	1	100.0%			
UB rupture	1	1	100.0%			
vental hernia	1	1	100.0%			

CHAPTER 5: DISCUSSION

Non-traumatic acute abdomen (NTAA) is a clinical symptom that results from various causes. In the past, the classification methods of the causes were mostly based on the locations of pain, or the forms of pain. For example, Porter (2003) classified the forms of pain as visceral pain, somatic pain, and referred pain, and the locations of pain as right or left upper quadrant pain (RUQ or LUQ), and right or left lower quadrant pain (RLQ or LLQ) in Merck Manual of Medical Information (Figure 2.1). Different forms and locations of the pain indicate different potential diseases. In addition to considerable causes of NTAA, the severities and the treatments of NTAA also vary greatly from a benign self-limited disease to a life-threatening situation that requires surgery. Therefore, NTAA is not only the major chief complaints in the emergency room, but also a challenge that for a long time the emergency physicians have been facing.

The literatures and the textbooks suggest that there is no single diagnostic tool or criteria, which is sufficient to obtain accurate diagnosis. It is necessary to combine the clinical history, the physical examinations, the laboratory examinations, the imaging studies, and sometimes the diagnostic laparoscopy, to obtain an accurate diagnosis (Kavanagh, 2004; Mosby, 2008; Porter, 2003)。

There are various choices of medical imaging for NTAA in the emergency room, including abdominal radiography (AR), sonography, computerized tomography (CT), etc. It has been extensively discussed in the overall value of each imaging study for NTAA and for each disease of NTAA, the radiation injury to the patients by each type of the imaging studies, and the overall imaging strategy in the previous literatures. For example, Lameris, et al. (2009) thoroughly addressed the issues mentioned above in their paper.(Table 5.1) The radiation dosage of AR is 25 to 37 times of the chest X-ray which was published in previous literatures (Shrimpton, Wall, Jones, & Fisher, 1986) (Chilton, 1992) (Frankfurt, 1992) (Vienna, 1996) (Ng, et al., 1998). Lameris, et al. (2009) also showed that the radiation dosage of abdominal CT in NTAA is approximately10 mSv. Although it has been proven repetitively that sonography and CT are very useful for the diagnosis of NTAA, and that AR renders very poor sensitivity and specificity in NTAA diagnosis. AR is still the most popular imaging study that the emergency physicians would order when receiving

NTAA patients. In contrast to previous observations, our study showed that there were 2912 NTAA patients visiting our ER within 6 months period and receiving AR examination. In consideration of the total patient number (N＝24861) visiting our ER during the same period, there was 12% (2912 of 24861) of ER patients received AR examination in this 6 months interval, We think that AR is popularly used in our institution. (Figure 4.1)

Table 5.1: Diagnostic Accuracy and Use of Imaging for each Imaging Strategy. Values are percentages (Lameris, et al., 2009)

Imaging strategies	Sensitivity (true positives)	Specificity (true negatives)	Missed urgent diagnoses (false negatives)	False positives*	CT use	US use
1) Clinical diagnosis	88 (86 to 91); 582	41 (36 to 46); 147	12 (79)	27; 213/795	0	0
Single imaging strategies						
2) Clinical diagnosis after plain radiographs	88 (86 to 91); 583	43 (38 to 48); 154	12 (78)	26; 206/789	0	0
3) Ultrasonography in all patients	70 (67 to 74); 465	85 (81 to 88); 305	30 (196)	11; 55/520	0	100; 1021
4) Computed tomography in all patients	89 (87 to 92); 591	77 (72 to 81); 276	11 (70)	12; 84/675	100; 1021	0
Conditional strategies						
5) US in all patients; CT if US negative†	94 (92 to 96); 620	68 (64 to 73); 246	6 (41)	16; 114/734	49 (46 to 52); 501	100; 1021
6) US in all patients; CT if US inconclusive	85 (82 to 88); 563	76 (71 to 80); 272	15 (98)	14; 88/651	27 (24 to 29); 271	100; 1021
Strategies driven by patients' characteristics						
7) If age <45 then US and CT if US negative†; if age ≥45 then CT	90 (87 to 92); 593	72 (67 to 76); 258	10 (68)	15; 102/695	78 (76 to 81); 800	47 (44 to 50); 484
8) If BMI <30 then US and CT if US negative†; if BMI ≥30 then CT	91 (88 to 93); 599	71 (67 to 76); 257	9 (62)	15; 103/702	56 (53 to 59); 570	85 (82 to 87); 864
9) If BMI <30 or age <45 then US and CT if US negative†; CT in all other patients	90 (87 to 92); 593	72 (68 to 77); 260	10 (68)	14; 100/693	81 (78 to 83); 825	42 (39 to 45); 426
Strategies driven by location of pain						
10) If tenderness RUQ then US; if tenderness RLQ, LUQ, or LLQ then CT; if diffuse tenderness then CT; CT in all other patients	89 (87 to 92); 591	78 (73 to 82); 279	11 (70)	12; 81/672	95 (93 to 96); 970	5 (4 to 7); 51
11) If tenderness RUQ or RLQ then US; if tenderness LLQ or LUQ then CT; if diffuse tenderness then CT; CT in all other patients	84 (81 to 87); 555	79 (75 to 83); 285	16 (106)	12; 75/630	65 (62 to 68); 660	35 (32 to 38); 361

BMI=body mass index; CT=computed tomography; LLQ=left lower quadrant; LUQ=left upper quadrant; RLQ=right lower quadrant; RUQ=right upper quadrant; US=ultrasonography.
*Calculated as false positives/all positives.
†Including inconclusive ultrasonography.

5.1 Overuse of AR in Evaluation of Emergent Non-Traumatic Acute Abdomen Patients:

For medical examination, it has own diagnostic efficacy and limitations. It is true for AR in NTAA. For example, when the cause of NTAA is suspected to be the perforation of GI tract, one must see the free gas in intra-abdominal cavity in imaging study. We know that AR is sufficient to see the free gas, and therefore AR has a diagnostic value to GI tract perforation-caused NTAA.

Take another example, when the NTAA is caused by a hepatic tumor, the diagnostic criterion is to see the tumor in the liver. However, the information required by such diagnostic criterion could not be obtained from AR examination. Therefore, AR doesn't have diagnostic value to hepatic tumor-caused NTAA.

In this study, among the 2912 patients who received the AR examinations, the percentages of male and of female were quite close (53.2% and 46.8%, respectively). The average age was 45.88±20.13 years old, and the median age was 43 years. The AR examinations only reported 14.8% of the patients as "abnormal" (431 of 2912 patients) (Table 4.2). This result is consistent with several previous studies. Eisenberg, et al.(1983) found that the AR abnormality in 1780 patients was 10%, 179 out of 1780 patients. Ahn, et al. (2002) reported that the abnormal rate among 871 patients was 10%, 83 of 871 patients. Kellow, et al.(2008) showed abnormal rate was 19.2%, 168 of 874 patients. In our study, the positive rate (14.8%) and sensitivity rate (14.9%) of AR examinations are relatively low, the negative rate (85.2%) and specificity rate (85.2%) are relatively high (Table 4.8), This is similar to Mackersie's study in 2005 that among 91 NTAA patients, the sensitivity was 30.0% and the specificity was 87.8%. (MacKersie, et al., 2005)

Moreover, Anyanwu,et al.(1998) indicated that the AR results only accounted for 10.4% diagnostic value for 125 NTAA patients. Tasu, et al.(2001) also mentioned 13% of the AR results having diagnostic value. These conclusions resembled the finding of low efficiency in our AR results (22.3%).

In this research, there were 27.1% of the patients (672 of 2481) with normal or nonspecific AR results who received other image examinations (Table 4.5). This reflected that the emergency physicians thought the AR result of "no abnormality" questionable. The subsequent follow-up for the image examinations of these 672 patients showed 84.2% of the patients (566 of 672) were found to be "abnormal" (Table 4.6). The follow-up imaging result was similar to the research by Kellow, et al. (2008) which showed that 75.5% (255 of 337) of the patients with normal or non-specific AR results had abnormal results in the follow-up image studies. It was reasonable for the emergency physicians to doubt the AR results. Based on the fore-mentioned findings, when the AR results showed normal or non-specific, AR could not fully support the emergency physicians to find the true culprit of NTAA.

As for the rate of AR abnormality in both studies, 14.8% in this article and 19.2% in the study by Kellow, et al.(2008), were both less than 20%, there were only 29% of patients receiving image follow-up in our study but 50% in Kellow's study. The differences between these two studies were not formally discussed here, but this might be due to the restrictions on the CT examination,

sonography, and others, set by global budget under National Health Insurance (NHI) in Taiwan. If the insurance influenced the behaviors of medical care and even the diagnosis of diseases, it would be necessary to re-evaluate the benefits and disadvantages of the policy.

Meanwhile, since AR was not reliable for NTAA diagnosis, the optimized direct use of sonography and CT scans to replace AR can remove the constraints of the insurance system, reduce unnecessary use of AR, and improve the efficiency of disease diagnosis (Fig.5.1). Such discussion appeared in previous literatures. For example, Ann, et al.(2002) recruiting 1000 NTAA patients and suggested that AR has low sensitivity to examine patients of acute abdominal pain in the ER. Therefore, abdominal CT should be performed initially in patients with a high clinical impression of suspicion of intra-abdominal disease. Mackersie, et al.(2005) commented "AR is an insensitive technique in the evaluation of NTAA. Unenhanced helical CT is an effective technique in the evaluation of patients with NTAA and it should be considered as an alternative to AR as the initial imaging modality."

