
Clinical Presentation of Acute Appendicitis: Clinical Signs—Laboratory Findings—Clinical Scores, Alvarado Score and Derivate Scores

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Abstract

Appendicectomy is the most commonly performed emergency operation worldwide with a lifetime risk of appendicitis of 8.6% in males and 6.7% in females (Flum and Koepsell 2002; Addiss et al. 1990). The diagnosis of acute appendicitis is predominantly based on clinical findings (Humes and Simpson 2006). Whilst a clinical diagnosis can often be made there are groups of patients in whom the clinical diagnosis is difficult and these patients provide a degree of diagnostic uncertainty. Studies reporting the mortality associated with appendicitis have demonstrated a significant increase in mortality associated with perforation (Blomqvist et al. 2001). The rate of perforation is reported to increase by 5% per 12 h period 36 h after the onset of symptoms, therefore, expedient diagnosis and treatment are required (Bickell et al. 2006). High rates of negative appendicectomy (operation without histological confirmation of appendicitis) have been reported with some groups such as females of reproductive age having rates of up to 26% (Flum et al. 2001). Delayed or incorrect diagnosis therefore has both clinical and economic consequences (Flum and Koepsell 2002) and this has resulted in considerable research to identify clinical, laboratory and radiological findings that are diagnostic of appendicitis and the development of clinical scoring systems (some computer aided) to guide the clinician in making the correct diagnosis. Thus reducing the delay in diagnosis and decreasing the rates of negative appendicectomy. There is evidence that despite the introduction of new specialist tests that the diagnosis of appendicitis has not improved on a

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population level (Flum et al. 2001). This chapter aims to outline the presentation, investigation and diagnosis of acute appendicitis.

1 Clinical Presentation

The clinical diagnosis of acute appendicitis relies upon a detailed history and thorough physical examination. The differential diagnosis is that of the acute abdomen as it can mimic the presentation of most abdominal emergencies (Box 1).

1.1 History

The principal presenting complaint of patients with acute appendicitis is abdominal pain. Murphy was the first to describe the sequence of colicky central abdominal pain followed by vomiting and migration of the pain to the right iliac fossa (Murphy 1904). This classical presentation is only seen in approximately 50% of patients. The history of pain is usually 24 h of colicky peri-umbilical pain followed by migration of the pain to the right iliac fossa with a progression to a more constant severe pain (Wagner et al. 1996). This progression results from the initial pain being referred from the visceral innervation of the midgut followed by more defined localization of the pain when the parietal peritoneum is involved by the inflammatory process. Associated symptoms include loss of appetite and nausea but profuse vomiting is rarely a feature of simple appendicitis and may well represent the development of diffuse peritonitis following perforation. Patients will often have a low grade fever. It is common for patients to report no change in bowel habit but a range of bowel habit disturbances may be associated with the onset of pain. Cope reported that patients may feel constipated and anticipate relief of pain with defecation but this does not occur (Cope 2000).

The appendix can take a variety of anatomical positions and as a result the clinical presentation is influenced by the surrounding structures that become involved in the inflammatory process (Box 2). Those at the extremes of age often present a significant diagnostic challenge as they may present with atypical signs and symptoms (Paulson et al. 2003). Infants may appear listless whilst the elderly may present with

Box 1 Differential diagnosis of acute appendicitis

<i>Surgical</i>
Acute cholecystitis
Perforated peptic ulcer
Intestinal obstruction
Pancreatitis
Intussusception
Mesenteric adenitis
Meckel's diverticulitis
Colonic/appendicular diverticulitis
Rectus sheath haematoma
<i>Urological</i>
Right ureteric colic
Urinary tract infection
Right pyelonephritis
<i>Gynaecological</i>
Ectopic pregnancy
Salpingitis/pelvic inflammatory disease
Ruptured ovarian follicle
Torted ovarian cyst
<i>Medical</i>
Pneumonia
Gastroenteritis
Diabetic ketoacidosis
Terminal ileitis
Porphyria
Preherpetic pain on the right 10th and 11th dorsal nerves

