Introduction

A 17 year old woman, born and raised in Russia, was admitted to the hospital with a 5 month history of bloody diarrhoea, weight loss of 9 kg, weakness, anorexia, low grade fever and episodes of pain in the right lower abdominal quadrant. There was no family history of inflammatory bowel disease or colon cancer.

Physical examination revealed mild abdominal tenderness, mostly confined to the right lower quadrant. The laboratory tests showed a mild anaemia of 10.5 haemoglobin (normal is11.5 to 15.5 g/dl), a serum ferritin of 8.75 (normal is12–237 ng/ml) and a serum folate of 4.9 ng/ml (normal is 5.3–14.4 ng/ml). Stool samples were negative for infectious organisms. A pregnancy test was also negative.

The health care professional suspected that Crohn's disease was the cause of the symptoms and further investigations to confirm diagnosis was suggested. This report will discuss the pathway of the patient undergoing various diagnostic imaging investigations in the initial diagnosis of Crohn's disease.

What is Crohn's Disease?

Crohn's disease is an inflammatory bowel disease affecting any part of the gastrointestinal tract from the mouth to the anus frequently leading to discontinuous inflammation, bowel strictures, ileus and fistulas (Podolsky, 2002). About 31,000 people in England and 1,800 in Wales have Crohn's disease and there are about 2,650 new cases each year (www.nice.org.uk). The disease typically affects young adults of both sexes between the ages of 15 to 25. However, Crohn's disease can also occur in people who are 50 or older (Armstrong & Wastie, 2001). The aetiology of the disease is unknown, but it has been suggested that a genetic predisposition combined with an abnormal interaction between the gastrointestinal tract and enteric microorganisms may play a key role in the pathogenesis (Neurath, et al. 2001, Sartor, 1998).

Crohn's disease is closely related to a similar condition known as ulcerative colitis. In most cases, these two diseases may be readily distinguished from each other pathologically, particularly when each exhibits classic histological features (Yantis & Odze, 2006, See Appendix A**).** Occasionally a definitive diagnosis of Crohn's disease can not be made. This occurs in approximately 10% to 20% of patients at presentation (Knigge, 2002). For these patients the diagnosis is usually made on follow-up with further examinations (Ogorek & Fisher, 1994). Later change in diagnosis is always from ulcerative colitis to Crohn's disease (Carroll, 1998).

What are the symptoms of Crohn's Disease?

Crohn's disease can present with a variety of symptoms, the most common of which are abdominal pain (about 75% of patients), diarrhoea (usually mild), weight loss, fever and non-specific illness (Carroll, 1998, Simpkins, et al. 1994).

How does Crohn's disease affect the bowel?

Crohn's disease starts as mucosal inflammation with ulceration of all bowel wall layers (Mace, et al. 1998). The small bowel and colon are most commonly affected. The small bowel alone is affected in about a third of patients, the colon alone in 20 to 30% of patients, and combined involvement of the colon and the small bowel is seen in 40 to 50% of patients (Huprich, et al. 2005). The early radiological features of small bowel and colon are a coarse granular pattern, aphtoid ulceration, cobblestoning and fissuring. Moreover, mucosal folds may be thickened, distorted, fused, interrupted or absent (Carroll, 1998). However, not all of these early radiological features progress to establish Crohn's disease.

How is Crohn's disease treated?

Depending on the severity of the symptoms, medical treatment of Crohn's disease involves a three-way approach:

1) Drug therapy and a restricted diet,
2) Hospital treatment (if necessary),
3) Surgery to remove the affected sections of the intestine.

(Gupta, et al 2004)

Despite medical advances in treatment, there is still no medication that can cure Crohn's disease.

Diagnosis of Crohn's disease

No single diagnostic investigation allows definite Crohn's disease diagnosis. Thus, a combination of clinical, laboratory and imaging techniques are used in the investigation of Crohn's disease.

The role of non imaging diagnostic investigations

Diagnosis of Crohn's disease is usually based on a thorough evaluation of patient's medical history and symptoms of the illness. There are few physical signs apart from loss of weight, diarrhoea, abdominal pain and obvious ill-health. Sometimes a mass can be felt in the abdomen when loops of inflamed bowels are stuck together or clubbing of the fingers and curvature of the nails may be seen (Armstrong & Wastie, 2001). In addition to the physical examination, the blood tests to detect anaemia, infection, degree of inflammation, and to determine liver function or other abnormalities is necessary. Furthermore, stool samples are taken and examined to determine the signs of hidden blood, which point to bleeding and for white blood cells, which indicate an infection in the intestines. This test is sensitive of detection of

bleeding from almost anywhere in the digestive tract and can also help to rule out other causes of a patient's symptoms, such as bacterial infections or parasites (Huprich, et al. 2005).

It is important for the health care professionals to have all of this information before recommending other diagnostic imaging investigations.