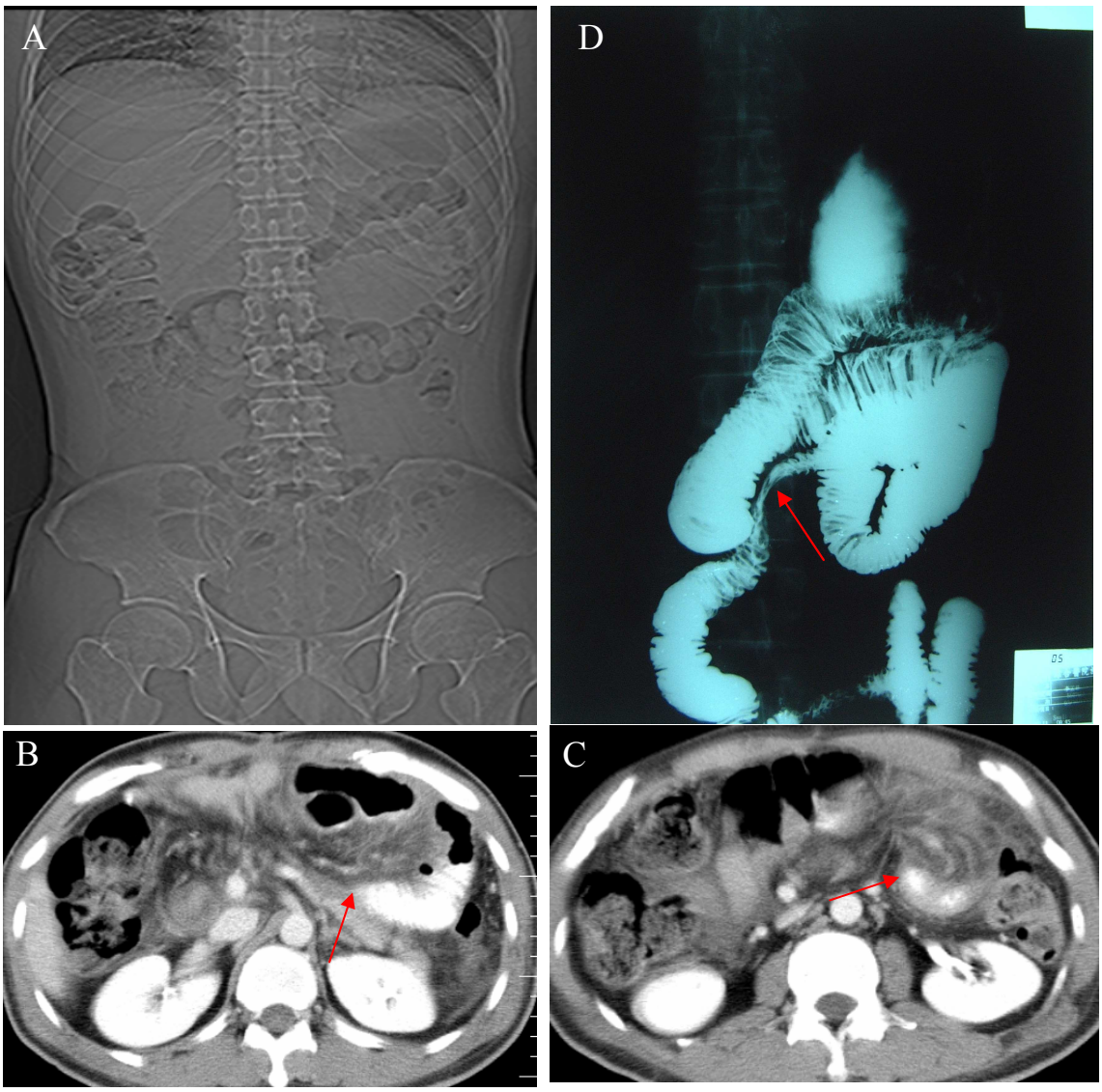

Fig.5.1 43Y/O Male with NTAA and had received Whipple Procedure due to distal CBD adenocarcinoma. (A):AR showed non-specific findings. (B)&(C): CECT showed adhesive small bowel obstruction at jejunum. (D).Small bowel series confirmed the diagnosis.

Foinant,et al.(2007) studied 90 NTAA patients and concluded "CT was contributed to reducing costs in 15.5% of patients, for an additional cost estimated at 104-139 Euros, CT appears to be a choice of examination to guide patient care in NTAA. Kellow,et al.(2008) concluded that the AR results contribute to patient treatment in a small percentage of NTAA cases. If patient requires investigation beyond clinical history, PE, and lab. As a result, the emergency physician should be encouraged to request more definitive imaging."

In Table 4.8, 2912 NTAA patients of different causes in this study were found to have true negative (TN) rate as 10.5%, false negative (FN) rate as 89.5%, false positive (FP) rate as 9.5%, and true positive (TP) rate as 90.5%.

With Chi-Square test, we found that the AR results did not have significant diagnostic power ($p > .05$).

To summarize, the AR results have a low rate of abnormality, a low sensitivity rate, low accuracy, and do not exhibit significant diagnostic values. We reasoned that AR has been overused in the diagnosis processes of the NTAA patients in our study. This is consistent with the literatures abroad in the past three decades. Therefore, we believe that the use of AR, as a diagnostic tool in emergency room, needs to be further restricted and specified, in order to reduce un-necessary financial waste and to decrease the negative effects of AR, including the radiation damages, pain caused when the patients are transported, the delay of appropriate diagnosis, etc.

Since AR is considered overused, we will discuss the reasons of abuse in the views of the clinical practices and the past literatures:

1. Unclear clinical impression before ordering an AR test

   Each AR test depends on the clinical impression. According to the X-ray findings, it will finally obtain an AR result with interpretations as normal, non-specific, or abnormal. When the clinical impression of prescribed AR tests is not clear, the accuracy of the AR test will inevitably decrease and therefore delay the diagnosis.(Morris-Stiff, et al., 2006)

2. The insufficiency of emergency physicians' knowledge toward the AR tests includes the radiation of the AR examination, the interpretation of the AR examination (misuse and misinterpretation). Finally, this leads to the abuse of AR tests and the decrease of diagnostic power.

   Anyanwu, et al.(1998) described AR is used in a high rate as a screening tool for normality. Emergency physicians may lack sufficient skills to reliably interpret AR films. Some AR films are probably requested simply to avoid criticisms from senior physicians or to complete a set of assessment without any real interest in the outcome of investigation. The persistently high utilization of AR is a result of the ignorance of young emergency physicians without radiology training in interpreting radiographs. Stower, et al.(1985) mentioned that in a third of the patients in their study, the ED house doctors did not think the radiological results would be abnormal in 60.8% of cases. AR was requested just to exclude a serious problem, which suggests that the AR is being used as a defensive screening investigation, perhaps to avoid subsequent criticism from more senior staff.

3. There is no AR guideline for the NTAA patients, or the emergency physicians do not obey the guideline. Eisenberg, et al.(1983) indicated that if the emergency physicians obeyed the AR guidelines to treat NTAA, then 53.7% of patients could avoid AR tests. Morris, et al.(2006) said that if the emergency physicians followed the guidelines to use AR tests, the positive rate of AR exams would be 76.6% and, if the guidelines not followed, the positive rate would be only 8.9%. Mackersie, et al.(2005) reported there were a lot of reasons why the emergency physicians disobeyed the guidelines, including the demand on the emergency physicians to quickly diagnose the cause of the symptoms and to provide a disposition in a busy emergency room. Billittier, et al.(1996) indicated that the reason why the emergency physicians disobeyed the guidelines was the concern of documentation and defense medicine.
4. The wrong choices of the types of AR films:

   Mirvis, et al. (1986) and Ukrisana, et al. (2002) agreed that the AR films of erect positions did not help in NTAA diagnosis. Therefore, avoiding using the AR films of erect positions could reduce the overuse of AR tests.

5.2 The Diagnostic Value of AR examination for each kind of NTAA Causes

Overall, the abuse of AR tests was concluded from the discussion of the diagnostic value of AR films. However, questions remained: whether the abuse was caused in treating some of the 37 causes or not, whether the use of AR examination was still having diagnostic value for some diseases and how to correctly use the AR test for these numerous diseases of NTAA. Based on these questions, we will further discuss the relationship between AR examination and the 37 diseases causing NTAA in the following discussion.

In 2912 patients, there were 37 kinds of clinical impressions that required AR examination. (Table 4.9) For different causes, the relationships between the AR results and the degree of follow-up images (Table 4.9) and between the AR results and the results of follow-up images (Table 4.10) resembled the results in Table 4.5 and 4.6. It is to say that AR results were not trusted by the emergency physicians, even based on disease-specific analysis, which was proven from the high degree of follow-up images no matter what the AR results were and high rate of abnormality in follow-up images(Appendix 2). The follow-up rate was

higher for diseases such as biliary tract infection (74.2%, 23/31), acute appendicitis (63.9%, 62/97) (Fig 5.2), acute pancreatitis (59.5%, 50/84) (Fig.5.3), peritonitis (57.9%, 11/19), biliary tract stone (55.9%, 33/59), urolithiasis (50%, 227/456). This implied that the emergency physicians had the least confidence in the AR results of these diseases.