Box 2 Anatomical position of the appendix and possible changes in clinical presentation

<i>Retrocaecal/Retrocolic (75%)</i> —Right loin pain is often present with tenderness on examination. Muscular rigidity and tenderness to deep palpation are often absent due to protection from the overlying caecum. The psoas muscle may be irritated in this position leading to hip flexion and exacerbation of the pain on hip extension (psoas stretch sign).
<i>Subcaecal and Pelvic appendix (20%)</i> —Suprapubic pain and urinary frequency may predominate. Diarrhoea may be present due to irritation of the rectum. Abdominal tenderness may be lacking but rectal or vaginal tenderness may be present on the right. Microscopic haematuria and leucocytes may be present on urinalysis.
<i>Pre and Post-ileal (5%)</i> —Signs and symptoms may be lacking. Vomiting may be more prominent and diarrhoea due to irritation of the distal ileum.

confusion. A high index of suspicion is therefore required to make the diagnosis in such cases.

A systematic review of the symptoms which are associated with acute appendicitis has revealed that two symptoms have a high positive likelihood ratio (LR+) when present for diagnosing acute appendicitis; a history of right lower quadrant pain (LR += 8.0, 95% CI 7.3–8.5) and migration of initial periumbilical pain to the right lower quadrant (LR += 3.1, 95% CI 2.4–4.2) (Wagner et al. 1996). A further systematic review and meta-analysis of studies of patients admitted to hospital with suspected appendicitis concluded that individual elements of the history were of weak predictive value in the diagnosis of acute appendicitis. Pain migration was the best individual predictor of acute appendicitis (LR + 2.1, 95% CI 1.6–2.6) (Andersson 2004). Anorexia, nausea and vomiting were found in both reviews not to alter the likelihood of acute appendicitis. The likelihood of acute appendicitis also decreased with a history of similar previous pain (LR -= 0.3, 95% CI 0.2–0.4) and with the absence of right lower quadrant pain (LR -= 0.2, 95% CI 0.0–0.3). A synthesis of information based on clinical and laboratory findings was reported as the most useful mechanism of diagnosing acute appendicitis.

1.2 Examination

The patient presents with systemic features of an inflammatory response. They usually have a low grade fever ($<38^{\circ}\text{C}$) with associated tachycardia, and appear flushed and a fetor oris may be present. The patient will often lie still as movement and coughing exacerbate the pain. In children the hop test has been advocated as a test to confirm appendicitis. The child is asked to hop but refuses as this causes pain. On abdominal palpation the maximal site of tenderness is said to lie over McBurney's point, which lies two-thirds of a way along a line drawn from the umbilicus to the anterior superior iliac spine (McBurney 1889). The patient will be tender and may display signs of peritoneal irritation with localized guarding and muscular rigidity. Rebound tenderness should not be elicited to avoid distressing the patient. The signs found on clinical examination which are associated with a high positive likelihood ratio are signs of peritoneal irritation (rebound and percussion

tenderness, guarding and rigidity) (Andersson 2004) these were confirmed in a further systematic review which demonstrated a LR += 4.0 for the presence of rigidity (Wagner et al. 1996).

Findings on rectal or vaginal examination may be normal although pain on the right on rectal examination may indicate a pelvic appendix. A rectal examination is part of a thorough assessment of the patient with acute abdominal pain, however, the value of rectal examination in the diagnosis of appendicitis is debatable. In the presence of tenderness and guarding in the right iliac fossa in a study of 1,204 patients admitted to hospital with right lower quadrant pain little extra information was gained. The presence of right sided pain on rectal examination was more common in those with appendicitis (Odds Ratio [OR] 1.3) but this gave little diagnostic information (Dixon et al. 1991). These findings were confirmed in a further study of 477 patients with acute appendicitis and a systematic review and meta-analysis which concluded that the opinion that rectal examination is indispensable in the diagnosis of appendicitis cannot be supported (Andersson 2004; Kremer et al. 1998).