The role of diagnostic imaging investigations

The main indications for diagnostic imaging investigations include making the diagnosis, determination of the extent and severity of the disease and management of the disease (Carroll, K. 1998). A variety of diagnostic imaging investigations can be used in the diagnosis of Crohn's disease. The complexity and severity of a patient's clinical condition and the clinical question to be answered should determine the selection of appropriate imaging investigations. The choice of which diagnostic imaging investigations to perform depends on local availability and expertise.

The Royal College of Radiologists (2003) has produced recommendations for determining the pathway of the patient undergoing various diagnostic imaging investigations in the initial diagnosis of Crohn's disease. The plain abdomen radiograph is recommended as the first diagnostic imaging investigation.

Plain Radiographs of the Abdomen

Plain abdominal radiographs are usually obtained as the first line of the diagnostic imaging investigation. In cases of "acute abdomen", an erect chest x-ray is obtained at the same time as this is better at demonstrating free intraperitoneal gas and there may be coexisting chest pathology (Carroll, 1998). The examination does not require any special preparation and is a quick, inexpensive and effective way of detecting the presence of bowel obstruction, perforation, or toxic colon distention. However, a false

positive rate of 16 to 20% makes plain abdominal radiography a poor diagno stic imaging modality in patients with Crohn's disease; negative findings cannot prevent further studies, and positive findings would also lead to other diagnostic imaging investigations to accurately characterise the disease (Huprich et al. 2005). For these reasons, plain radiographs of the abdomen are not essential when the Crohn's disease initial presentation is typical and not severe. If the health care professional suspects this, a colonoscopy/sigmoidoscopy may be performed instead of plain abdominal radiograph.

Colonoscopy/ Sigmoidoscopy

Several types of endoscopes are used to examine the gastrointestinal tract and to determine the nature and extent of Crohn's disease.

Colonoscopy is the gold standard and most sensitive test for diagnosis of Crohn's disease (Yantis, et al. 2006). The examination requires some advanced bowel preparation and may take up to 1 ½ hours to visualise the entire colon. An examination is only complete if al of the entire colon has been examined. However, lack of proper bowel preparation is a potential problem in both colonoscopy and barium enema investigations (Huprich, et al. 2005). Nevertheless, colonoscopy is superior to the barium enema examination in detecting early changes and blockages, abnormal growths, small ulcers or small areas of inflammation of the colon and terminal ileum and in assessing the degree of inflammation (Carroll, 1998). The barium enema is reserved for those patients who had an unsuccessful colonoscopy.

In sigmoidoscopy, the endoscope is inserted through the anus to look for inflammation or bleeding in the rectum and lower part of the large intestine. Risks of this procedure include perforation of the colon wall, bleeding and infection (Huprich, et al. 2005).

The advantage of these procedures is that any time during the examination a biopsy may be taken, and the tissue sent for analysis to help the health care professional to determine the cause of inflammation.

Occasionally, Crohn's disease affects only the small bowel and not the colon. If the health care professional suspects this, a small bowel follow through may be performed instead of colonoscopy.

Small Bowel Follow-Through (SBFT) and Small Bowel Enema (Enteroclysis)

Because colonoscopy allows direct visualization of the terminal ileum and beginning of the duodenum only, it can not be used to evaluate the remainder of the small intestine. The small bowel can be evaluated by either conventional Small bowel follow through (SBFT) or Small bowel enema (enteroclysis) and each has its proponents. Each diagnostic imaging investigation is quite accurate in detecting small bowel involvement when performed correctly (89 to 97% for SBFT and 83 to 100% for enteroclysis) (Huprich, et al. 2005). However, while enteroclysis has a shorter overall examination time, the SBFT requires less total room time and radiologist time, and substantially less radiation exposure. The typical effective dose for SBFT is 3mSv (equivalent to 16 months of natural background radiation), compared to the enteroclysis examination, which is 7mSv (equivalent to 3.2 years of natural background radiation) (Hart & Wall, 2004). For these reasons, SBFT is better diagnostic imaging investigation of evaluating the small bowel, particularly in younger patients. Enteroclysis is usually reserved for more difficult cases.

Moreover, enteroclysis is not the preferred way to evaluate the colon, but the health care professionals may use this investigation in conjunction with a sigmoidoscopy or in cases when a colonoscopy can not be performed. The examination is generally safe. However it should not be carried out if there is a chance that an acute bowel

obstruction or perforation is present. Similarly, to reduce the chance of complications, an enteroclysis should not be performed if there is severe inflammation in the colon or in patients who are acutely ill, with peritoneal signs or acute diarrhoea. Barium leaking into peritoneal cavity may result in a severe peritonitis (Carroll, 1998).