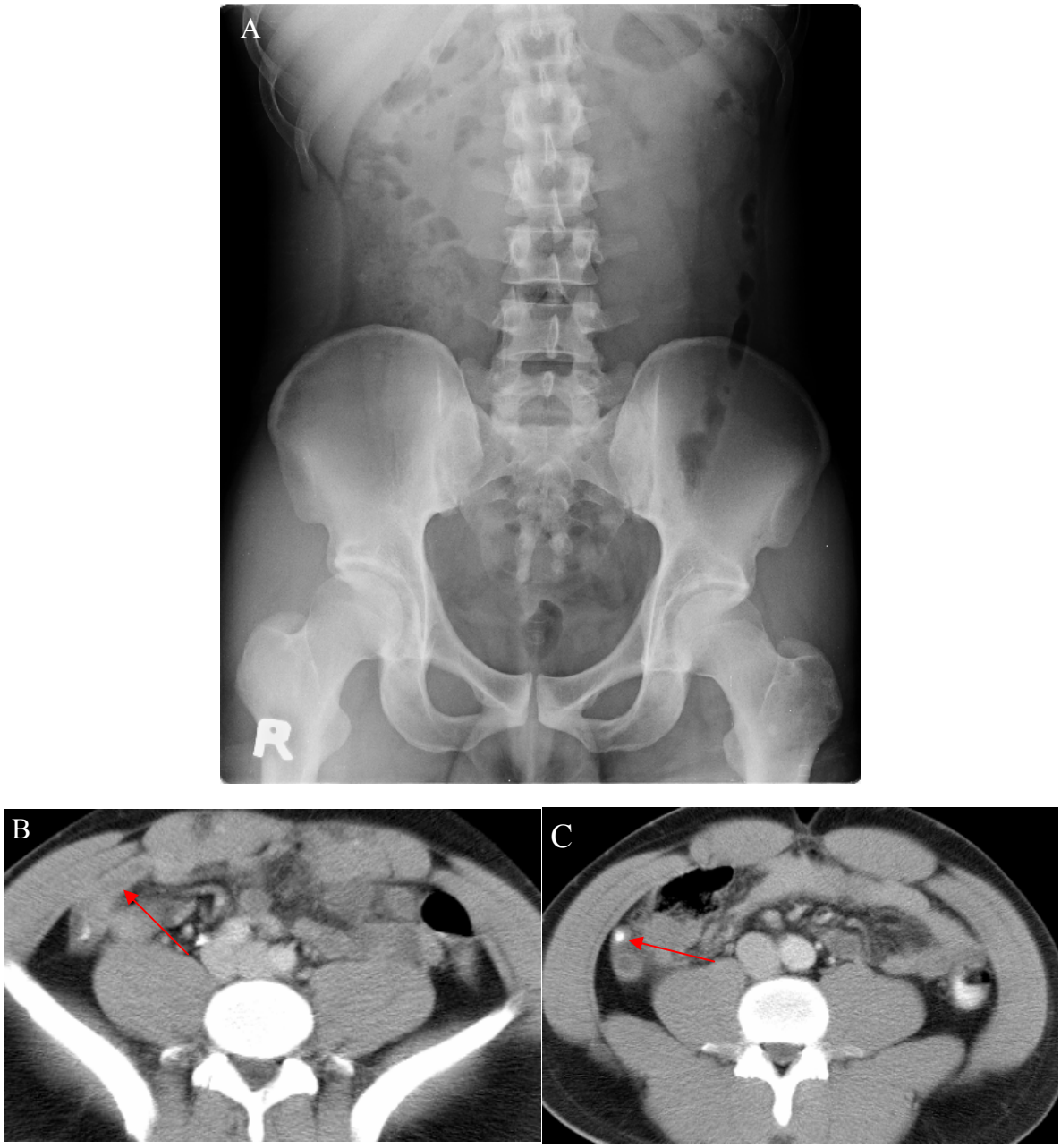

Fig.5.2: **a 29 Y/O Male with clinical impression of acute appendicitis. (A):AR showed "Negative". (B)&(C): CECTshowed "positive" with appendicolith formation.**

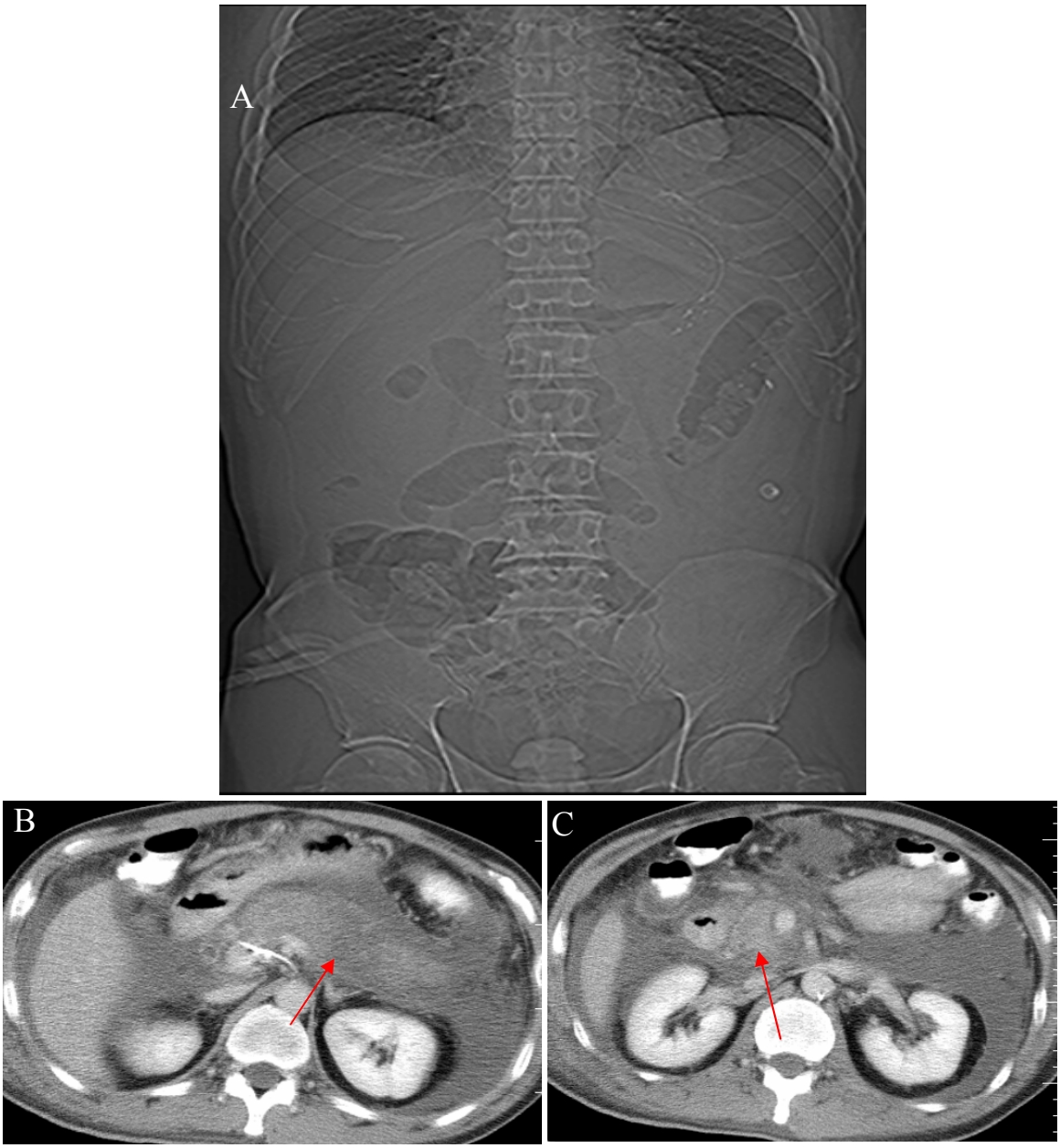

Fig.5.3: **46 Y/O Male with clinical impression of acute pancreatitis. (A):AR result showed :Non-specific". (B)&(C): CECT showed "major positive"**

In the analysis of Table 4.9 and 4.10, we observed something interesting, such as that the abnormal results of follow-up images was as high as 93.8% for the "abnormal" results of AR films in the initial diagnosis "abdominal fullness". Eisenberg, et al.(1983) reported the prescription of AR tests might aim to (1). Confirm the suspected diagnosis, and (2). Rule out the diagnosis. For "abdominal fullness", the physicians ordering the AR might expect to rule out the disease, the higher of the abnormality in AR tests was, the emergency physicians had more doubt for it and the rate of follow-up images increased

significantly. Moreover, Prasannan, et al.(2005) mentioned that although urinary stone might be visible, it is possible to have false positive (FP) and false negative (FN) as high as 50% of the patients. In our study, although abnormality in AR results and the abnormality in follow-up results were highly associated for urolithiasis, the emergency physicians did not trust the results of AR examination and prescribed other imaging studies. It is worth thinking whether this is the overuse of AR examinations.

Analysized the AR diagnostic value for each 37 clinical impressions, we found the negative rate and FN rate were high for AR examination. For each disease, the AR abnormal rate was low (Table 4.11). Meanwhile, every one of the 37 diseases had very high positive predictive value (PPV) and high specificity, very low negative predictive value (NPV) and sensitivity. (Table 4.12) This result was similar to the conclusion of Table 4.8. In other words, in the 37 diseases indicated for AR prescription, there was no any disease showing the significant diagnostic value of AR tests. This was slightly different from previous literatures. For example, Anynwu et al.(1998) thought that AR examinations were valuable to diagnose gastrointestinal obstruction, perforation or ischemia or renal coli. Ahn,et al.(2002) considered that AR examination had higher sensitivity for intra-abdominal foreign body (90%) and bowel obstruction (49%). Reviewing the literature from 1976 to 2009, we found that even the authors thought the AR tests were valuable for certain diseases, but not all of them concluded uniformly for the diseases of diagnostic values. Similar to our results, Kellow, et al.(2008) thought that, except Catheter placement, AR examination did not have significant value for NTAA-related diseases. In addition, even some authors proposed that AR tests benefited some diseases, but everyone agreed that it would be necessary to perform nice evaluations before ordering the AR and follow the guidelines for AR tests. Based on our results, there were very high normal and non-specific AR results (85.2%) and very high

FN rate (89.5%); meanwhile, there were no referral guideline of AR for NTAA in our emergency department, the future focus to discuss is the emergency physicians' knowledge toward the AR examination and the follow-up guidelines.