It has been suggested that opiate analgesia should be withheld from patients with suspected acute appendicitis as its administration masks clinical signs (Rusnak and Borer JM 1994). Two small randomized controlled studies in adult and paediatric cohorts have concluded that analgesia does not alter the clinician's ability to accurately diagnose acute appendicitis, and therefore, appropriate analgesia should be given to all patients on admission (Attard et al. 1992; Green et al. 2005).

Further examination findings have been suggested to aid in the diagnosis of appendicitis. Rovsing's sign is named after Danish surgeon Niels Rovsing and is said to be present when palpation in the left iliac fossa results in pain in the right iliac fossa (Wagner et al. 1996). The psoas muscle can be irritated by an inflamed appendix and movement of the muscle can result in pain. The patient may lie in the supine position with the hip flexed. This can be tested by asking the supine patient to lift the thigh whilst applying pressure just above the knee or by extending the right leg at the hip with the patient in the left lateral decubitus position. Pain with either maneuver confirms psoas irritation and is regarded as a positive psoas sign (Wagner et al. 1996). Lastly the obturator sign results from irritation of the obturator muscle. This can be elicited by passively flexing the right hip

and knee and internally rotating the leg at the hip which stretches the obturator muscle and causes pain in the right side of the abdomen (Wagner et al. 1996).

2 Laboratory Investigations

Specialist investigations are rarely needed to make the diagnosis of appendicitis as the diagnosis is predominantly clinical. The judicious use of simple bedside tests and laboratory markers of inflammation can provide additional evidence to support the diagnosis of acute appendicitis and exclude important differentials. The majority of patients presenting with abdominal pain will have blood drawn for a full blood count and urea and electrolyte analysis. Urine analysis and microscopy can exclude urinary tract infection but may be abnormal in up to 48% of patients undergoing appendicectomy (Puskar et al. 1995). The cause for abnormalities often leukocytosis and microscopic haematuria is the underlying inflammatory process irritating the renal tract along the line of the inflamed appendix (Puskar et al. 1995).

The most commonly used serological markers of inflammation in the diagnosis of acute appendicitis are the leukocyte count and C-reactive protein (CRP). Neither is diagnostic of acute appendicitis and studies have attempted to define potential threshold values which are predictive of a diagnosis and disease severity (Coleman et al. 1998; Korner et al. 1999; Hallan et al. 1997; Gurleyik et al. 1995). Repeated tests may also be useful in the context of patients in whom the diagnosis is unclear initially and are observed clinically with two studies suggesting other diagnoses or further tests should be considered if repeat measures are normal (Thompson et al. 1992; Eriksson et al. 1994). In the presence of normal inflammatory markers CRP, WBC and neutrophil count the diagnosis of acute appendicitis is unlikely (Andersson 2004; Grönroos and Grönroos 1999; Dueholm et al. 1989; Yang et al. 2006). The performance of these tests is clearly related to the population under study and a meta-analysis of studies of reporting results on patients admitted to hospital with acute abdominal pain and those selected for appendicectomy demonstrated that CRP performed better as a diagnostic test in those with an acute abdomen than in those selected already for surgery (Hallan et al. 1997). A further meta-analysis of studies reporting on

patients with a clinical suspicion of appendicitis concluded that the diagnosis of acute appendicitis was more likely when two or more inflammatory variables [granulocyte count, proportion of polymorphonuclear blood cells, white blood cell count (WBC) and CRP] were elevated (Andersson 2004). Studies of inflammatory markers in children notably of CRP and WBC count have concluded that an elevation of both parameters can support the diagnosis of acute appendicitis (Sack et al. 2006; Beltrán et al. 2007; Kwan and Nager 2010). These studies have all used different cut off levels to determine abnormal results and have generally been small single centre studies. The authors, therefore, suggest that the use of inflammatory variables should be used to support a clinical diagnosis of acute appendicitis and to exclude other pathologies. All women of child bearing age should have a serum or urine beta HCG requested to confirm pregnancy status. Given the differential diagnosis of acute appendicitis other blood tests including amylase, lipase, liver function tests, and clotting studies may be required to confirm or exclude other diagnoses.