Ultrasound

Ultrasound is particularly useful in identifying the extent and severity of Crohn's disease and is often used in combination with other radiological tests. Bowel wall thickening (4-5 mm or greater) and extraluminal complications such as phlegmons and abscesses can be demonstrated without the use of ionising radiation or discomfort to the patient (Solvig et al 1995). Moreover, ultrasound is readily available, well tolerated, even in acutely ill patients and may also be used for imaging guided drainage of abscesses. More recently, researchers have argued that ultrasound could replace SBFT in the initial evaluation of patients suspected to have Crohn's disease, because of its acceptable sensitivity and the advantage of no radiation exposure. Moreover, in the one prospective comparison of ultrasound and barium studies, which used the barium study as the gold standard in the initial evaluation of suspected Crohn's disease, the sensitivity of ultrasound was 75% and the specificity was 97% (Huprich et al. 2005). However, ultrasound is highly operator dependant and images are degraded by bowel gas. If patient has excess gas the computed tomography abdomen examination can be performed.

Computed Tomography (CT)

Computed tomography (CT) provides a superb demonstration of bowel wall thickening, which is the most common feature, luminal narrowing (the "string sign" appearance), fistula and sinus tract formation, abscesses, small bowel obstructions and

bowel perforation (Carroll, 1998). Occasionally, abscesses and collections demonstrated on CT scans may be drained under imaging guidance, thus avoiding surgery. Soft tissues are not degraded by bowel gas and are clearly visualised in CT abdomen images but at the expense of relatively high patient doses. The typical effective dose for CT abdomen examination is 10 mSv, which is equivalent to 4.5 years of natural background radiation.

Magnetic Resonance Imaging (MRI)

Magnetic resonance imaging (MRI) is another diagnostic imaging investigation that has been shown to be effective for detecting Crohn's disease, because of its inherently high soft tissue contrast resolution and direct multiplanar imaging (Mirowitz, 1993). Improvements in MRI technology, such as fast scanning techniques, have permitted accurate diagnosis of Crohn's disease complications, including abscess, fistula, and stenosis (Shoenut at al 1994). Moreover, MRI has the advantage of avoiding ionising radiation, thus may be repeated without this concern. Direct sagittal and coronal imaging and the limited bowel preparation are other advantages of MRI over other techniques such as colonoscopy, enteroclysis, SBFT. Along with ultrasound, MRI is the preferred tool for evaluating perianal complications of Crohn's disease.

Nuclear Medicine

Leukocyte scintigraphy (tagged white blood cell scan) is complementary to barium studies and can be used to assess the distribution and extension of Crohn's disease (Navab & Boyd, 1995). Its advantages over barium studies include the examination of both large and small bowel in one encounter, no bowel preparation is required, entails less radiation exposure (the typical effective dose for is 2.2 mSv) than barium studies or CT scan and higher patient acceptance (Navab, et al. 1995). In addition, leukocyte

scintigraphy investigation can accurately distinguish Crohn's disease from ulcerative colitis in a large proportion of patients (Huprich et al 2005). However, this examination is not as effective as colonoscopy, SBFT, enteroclysis in assessing disease extent, due to lack of anatomical details.

Wireless Capsule Endoscopy (WCE)

If a patient has symptoms that suggest Crohn's disease but the usual imaging diagnostic investigations, such as colonoscopy, small bowel follow through, enteroclysis are negative, the health care professional may suggest wireless capsule endoscopy.

Wireless capsule endoscopy (WCE) is a new diagnostic imaging modality that can greatly assist in making the diagnosis of Crohn's disease or determining the extent and severity of involvement (Reddy et al. 2004). The examination allows painless, non-invasive, physiological imaging of the entire small bowel. Some studies have found it to be more accurate in evaluating Crohn's disease than the use of barium investigations or CT scans (Appleyard et al. 2000**,** Eliakim, et al. 2003, Fireman, et al. 2003). Conversely, all patients should undergo SBFT prior to ingesting the wireless capsule to exclude stricture formation, even though this does not completely protect from capsule retention at a stricture site. If the capsule does become lodged in the bowel, it may need to be surgically removed. Moreover, due to the limited battery life, imaging of the entire small intestine does not occur in about 25% of all examinations (Chong et al. 2003). Nevertheless, increased use of WCE is very likely in the future.

Summary

Imaging and non imaging diagnostic investigations remain important tools in diagnosing and managing patients with Crohn's disease. The choice of which imaging investigations to use in a particular clinical situation will depend on local availability of equipment, expertise and the clinical question to be answered. Algorithm summarising the Royal College of Radiologists recommendations for the diagnosis of Crohn's disease can be found in the Appendix B.

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Appendix A

Classic features Crohn's disease and Ulcerative colitis

Feature	**Ulcerative colitis**	**Crohn's disease**
Disease distribution	Diffuse and continuous	Segmental
Rectal involvement	Always (adults)	Occasionally
Disease severity	Increased distally	Patchy and variable
Ileal involvement	Occasional ('backwash')	Often
Disease location in colonic wall	Superficial (mucosal)	Transmural
Transmural lymphoid aggregates	Rare, underneath ulcers	Any location
Fissures	Rare, superficial in fulminant colitis	Deep, any location
Sinuses and fistulas	Absent	Present
Granulomas	Related to ruptured crypts	Not crypt related

(Yantiss & Odze, 2006)

Appendix B

Algorithm summarising recommendations for the diagnosis of Crohn's disease