Besides, in these 37 clinical impressions, there were six cases of "intra-abdominal foreign body retention" not receiving other image follow-up. In these six cases, two cases had negative AR results and four cases had abnormal AR

results.(Fig. 5.4) The final result was TP：100% (4 of 4) and TN：100% (2 of 2). Similar to Rothrock's study (1992), they found that restricting AR tests to patients with at least one of these five high-yield clinical features (prior abdominal surgery, foreign body ingestion, abnormal bowel sounds, distention, peritoneal signs) would provide the most diagnostic power. Ahn, et al.(2002) interpreted "the highest sensitivity of AR as 90% for intra-abdominal foreign body" was similar to our results. Although the sample size of" foreign body retention" was small in our study, we still had the confidence to believe that AR test had high diagnostic power for "intra-abdominal radiopaque foreign body retention".

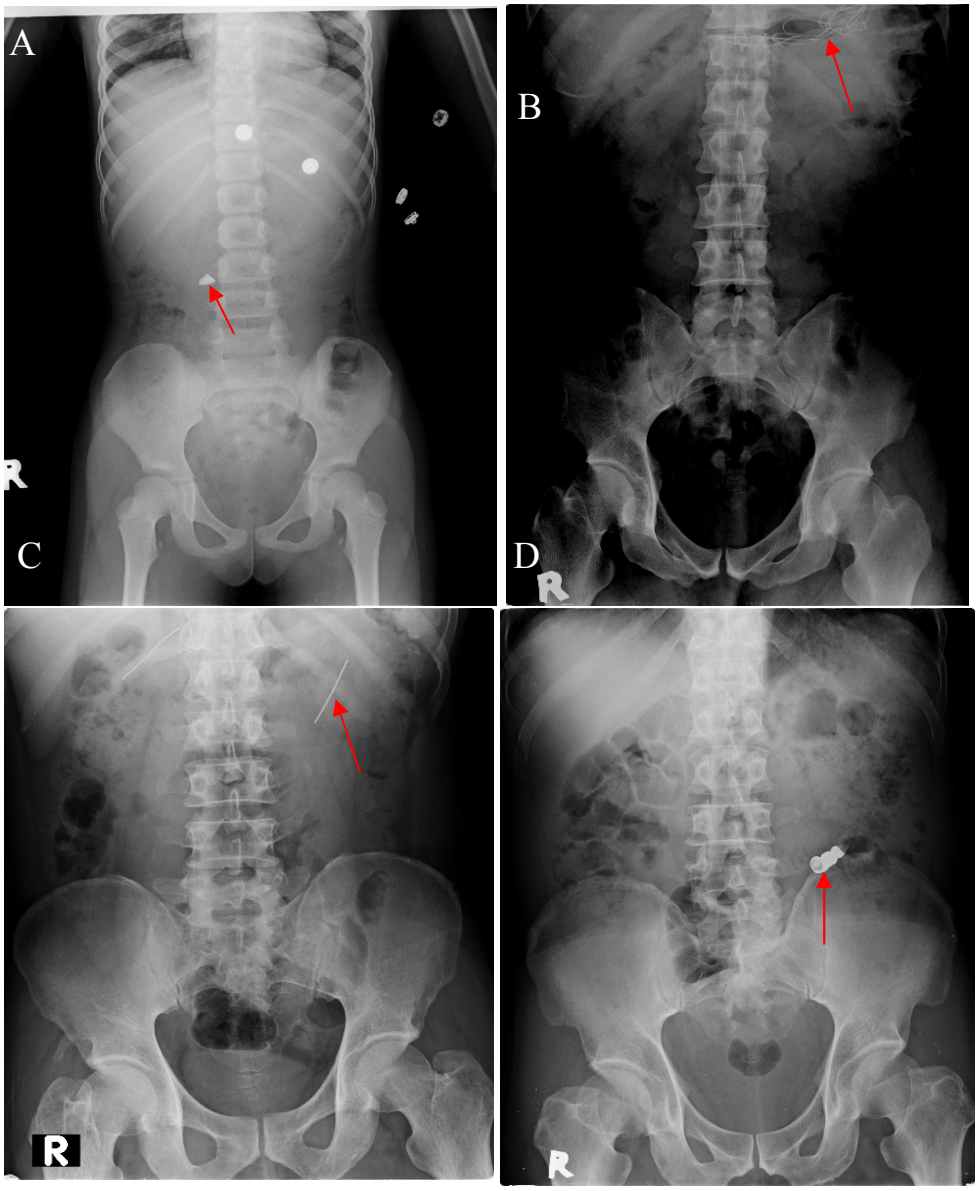

Fig.5.4: **Clinical impression of radiopaque foreign body retention. (A).7Y/O, Female, miss-swallow of magnet. (B).46Y/O, Male, miss-swallow of iron-wire. (C).43Y/O,Male with metallic pin retention. (D).55Y/O, male with artificial- tooth retention.**

Though the diagnostic value of AR tests for each clinical impression was not as expected in this study, if studies for the relation between separating AR results as positive and negative (Table 4.13) or analyzing the diagnostic value based on the efficiency of AR tests with the individual disease(Table 4.14), we found as follows.

1. If the AR results were positive (abnormal), it had significance toward five diseases, including urolithiasis, non-specific diffuse abdominal pain, epigastric pain, diarrhea, and dysuria. Besides, the odds ratio of urolithiasis

was greater than one (2.14). The Odds Ratios of the other four diseases were less than one. The result showed that the AR examination would be an acceptable test for emergency physicians to prove the diagnosis of urolithiasis, based on the 37 diseases covered in this study. By the same token, among these 37 diseases, if the emergency physicians would like to prove any one of the four diseases, non-specific diffuse abdominal pain, epigastric pain, diarrhea, and dysuria, AR test was not indicated.

2. If AR results were negative or non-specific (no abnormal), even there were ten diseases had significance, no matter the Odds Ratio greater or less than one, but the NPV of AR results were very low for any disease in this study. Hence the study considered that, if emergency physicians want to exclude the disease in these 37 clinical impressions, AR results had no value for diagnosis.
3. Similarly, considering the diagnostic value of AR efficiency for each clinical impression, AR tests had efficiency as 49.3% for urolithiasis and Odds ratio as 4.64, $p < .01$. This suggested AR tests could be considered for emergency physicians.

In summary, we could conclude for the AR's diagnostic value for NTAA in this study as follows:

1. Based on the study of 2912 NTAA patients, we thought the AR examination was abused.
2. If the emergency physicians would like to prove that urolithiasis caused NTAA, AR test had the diagnostic value.
3. On the contrary, if the emergency physicians would like to prove that the abdominal pain was caused by one of the four diseases: non-specific diffuse abdominal pain, epigastric pain, diarrhea, or dysuria, AR test had no value for diagnosis.
4. For the 37 clinical impressions listed in this study, if the emergency physicians would like to exclude these diseases, AR test had no diagnostic value.
5. For disease of "intra-abdominal radiopaque foreign body retention", although the sample size in this study was small, we believed that AR tests had diagnostic value.

Reference

Ahn, S. H., Mayo-Smith, W. W., Murphy, B. L., Reinert, S. E., Cronan, J. J., Ahn, S. H., et al. (2002). Acute nontraumatic abdominal pain in adult patients: abdominal radiography compared with CT evaluation. [Comparative Study]. *Radiology, 225*(1), 159-164.

Anyanwu, A. C., & Moalypour, S. M. (1998). Are abdominal radiographs still overutilized in the assessment of acute abdominal pain? A district general hospital audit.[see comment]. *Journal of the Royal College of Surgeons of Edinburgh, 43*(4), 267-270.

Balthazar, E., & Chako, A. (1990). Computerised tomography in acute gastrointestinal disorders. *Am J gastroenterol, 85*, 1445-1452.

Berry, M., Chowdahury, V., & Suri, S. (2004). Diagnostic Radiography gastrointestinal and hepatobiliary imaging 2nd. Ed. *text book*, 21-36.

Billittier, A. J., Abrams, B. J., & Brunetto, A. (1996). Radiographic imaging modalities for the patient in the emergency department with abdominal complaints. [Review]. *Emergency Medicine Clinics of North America, 14*(4), 789-850.

Campbell, J. P., & Gunn, A. A. (1988). Plain abdominal radiographs and acute abdominal pain. *British Journal of Surgery, 75*(6), 554-556.

Chilton (1992). National protocol for patent dose measurements in diagnostic radiology dosimetry. *National Radiological Protection Board (NRPB)*.

Debombal, F. T. (1991). Diagnosis of acute abdominal pain. *text book, 2nd. ed.*, 1-10.

Eisenberg, R. L., Heineken, P., Hedgcock, M. W., Federle, M., & Goldberg, H. I. (1983). Evaluation of plain abdominal radiographs in the diagnosis of abdominal pain. [Research Support, Non-U.S. Gov't]. *Annals of Surgery, 197*(4), 464-469.

Feyler, S., Williamson, V., & King, D. (2002). Plain abdominal radiographs in acute medical emergencies: an abused investigation?[see comment]. *Postgraduate Medical Journal, 78*(916), 94-96.

Foinant M, L. E., Buc E, Boire J Y, Schmidt J, Garcier J M, Pezet D, Boyer L (2007). Impact of computed tomography on patient's care in nontraumatic acute abdomen: 90 patients *Journal de Radiologie, 88*(4), 559-566.

Frankfurt (1992). Average patient exposure/dose guides. *Council of radiation Control Program Directors (CRCPD)* 92-94.

Gerhardt, R. T., Nelson, B. K., Keenan, S., Kernan, L., MacKersie, A., Lane, M. S., et al. (2005). 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. [Clinical Trial, Phase I]. *American Journal of Emergency Medicine, 23*(6), 709-717.

Greene, C. S. (1986). Indications for plain abdominal radiography in the emergency department [Review]. *Annals of Emergency Medicine, 15*(3), 257-260.

Hart, D., & Wall, B. (2002). Radiation exposure of the UK population from medical and dental X-ray examinations. *Didcot National Radiological Protection Board*.

Johnson, J. L., & Abernacy, D. L. (1983). Diagnostic imaging procedure volumes in the United States *Radiology, 146*, 851-853.