Given the limitations of the current inflammatory markers there has been considerable research interest in identifying other potential biomarkers for the diagnosis of acute appendicitis and for predicting perforation. Hyper-bilirubinaemia has been shown to correlate with a diagnosis of perforated appendicitis (Estrada et al. 2007) but a stronger correlation has been recently reported for CRP (Käser et al. 2010). Interleukin-6 serum levels have not been shown to aid the diagnosis of appendicitis or reduce negative laparotomy rates (Gurleyik et al. 2002; Paajanen et al. 2002; Goodwin et al. 1997). The use of plasma D-lactate levels in the diagnosis of appendicitis is unclear with some studies suggesting it may (Demircan et al. 2004; Duzgun et al. 2007) or may not be a useful adjunct (Caglayan et al. 2003). A recent study of 51 patients with appendicitis suggested plasma concentration of lactoferrin and calprotectin are elevated in those with appendicitis but their role in diagnosis is unclear (Thuijls et al. 2011). Clearly the use of these markers in routine clinical practice will require much larger validation studies in defined cohorts of patients.

Laboratory tests have also been used to try and determine the need for further investigation in patients presenting with abdominal pain. Due to the non specific nature of most inflammatory variables,

however, no single specific test has been able to predict the need for further radiological investigation (Scheinfeld et al. 2010).

3 Scoring Systems

The diagnosis of acute appendicitis can be difficult and any delay in definitive treatment with surgery can lead to an increase in mortality and morbidity as the disease progresses to appendiceal perforation. This increase in morbidity and mortality has been used to justify the high rates of negative appendectomy which range from 14 to 75% (Alvarado 1986). A drive, therefore, has been to improve the diagnosis of appendicitis using clinical scoring systems. These systems have been based on symptoms, signs and laboratory findings. In some instances they have been part of a computer-aided diagnostic algorithm. The most widely cited score in the diagnosis of adults with acute appendicitis is the Alvarado score (Alvarado 1986). Whereas, in children the pediatric appendicitis score or Samuel score is most widely used (Samuel 2002). The scores have now been validated in a wide variety of populations, however, they have not made it into routine clinical practice in all settings. A number of studies have also used computer aided diagnosis in patients with acute abdominal pain in an attempt to improve the management of patients presenting with acute abdominal pain (De Dombal et al. 1974; Wellwood et al. 1992; Scarlett et al. 1986). These systems have reported a diagnostic accuracy of 97.2% in acute appendicitis (De Dombal et al. 1974), improvement in time to surgery, with a reduction in the number of perforations over a 2 year period (Scarlett et al. 1986). They have, however, not been introduced into routine clinical practice. In an aid to further improve diagnosis artificial neural networks have been suggested as adjuncts to diagnosis but this remains an area of research with only a small number of patients having had diagnoses made in this way (Prabhudesai et al. 2008; Hsieh et al. 2011).