Kamin, R. A., Nowicki, T. A., Courtney, D. S., Powers, R. D., Kamin, R. A., Nowicki, T. A., et al. (2003 Feb). Pearls and pitfalls in the emergency department evaluation of abdominal pain. [Review]. *Emergency Medicine Clinics of North America, 21*(1), 61-72.

Kavanagh, S. (2004). The acute abdomen - assessment, diagnosis and pitfalls. *UK MPS Casebook (text book), 12(1)*, 11-17.

Kellow, Z. S., MacInnes, M., Kurzencwyg, D., Rawal, S., Jaffer, R., Kovacina, B., et al. (2008). The role of abdominal radiography in the evaluation of the nontrauma emergency patient.[see comment]. *Radiology, 248*(3), 887-893.

Laing, F. (1981). Ultrasonic evaluation of patients with acute right upper quadrant pain. *Radiology 140*, 449-455.

Lameris, W., van Randen, A., van Es, H. W., van Heesewijk, J. P., van Ramshorst, B., Bouma, W. H., et al. (2009). Imaging strategies for detection of urgent conditions in patients with acute abdominal pain: diagnostic accuracy study. [Multicenter Study

Research Support, Non-U.S. Gov't]. *BMJ, 338*, b2431.

Lee, P. W. (1976). The plain X-ray in the acute abdomen: a surgeon's evaluation *British Journal of Surgery, 63*(10), 763-766.

MacKersie, A. B., Lane, M. J., Gerhardt, R. T., Claypool, H. A., Keenan, S., Katz, D. S., et al. (2005). Nontraumatic acute abdominal pain: unenhanced helical CT compared with three-view acute abdominal series. [Comparative Study]. *Radiology, 237*(1), 114-122.

McCook, T. A., Ravin, C. E., & Rice, R. P. (1982). Abdominal radiography in the emergency department: a prospective analysis. *Annals of Emergency Medicine, 11*(1), 7-8.

Mirvis, S. E., Young, J. W., Keramati, B., McCrea, E. S., & Tarr, R. (1986). Plain film evaluation of patients with abdominal pain: are three radiographs necessary? *AJR American Journal of Roentgenology, 147*(3), 501-503.

Morris-Stiff, G., Stiff, R. E., & Morris-Stiff, H. (2006). Abdominal radiograph requesting in the setting of acute abdominal pain: temporal trends and appropriateness of requesting. *Annals of the Royal College of Surgeons of England, 88*(3), 270-274.

Mosby (2008). Definition of acute abdomen in the medial dictionary. *Mosby's Medical Dictionary, 8th edition*.

Ng, K., P, R., & HB, W. (1998). Doses to patients in routine x-rayexaminations in Malaysia

Br J Radiol71, 654-660.

Porter, R. S. (2003). Acute Abdominal Pain. *The Merck Manual of Medical Information (2nd. edition)*.

Prasannan, S., Zhueng, T. J., Gul, Y. A., Prasannan, S., Zhueng, T. J., & Gul, Y. A. (2005). Diagnostic value of plain abdominal radiographs in patients with acute abdominal pain. *Asian Journal of Surgery, 28*(4), 246-251.

Robert, S., & Porter (2003). Acute Abdominal Pain. *Merck Manual (Text book)*.

Rockville, M. D. (1976). Gonad doses and genetically significant dose from diagnostic radiology.United States-1964 and 1970964. *DHEW publication No. FDA-76-8034. Bureau of Radiologic Health.* .

Rothrock, S. G., Green, S. M., & Hummel, C. B. (1992). Plain abdominal radiography in the detection of major disease in children: a prospective analysis. [Review]. *Annals of Emergency Medicine, 21*(12), 1423-1429.

Sala, E. (2007). A randomized, controlled trial of routine early abdominal computed tomography in patients presenting with non-specific acute abdominal pain. *Clinic radiology, 63*(10), 961-969.

Shrimpton, P. C., Wall, B., Jones, D., & Fisher, E. (1986). A national survey of doses to patients undergoing a selecton of routine examinations in English hospitals. *NRPB-R200.London:HMSO*.

Silen, W. (1996). Cope's early diagnosis of the acute abdomen. [text book]. *Text book, 19th. ed.*

Staniland, J. (1972). Clinical presentation of acute abdomen: study of 600 patients. *BMJ, 3*, 393-398.

Stower, M. J., Amar, S. S., Mikulin, T., Kean, D. M., & Hardcastle, J. D. (1985). Evaluation of the plain abdominal X-ray in the acute abdomen. *Journal of the Royal Society of Medicine, 78*(8), 630-633.

Tasu, J. P., Takun, K., Rocher, L., Livartowski, J., Nguyen, D. T., Miquel, A., et al. (2001). [Evaluation of plain abdominal radiography prescriptions in a university hospital center]. [English Abstract]. *Presse Medicale, 30*(22), 1097-1101.

Ukrisana, P., & Yenarkarn, P. (2002). Evaluation of the necessity of the three-film abdominal series in the diagnosis of abdominal pain.[erratum appears in J Med Assoc Thai. 12004 Sep;87(9):140]. [Evaluation Studies]. *Journal of the Medical Association of Thailand, 85*(9), 998-1002.

Vienna (1996). International Basic Safety Standards for Protection Against Ionizing Radiation and for the safety of Radiation Sources *International Atomic Energy Agency (IAEA), Safety series no. 115-1*.

Appendix

Appendix 1: Relation between Radiography Result & Follow-up Image by Clinical Indication

Clinical Impression	Radiography results	N	Follow-up image		Odds Ratio	95%CI	p value
			No	Yes			
1							
Urolithiasis	Normal	203	102 (50.2%)	101 (49.8%)	1.00	Reference	
	Non-specific	67	37 (55.2%)	30 (44.8%)	0.82	(0.47 , 1.43)	0.571
	Abnormal	186	90 (48.4%)	96 (51.6%)	1.08	(0.72 , 1.60)	0.791
		456	229 (50.2%)	227 (49.8%)			
2							
gastroenteritis	Normal	269	230 (85.5%)	39 (14.5%)	1.00	Reference	
	Non-specific	124	106 (85.5%)	18 (14.5%)	1.00	(0.55 , 1.83)	1.000
	Abnormal	26	21 (80.8%)	5 (19.2%)	1.40	(0.50 , 3.94)	0.719
		419	357 (85.2%)	62 (14.8%)			
3							
Gastritis	Normal	256	234 (91.4%)	22 (8.6%)	1.00	Reference	
	Non-specific	122	113 (92.6%)	9 (7.4%)	0.85	(0.38 , 1.90)	0.839
	Abnormal	2	2 (100.0%)	0 (0.0%)			1.000
		380	349 (91.8%)	31 (8.2%)			
4							
Non-specific diffuse abdominal Pain	Normal	189	132 (69.8%)	57 (30.2%)	1.00	Reference	
	Non-specific	112	74 (66.1%)	38 (33.9%)	1.19	(0.72 , 1.96)	0.581
	Abnormal	44	28 (63.6%)	16 (36.4%)	1.32	(0.66 , 2.63)	0.536
		345	234 (67.8%)	111 (32.2%)			
5							
constipation	Normal	96	95 (99.0%)	1 (1.0%)	1.00	Reference	
	Non-specific	39	38 (97.4%)	1 (2.6%)	2.50	(0.15, 41.00)	0.495
	Abnormal	52	48 (92.3%)	4 (7.7%)	7.92	(0.86 , 72.79	0.051
		187	181 (96.8%)	6 (3.2%)			
6							
abdominal fullness	Normal	74	57 (77.0%)	17 (23.0%)	1.00	Reference	
	Non-specific	33	27 (81.8%)	6 (18.2%)	0.75	(0.26 , 2.10)	0.076
	Abnormal	20	10 (50.0%)	10 (50.0%)	3.35	(1.20 , 9.40)	<0.001*
		127	94 (74.0%)	33 (26.0%)			
7							
GU infection	Normal	61	53 (86.9%)	8 (13.1%)	1.00	Reference	
	Non-specific	32	24 (75.0%)	8 (25.0%)	2.21	(0.74 , 6.58)	0.248
	Abnormal	17	14 (82.4%)	3 (17.6%)	1.42	(0.33 , 6.06)	0.696
		110	91 (82.7%)	19 (17.3%)			
8							
Acute appendicitis	Normal	59	22 (37.3%)	37 (62.7%)	1.00	Reference	
	Non-specific	37	13 (35.1%)	24 (64.9%)	1.10	(0.47 , 2.59)	1.000
	Abnormal	1	0 (0.0%)	1 (100.0%)			1.000
		97	35 (36.1%)	62 (63.9%)			

Clinical Impression	Radiography results	N	Follow-up image		Odds Ratio	95%CI	p value
			No	Yes			
9							
epigastric pain	Normal	55	42 (76.4%)	13 (23.6%)	1.00	Reference	
	Non-specific	33	26 (78.8%)	7 (21.2%)	0.87	(0.31 , 2.46)	1.000
	Abnormal	3	1 (33.3%)	2 (66.7%)	6.46	(0.54 , 77.14)	0.161
		91	69 (75.8%)	22 (24.2%)			
10							
Acute pancreatitis	Normal	46	23 (50.0%)	23 (50.0%)	1.00	Reference	
	Non-specific	35	11 (31.4%)	24 (68.6%)	2.18	(0.87 , 5.47)	0.146
	Abnormal	3	0 (0.0%)	3 (100.0%)			0.278
		84	34 (40.5%)	50 (59.5%)			
11							
peptic ulcer	Normal	40	28 (70.0%)	12 (30.0%)	1.00	Reference	
	Non-specific	36	24 (66.7%)	12 (33.3%)	1.17	(0.44 , 3.07)	0.948
	Abnormal	4	3 (75.0%)	1 (25.0%)	0.78	(0.07 , 8.25)	1.000
		80	55 (68.8%)	25 (31.3%)			
12							
GI bleeding	Normal	45	39 (86.7%)	6 (13.3%)	1.00	Reference	
	Non-specific	30	20 (66.7%)	10 (33.3%)	3.25	(1.03 , 10.23)	0.074
	Abnormal	2	0 (0.0%)	2 (100.0%)			0.025*
		77	59 (76.6%)	18 (23.4%)			
13							
Intestinal obstruction	Normal	19	11 (57.9%)	8 (42.1%)	1.00	Reference	
	Non-specific	41	24 (58.5%)	17 (41.5%)	0.97	(0.32 , 2.93)	1.000
	Abnormal	15	5 (33.3%)	10 (66.7%)	2.75	(0.67 , 11.24)	0.185
		75	40 (53.3%)	35 (46.7%)			
14							
vomiting	Normal	47	40 (85.1%)	7 (14.9%)	1.00	Reference	
	Non-specific	6	5 (83.3%)	1 (16.7%)	1.14	(0.12 , 11.31)	1.000
	Abnormal	20	15 (75.0%)	5 (25.0%)	1.90	(0.52 , 6.93)	0.522
		73	60 (82.2%)	13 (17.8%)			
15							
biliary tract stone	Normal	34	17 (50.0%)	17 (50.0%)	1.00	Reference	
	Non-specific	20	8 (40.0%)	12 (60.0%)	1.50	(0.49 , 4.59)	0.667
	Abnormal	5	1 (20.0%)	4 (80.0%)	4.00	(0.40 , 39.58)	0.348
		59	26 (44.1%)	33 (55.9%)			
16							
hematuria	Normal	29	16 (55.2%)	13 (44.8%)	1.00	Reference	
	Non-specific	14	8 (57.1%)	6 (42.9%)	0.92	(0.25 , 3.34)	1.000
	Abnormal	8	6 (75.0%)	2 (25.0%)	0.41	(0.07 , 2.38)	0.431
		51	30 (58.8%)	21 (41.2%)			
17							
diarrhea	Normal	21	17 (81.0%)	4 (19.0%)	1.00	Reference	
	Non-specific	11	9 (81.8%)	2 (18.2%)	0.94	(0.14 , 6.19)	1.000
	Abnormal	5	5 (100.0%)	0 (0.0%)			0.555
		37	31 (83.8%)	6 (16.2%)			
18							
biliary tract infection	Normal	19	4 (21.1%)	15 (78.9%)	1.00	Reference	
	Non-specific	9	3 (33.3%)	6 (66.7%)	0.53	(0.09 , 3.13)	0.646
	Abnormal	3	1 (33.3%)	2 (66.7%)	0.53	(0.04 , 7.49)	1.000

Clinical Impression	Radiography results	N	Follow-up image		Odds Ratio	95%CI	p value
			No	Yes			
		31	8 (25.8%)	23 (74.2%)			
19							
PID	Normal	14	10 (71.4%)	4 (28.6%)	1.00	Reference	
	Non-specific	10	9 (90.0%)	1 (10.0%)	0.28	(0.03 , 2.97)	0.357
	Abnormal	0	0	0			
		24	19 (79.2%)	5 (20.8%)			
20							
dysuria	Normal	8	6 (75.0%)	2 (25.0%)	1.00	Reference	
	Non-specific	8	5 (62.5%)	3 (37.5%)	1.80	(0.21 , 15.41)	1.000
	Abnormal	3	1 (33.3%)	2 (66.7%)	6.00	(0.34 , 107.42)	0.490
		19	12 (63.2%)	7 (36.8%)			
21							
Peritonitis	Normal	9	4 (44.4%)	5 (55.6%)	1.00	Reference	
	Non-specific	4	2 (50.0%)	2 (50.0%)	0.80	(0.08 , 8.47)	1.000
	Abnormal	6	2 (33.3%)	4 (66.7%)	1.60	(0.19 , 13.70)	1.000
		19	8 (42.1%)	11 (57.9%)			
22							
Colonic diverticulitis	Normal	7	2 (28.6%)	5 (71.4%)	1.00	Reference	
	Non-specific	6	1 (16.7%)	5 (83.3%)	2.00	(0.13 , 29.81)	1.000
	Abnormal	1	0 (0.0%)	1 (100.0%)			
		14	3 (21.4%)	11 (78.6%)			
23							
BPH	Normal	7	4 (57.1%)	3 (42.9%)	1.00	Reference	
	Non-specific	5	2 (40.0%)	3 (60.0%)	2.00	(0.19 , 20.61)	1.000
	Abnormal	0	0	0			
		12	6 (50.0%)	6 (50.0%)			
24							
dysmenorrhea	Normal	4	4 (100.0%)	0 (0.0%)			
	Non-specific	7	5 (71.4%)	2 (28.6%)			0.490
	Abnormal	0	0	0			
		11	9 (81.8%)	2 (18.2%)			
25							
Urine retention	Normal	4	4 (100.0%)	0 (0.0%)			
	Non-specific	2	2 (100.0%)	0 (0.0%)			
	Abnormal	1	1 (100.0%)	0 (0.0%)			
		7	7 (100.0%)	0 (0.0%)			
26							
Foreign body retention	Normal	1	1 (100.0%)	0 (0.0%)			
	Non-specific	1	1 (100.0%)	0 (0.0%)			
	Abnormal	4	4 (100.0%)	0 (0.0%)			
		6	6 (100.0%)	0 (0.0%)			
27							
hernia	Normal	3	2 (66.7%)	1 (33.3%)	1.00	Reference	
	Non-specific	3	2 (66.7%)	1 (33.3%)	1.00	(0.03 , 29.81)	1.000
	Abnormal	0	0	0			
		6	4 (66.7%)	2 (33.3%)			
28							
inguinal hernia	Normal	2	2 (100.0%)	0 (0.0%)			

Clinical Impression	Radiography results	N	Follow-up image		Odds Ratio	95%CI	p value
			No	Yes			
	Non-specific	3	2 (66.7%)	1 (33.3%)			
	Abnormal	0	0	0			
		5	4 (80.0%)	1 (20.0%)			
29							
vaginal bleeding	Normal	1	1 (100.0%)	0 (0.0%)			
	Non-specific	1	1 (100.0%)	0 (0.0%)			
	Abnormal	0	0	0			
		2	2 (100.0%)	0 (0.0%)			
30							
anal bleeding	Normal	0	0	0			
	Non-specific	1	1 (100.0%)	0 (0.0%)			
	Abnormal	0	0				
		1	1 (100.0%)	0 (0.0%)			
31							
dirty discharge and wound reddish via gastrostomy	Normal	1	1 (100.0%)	0 (0.0%)			
	Non-specific	0	0	0			
	Abnormal	0	0	0			
		1	1 (100.0%)	0 (0.0%)			
32							
feeding jejunostomy tube wound pain	Normal	0	0	0			
	Non-specific	1	1 (100.0%)	0 (0.0%)			
	Abnormal	0	0	0			
		1	1 (100.0%)	0 (0.0%)			
33							
inguinal pain	Normal	1	0 (0.0%)	1 (100.0%)			
	Non-specific	0	0	0			
	Abnormal	0	0	0			
		1	0 (0.0%)	1 (100.0%)			
34							
liver cirrhosis	Normal	0	0	0			
	Non-specific	1	0 (0.0%)	1 (100.0%)			
	Abnormal	0	0	0			
		1	0 (0.0%)	1 (100.0%)			
35							
r/o spleen rupture	Normal	0	0	0			
	Non-specific	1	0 (0.0%)	1 (100.0%)			
	Abnormal	0	0	0			
		1	0 (0.0%)	1 (100.0%)			
36							
UB rupture	Normal	0	0	0			
	Non-specific	1	1 (100.0%)	0 (0.0%)			
	Abnormal	0	0	0			
		1	1 (100.0%)	0 (0.0%)			
37							

Clinical Impression	Radiography results	N	Follow-up image		Odds Ratio	95%CI	p value
			No	Yes			
vental hernia	Normal	1	1 (100.0%)	0 (0.0%)			
	Non-specific	0	0	0			
	Abnormal	0	0	0			
		1	1 (100.0%)	0 (0.0%)			

Appendix 2. Relation between Abdominal Radiography result & F/U Image results by Clinical Indication

Clinical Impression	Radiography results	N	Imaging Results		Odds Ratio	95%CI	p value
			Normal	Abnormal			
1							
Urolithiasis	Normal	101	20 (19.8%)	81 (80.2%)	1.00	Reference	
	Non-specific	30	3 (10.0%)	27 (90.0%)	2.22	(0.61 , 8.07)	0.334
	Abnormal	96	6 (6.3%)	90 (93.8%)	3.70	(1.42 , 9.68)	0.009*
		227	29 (12.8%)	198 (87.2%)			
2							
gastroenteritis	Normal	39	14 (35.9%)	25 (64.1%)	1.00	Reference	
	Non-specific	18	5 (27.8%)	13 (72.2%)	0.89	(0.61 , 1.29)	0.762
	Abnormal	5	2 (40.0%)	3 (60.0%)	0.84	(0.13 , 5.64)	1.000
		62	21 (33.9%)	41 (66.1%)			
3							
Gastritis	Normal	22	3 (13.6%)	19 (86.4%)	1.00	Reference	
	Non-specific	9	4 (44.4%)	5 (55.6%)	1.55	(0.85 , 2.85)	0.150
	Abnormal	0	0	0			
		31	7 (22.6%)	24 (77.4%)			
4							
Non-nspecific diffuse abdominal Pain	Normal	57	16 (28.1%)	41 (71.9%)	1.00	Reference	
	Non-specific	38	2 (5.3%)	36 (94.7%)	7.02	(1.51 , 32.66)	0.012*
	Abnormal	16	1 (6.3%)	15 (93.8%)	5.85	(0.71 , 48.05)	0.096
		111	19 (17.1%)	92 (82.9%)			
5							
constipation	Normal	1	0 (0.0%)	1 (100.0%)			
	Non-specific	1	0 (0.0%)	1 (100.0%)			
	Abnormal	4	3 (75.0%)	1 (25.0%)			
		6	3 (50.0%)	3 (50.0%)			
6							
abdominal fullness	Normal	17	1 (5.9%)	16 (94.1%)	1.00	Reference	
	Non-specific	6	0 (0.0%)	6 (100.0%)			1.000
	Abnormal	10	2 (20.0%)	8 (80.0%)	0.25	(0.02 , 3.19)	0.535
		33	3 (9.1%)	30 (90.9%)			
7							
GU infection	Normal	8	2 (25.0%)	6 (75.0%)	1.00	Reference	
	Non-specific	8	3 (37.5%)	5 (62.5%)	1.20	(0.61 , 2.34)	1.000
	Abnormal	3	0 (0.0%)	3 (100.0%)			
		19	5 (26.3%)	14 (73.7%)			
8							
Acute appendicitis	Normal	37	4 (10.8%)	33 (89.2%)	1.00	Reference	
	Non-specific	24	2 (8.3%)	22 (91.7%)	0.97	(0.83 , 1.15)	1.000
	Abnormal	1	0 (0.0%)	1 (100.0%)			1.000

Clinical Impression	Radiography results	N	Imaging Results		Odds Ratio	95%CI	p value
			Normal	Abnormal			
		62	6 (9.7%)	56 (90.3%)			
9							
epigastric pain	Normal	13	1 (7.7%)	12 (92.3%)	1.00	Reference	
	Non-specific	7	1 (14.3%)	6 (85.7%)	1.08	(0.77 , 1.51)	1.000
	Abnormal	2	0 (0.0%)	2 (100.0%)			1.000
		22	2 (9.1%)	20 (90.9%)			
10							
Acute pancreatitis	Normal	23	1 (4.3%)	22 (95.7%)			
	Non-specific	24	0 (0.0%)	24 (100.0%)			0.489
	Abnormal	3	0 (0.0%)	3 (100.0%)			1.000
		50	1 (2.0%)	49 (98.0%)			
11							
peptic ulcer	Normal	12	2 (16.7%)	10 (83.3%)	1.00	Reference	
	Non-specific	12	1 (8.3%)	11 (91.7%)	0.91	(0.67 , 1.23)	1.000
	Abnormal	1	0 (0.0%)	1 (100.0%)			
		25	3 (12.0%)	22 (88.0%)			
12							
GI bleeding	Normal	6	3 (50.0%)	3 (50.0%)	1.00	Reference	
	Non-specific	10	1 (10.0%)	9 (90.0%)	0.56	(0.24 , 1.27)	0.118
	Abnormal	2	0 (0.0%)	2 (100.0%)			
		18	4 (22.2%)	14 (77.8%)			
13							
Intestinal obstruction	Normal	8	1 (12.5%)	7 (87.5%)	1.00	Reference	
	Non-specific	17	3 (17.6%)	14 (82.4%)	1.06	(0.75 , 1.50)	1.000
	Abnormal	10	2 (20.0%)	8 (80.0%)	0.57	(0.04 , 7.74)	1.000
		35	6 (17.1%)	29 (82.9%)			
14							
vomiting	Normal	7	2 (28.6%)	5 (71.4%)			
	Non-specific	1	0 (0.0%)	1 (100.0%)			
	Abnormal	5	0 (0.0%)	5 (100.0%)			
		13	2 (15.4%)	11 (84.6%)			
15							
biliary tract stone	Normal	17	0 (0.0%)	17 (100.0%)			
	Non-specific	12	0 (0.0%)	12 (100.0%)			
	Abnormal	4	0 (0.0%)	4 (100.0%)			
		33	0 (0.0%)	33 (100.0%)			
16							
hematuria	Normal	13	3 (23.1%)	10 (76.9%)	1.00	Reference	
	Non-specific	6	3 (50.0%)	3 (50.0%)	1.54	(0.66 , 3.61)	0.320
	Abnormal	2	2 (1000%)	0 (0.0%)			0.095
		21	8 (38.1%)	13 (61.9%)			
17							
diarrhea	Normal	4	0 (0.0%)	4 (100.0%)			
	Non-specific	2	0 (0.0%)	2 (100.0%)			
	Abnormal	0	0	0			
		6	0 (0.0%)	6 (100.0%)			
18							

Clinical Impression	Radiography results	N	Imaging Results		Odds Ratio	95%CI	p value
			Normal	Abnormal			
biliary tract infection	Normal	15	0 (0.0%)	15 (100.0%)			
	Non-specific	6	0 (0.0%)	6 (100.0%)			
	Abnormal	2	0 (0.0%)	2 (100.0%)			
		23	0 (0.0%)	23 (100.0%)			
19							
PID	Normal	4	2 (50.0%)	2 (50.0%)			
	Non-specific	1	1 (100.0%)	0 (0.0%)			
	Abnormal	0	0	0			
		5	3 (60.0%)	2 (40.0%)			
20							
dysuria	Normal	2	0 (0.0%)	2 (100.0%)			
	Non-specific	3	0 (0.0%)	3 (100.0%)			
	Abnormal	2	0 (0.0%)	2 (100.0%)			
		7	0 (0.0%)	7 (100.0%)			
21							
Peritonitis	Normal	5	0 (0.0%)	5 (100.0%)			
	Non-specific	2	0 (0.0%)	2 (100.0%)			
	Abnormal	4	0 (0.0%)	4 (100.0%)			
		11	0 (0.0%)	11 (100.0%)			
22							
Colonic diverticulitis	Normal	5	0 (0.0%)	5 (100.0%)			
	Non-specific	5	0 (0.0%)	5 (100.0%)			
	Abnormal	1	0 (0.0%)	1 (100.0%)			
		11	0 (0.0%)	11 (100.0%)			
23							
BPH	Normal	3	0 (0.0%)	3 (100.0%)			
	Non-specific	3	0 (0.0%)	3 (100.0%)			
	Abnormal	0	0	0			
		6	0 (0.0%)	6 (100.0%)			
24							
dysmenorrhea	Normal	0	0	0			
	Non-specific	2	1 (50.0%)	1 (50.0%)			
	Abnormal	0	0	0			
		2	1 (50.0%)	1 (50.0%)			
25							
Urine retention	Normal	0	0	0			
	Non-specific	0	0	0			
	Abnormal	0	0	0			
		0	0	0			
26							
Foreign body retention	Normal	0	0	0			
	Non-specific	0	0	0			
	Abnormal	0	0	0			
		0	0	0			
27							
hernia	Normal	1	0 (0.0%)	1 (100.0%)			
	Non-specific	1	0 (0.0%)	1 (100.0%)			

Clinical Impression	Radiography results		Imaging Results		Odds Ratio	95%CI	p value
		N	Normal	Abnormal			
	Abnormal	0	0	0			
		2	0 (0.0%)	2 (100.0%)			
28							
inguinal hernia	Normal	0	0	0			
	Non-specific	1	0 (0.0%)	1 (100.0%)			
	Abnormal	0	0	0			
		1	0 (0.0%)	1 (100.0%)			
29							
vaginal bleeding	Normal	0	0	0			
	Non-specific	0	0	0			
	Abnormal	0	0	0			
		0	0	0			
30							
anal bleeding	Normal	0	0	0			
	Non-specific	0	0	0			
	Abnormal	0	0	0			
		0	0	0			
31							
dirty discharge and wound reddish via gastrostomy	Normal	0	0	0			
	Non-specific	0	0	0			
	Abnormal	0	0	0			
		0	0	0			
32							
feeding jejunostomy tube wound pain	Normal	0	0	0			
	Non-specific	0	0	0			
	Abnormal	0	0	0			
		0	0	0			
33							
inguinal pain	Normal	1	1 (100.0%)	0 (0.0%)			
	Non-specific	0	0	0			
	Abnormal	0	0	0			
		1	1 (100.0%)	0 (0.0%)			
34							
liver cirrhosis	Normal	0	0	0			
	Non-specific	1	0 (0.0%)	1 (100.0%)			
	Abnormal	0	0	0			
		1	0 (0.0%)	1 (100.0%)			
35							
r/o spleen rupture	Normal	0	0	0			
	Non-specific	1	0 (0.0%)	1 (100.0%)			
	Abnormal	0	0	0			
		1	0 (0.0%)	1 (100.0%)			
36							
UB rupture	Normal	0	0	0			

Clinical Impression	Radiography results	N	Imaging Results		Odds Ratio	95%CI	p value
			Normal	Abnormal			
	Non-specific	0	0	0			
	Abnormal	0	0	0			
		0	0	0			
37 vental hernia	Normal	0	0	0			
	Non-specific	0	0	0			
	Abnormal	0	0	0			
		0	0	0			

Appendix 3. Relation between Abdominal Radiography Result & F/U Image Abnormal result by Clinical Indication

Clinical Impression	Radiography results	N	Imaging Abnormal minor	Imaging Abnormal major	Odds Ratio	95%CI	p value
1							
Urolithiasis	Normal	81	13 (16.0%)	68 (84.0%)	1.00	Reference	
	Non-specific	27	5 (18.5%)	22 (81.5%)	0.84	(0.27 , 2.62)	0.770
	Abnormal	90	2 (2.2%)	88 (97.8%)	8.41	(1.84 , 38.54)	0.003*
		198	20 (10.1%)	178 (89.9%)			
2							
gastroenteritis	Normal	25	22 (88.0%)	3 (12.0%)	1.00	Reference	
	Non-specific	13	11 (84.6%)	2 (15.4%)	1.33	(0.19 , 9.19)	1.000
	Abnormal	3	2 (66.7%)	1 (33.3%)	3.67	(0.25 , 53.83)	0.382
		41	35 (85.4%)	6 (14.6%)			
3							
Gastritis	Normal	19	17 (89.5%)	2 (10.5%)	1.00	Reference	
	Non-specific	5	4 (80.0%)	1 (20.0%)	2.13	(0.15 , 29.66)	0.5212
	Abnormal	0	0	0			
		24	21 (87.5%)	3 (12.5%)			
4							
Non-nspecific diffuse abdominal. Pain	Normal	41	18 (43.9%)	23 (56.1%)	1.00	Reference	
	Non-specific	36	18 (50.0%)	18 (50.0%)	0.78	(0.32 , 1.92)	0.651
	Abnormal	15	4 (26.7%)	11 (73.3%)	2.15	(0.59 , 7.90)	0.389
		92	40 (43.5%)	52 (56.5%)			
5							
constipation	Normal	1	1 (100.0%)	0 (0.0%)			
	Non-specific	1	1 (100.0%)	0 (0.0%)			
	Abnormal	1	0 (0.0%)	1 (100.0%)			
		3	2 (66.7%)	1 (33.3%)			
6							
Abdominal fullness	Normal	16	9 (56.3%)	7 (43.8%)	1.00	Reference	
	Non-specific	6	2 (33.3%)	4 (66.7%)	2.57	(0.36 , 18.33)	0.635
	Abnormal	8	2 (25.0%)	6 (75.0%)	3.86	(0.59 , 25.29)	0.210
		30	13 (43.3%)	17 (56.7%)			
7							
GU infection	Normal	6	5 (83.3%)	1 (16.7%)	1.00	Reference	
	Non-specific	5	3 (60.0%)	2 (40.0%)	3.33	(0.10 , 24.70)	1.000
	Abnormal	3	0 (0.0%)	3 (100.0%)		(0.20 , 54.53)	0.545
		14	8 (57.1%)	6 (42.9%)			0.047*
8							
Acute appendicitis	Normal	33	6 (18.2%)	27 (81.8%)	1.00	Reference	
	Non-specific	22	2 (9.1%)	20 (90.9%)	2.22	(0.41 , 12.18)	0.454
	Abnormal	1	0 (0.0%)	1 (100.0%)			
		56	8 (14.3%)	48 (85.7%)			
9							

Clinical Impression	Radiography results	N	Imaging Abnormal		Odds Ratio	95%CI	p value
			minor	major			
epigastric pain	Normal	12	8 (66.7%)	4 (33.3%)	1.00	Reference	
	Non-specific	6	1 (16.7%)	5 (83.3%)	10.00	(0.85 , 117.02)	0.131
	Abnormal	2	0 (0.0%)	2 (100.0%)			0.164
		20	9 (45.0%)	11 (55.0%)			
10							
Acute pancreatitis	Normal	22	17 (77.3%)	5 (22.7%)	1.00	Reference	
	Non-specific	24	10 (41.7%)	14 (58.3%)	4.76	(1.32 , 17.22)	0.031*
	Abnormal	3	1 (33.3%)	2 (66.7%)	6.80	(0.51 , 91.49)	0.179
		49	28 (57.1%)	21 (42.9%)			
11							
peptic ulcer	Normal	10	7 (70.0%)	3 (30.0%)	1.00	Reference	
	Non-specific	11	7 (63.6%)	4 (36.4%)	1.33	(0.21 , 8.29)	1.000
	Abnormal	1	0 (0.0%)	1 (100.0%)			0.363
		22	14 (63.6%)	8 (36.4%)			
12							
GI bleeding	Normal	3	2 (66.7%)	1 (33.3%)	1.00	Reference	
	Non-specific	9	5 (55.6%)	4 (44.4%)	1.60	(0.10 , 24.70)	1.000
	Abnormal	2	2 (100.0%)	0 (0.0%)			
		14	9 (64.3%)	5 (35.7%)			
13							
Intestinal obstruction	Normal	7	5 (71.4%)	2 (28.6%)	1.00	Reference	
	Non-specific	14	0 (0.0%)	14 (100.0%)			0.001*
	Abnormal	8	1 (12.5%)	7 (87.5%)	17.50	(1.22 , 250.36)	0.040*
		29	6 (20.7%)	23 (79.3%)			
14							
vomiting	Normal	5	3 (60.0%)	2 (40.0%)	1.00		
	Non-specific	1	1 (100.0%)	0 (0.0%)			
	Abnormal	5	2 (40.0%)	3 (60.0%)	2.25	(0.18 , 28.25)	1.000
		11	6 (54.5%)	5 (45.5%)			
15							
biliary tract stone	Normal	17	0 (0.0%)	17 (100.0%)			
	Non-specific	12	1 (8.3%)	11 (91.7%)			
	Abnormal	4	0 (0.0%)	4 (100.0%)			
		33	1 (3.0%)	32 (97.0%)			
16							
hematuria	Normal	10	5 (50.0%)	5 (50.0%)			
	Non-specific	3	0 (0.0%)	3 (100.0%)			
	Abnormal	0	0	0			
		13	5 (38.5%)	8 (61.5%)			
17							
diarrhea	Normal	4	4 (100.0%)	0 (0.0%)			
	Non-specific	2	2 (100.0%)	0 (0.0%)			
	Abnormal	0	0	0			
		6	6 (100.0%)	0 (0.0%)			
18							
biliary tract infection	Normal	15	3 (20.0%)	12 (80.0%)	1.00	Reference	

Clinical Impression	Radiography results	N	Imaging Abnormal		Odds Ratio	95%CI	p value
			minor	major			
	Non-specific	6	2 (33.3%)	4 (66.7%)	0.50	(0.06 , 4.15)	0.597
	Abnormal	2	0 (0.0%)	2 (100.0%)			
		23	5 (21.7%)	18 (78.3%)			
19							
PID	Normal	2	2 (100.0%)	0 (0.0%)			
	Non-specific	0	0	0			
	Abnormal	0	0	0			
		2	2 (100.0%)	0 (0.0%)			
20							
dysuria	Normal	2	0 (0.0%)	2 (100.0%)			
	Non-specific	3	2 (66.7%)	1 (33.3%)			
	Abnormal	2	1 (50.0%)	1 (50.0%)			
		7	3 (42.9%)	4 (57.1%)			
21							
Peritonitis	Normal	5	1 (20.0%)	4 (80.0%)	1.00	Reference	
	Non-specific	2	1 (50.0%)	1 (50.0%)	0.25	(0.01 , 8.56)	1.000
	Abnormal	4	1 (25.0%)	3 (75.0%)	0.75	(0.03 , 17.51)	1.000
		11	3 (27.3%)	8 (72.7%)			
22							
Colonic diverticulitis	Normal	5	3 (60.0%)	2 (40.0%)	1.00	Reference	
	Non-specific	5	2 (40.0%)	3 (60.0%)	2.25	(0.18 , 28.25)	1.000
	Abnormal	1	0 (0.0%)	1 (100.0%)			
		11	5 (45.5%)	6 (54.5%)			
23							
BPH	Normal	3	1 (33.3%)	2 (66.7%)	1.00	Reference	
	Non-specific	3	1 (33.3%)	2 (66.7%)	1.00	(0.03 , 29.81)	1.000
	Abnormal	0	0	0			
		6	2 (33.3%)	4 (66.7%)			
24							
dysmenorrhea	Normal	0	0	0			
	Non-specific	1	1 (100.0%)	0 (0.0%)			
	Abnormal	0	0	0			
		1	1 (100.0%)	0 (0.0%)			
25							
Urine retention	Normal	0	0	0			
	Non-specific	0	0	0			
	Abnormal	0	0	0			
		0	0	0			
26							
Foreign body retention	Normal	0	0	0			
	Non-specific	0	0	0			
	Abnormal	0	0	0			
		0	0	0			
27							
hernia	Normal	1	1 (100.0%)	0 (0.0%)			
	Non-specific	1	0 (0.0%)	1 (100.0%)			
	Abnormal	0	0	0			
		2	1 (50.0%)	1 (50.0%)			
28							

Clinical Impression	Radiography results	N	Imaging Abnormal minor	Imaging Abnormal major	Odds Ratio	95%CI	p value
inguinal hernia	Normal	0	0	0			
	Non-specific	1	0 (0.0%)	1 (100.0%)			
	Abnormal	0	0	0			
		1	0 (0.0%)	1 (100.0%)			
29							
vaginal bleeding	Normal	0	0	0			
	Non-specific	0	0	0			
	Abnormal	0	0	0			
		0	0	0			
30							
anal bleeding	Normal	0	0	0			
	Non-specific	0	0	0			
	Abnormal	0	0	0			
		0	0	0			
31							
dirty discharge and wound reddish via gastrostomy	Normal	0	0	0			
	Non-specific	0	0	0			
	Abnormal	0	0	0			
		0	0	0			
32							
feeding jejunostomy tube wound pain	Normal	0	0	0			
	Non-specific	0	0	0			
	Abnormal	0	0	0			
		0	0	0			
33							
inguinal pain	Normal	0	0	0			
	Non-specific	0	0	0			
	Abnormal	0	0	0			
		0	0	0			
34							
liver cirrhosis	Normal	0	0	0			
	Non-specific	1	0 (0.0%)	1 (100.0%)			
	Abnormal	0	0	0			
		1	0 (0.0%)	1 (100.0%)			
35							
r/o spleen rupture	Normal	0	0	0			
	Non-specific	1	1 (100.0%)	0 (0.0%)			
	Abnormal	0	0	0			
		1	1 (100.0%)	0 (0.0%)			
36							
UB rupture	Normal	0	0	0			
	Non-specific	0	0	0			
	Abnormal	0	0	0			

Clinical Impression	Radiography results	N	Imaging Abnormal		Odds Ratio	95%CI	p value
			minor	major			
		0	0	0			
37 ventral hernia	Normal	0	0	0			
	Non-specific	0	0	0			
	Abnormal	0	0	0			
		0	0	0			