3.1 Alvarado Score or MANTRELS Score

The score was originally developed by Alfredo Alvarado in 1986 as an aid to the diagnosis of patients with appendicitis. The score was based on a cohort of 305 patients based at the Nazareth Hospital in Philadelphia

Table 1 Alvarado score

	Variable	Value
Symptoms	Migration	1
	Anorexia-acetone	1
	Nausea-vomiting	1
Signs	Tenderness in right lower quadrant	2
	Rebound pain	1
	Elevation of temperature >37.3°C	1
Laboratory	Leukocytosis >10.0 × 10 ⁹ /L	2
	Shift to the left >75%	1

in the United States of America who presented with suspected appendicitis. The charts of these patients were reviewed retrospectively and the sensitivity and specificity of a number of symptoms, signs and laboratory variables were assessed with those with the greatest diagnostic value being used to form a scoring system. This resulted in the formation of a simple score consisting of three symptoms, three signs and two laboratory markers of inflammation weighted as either one or two based on their importance in diagnosis (Table 1). These variables could be recalled using the mnemonic MANTRELS. The maximum total score achievable is, therefore, 10. A score of 5 or 6 is compatible with a diagnosis of acute appendicitis, with a score of 7 or 8 indicating probable appendicitis and a score of 9 or 10 indicating a very probable acute appendicitis. It has been suggested that score can used as a guide to determine which patients require further observation and which patients require surgery. Those with a score of 5 or 6 required observation while those with a score of 7 or above needed to proceed to surgery as it was likely that they had appendicitis.

The Alvarado score is the best performing of the clinical scoring systems in current use (Ohmann et al. 1995). The score, however, is not based on a formal mathematical model which has accounted for the variables independent ability to predict a diagnosis. It was also based on retrospective data. These factors have resulted in a number of authors proposing multiple other scoring systems including a variety of other clinical, laboratory and imaging findings.

3.2 Other Scoring Systems

All of the described clinical scoring systems have attempted to aid the clinician in the diagnosis of the

patient with acute appendicitis. The systems use a variety of signs, symptoms and investigations to form their respective scores. None has been adopted into wide spread clinical practice. They remain only as an aid to clinical diagnosis but do alert the clinician to all probable variables that should be considered in making a diagnosis of appendicitis.

The Tzanakis scoring system incorporated ultrasound scanning along with clinical and laboratory findings to predict the diagnosis of appendicitis. Following a multivariate logistic regression analysis four variables formed the scoring system (Ultrasound positive for acute appendicitis, tenderness in the right lower quadrant, rebound tenderness and a leukocyte count $>12,000/\mu\text{L}$) (Tzanakis et al. 2005).

The Appendicitis Inflammatory Response Score was constructed from eight independent predictive variables (right lower quadrant pain, rebound tenderness, muscular defense, WBC count, proportion of neutrophils, CRP, body temperature and vomiting) and performed better than the Alvarado score in a sample of 229 patients suspected of appendicitis (Sensitivity 0.97 vs. 0.92, $p = 0.0027$ and Specificity 0.93 vs. 0.88, $p = 0.0007$) (Andersson and Andersson 2008).

The Ohmann score was developed in Germany and was subject to a before and after intervention study and used computer – aided diagnosis. The variables completing the score are tenderness in the right lower quadrant, rebound tenderness, no micturition difficulties, steady pain, leukocyte count $>10.0 \times 10^9/\text{L}$, age <50 years, relocation of the pain to right lower quadrant and rigidity (Ohmann et al. 1995). The score was developed using stepwise logistic regression analysis of a German database and confirmed on a Dutch database. Following introduction of the score over a 4 month period the rates of delayed appendectomy (2 vs. 8%) and delayed discharge (11 vs. 22%) decreased significantly ($p < 0.02$), however, there were no changes in the number of perforations or complications.

The Lintula score was developed from 35 symptoms and signs recorded for 131 Finnish children with abdominal pain which were modeled using logistic regression for their predictive value for a diagnosis of acute appendicitis. The score was then validated on a cohort of prospectively collected children with abdominal pain. The score uses gender, intensity of pain, relocation of pain, vomiting, pain in the right lower quadrant, fever, guarding, bowel sounds and

rebound tenderness to form a score which if greater than 21 appendectomy was advocated (Lintula et al. 2005). The Lintula score was developed for use in children but has subsequently been validated in adults (Lintula 2010). The Fenyo-Lindberg scoring system was developed using a prospectively collected sample of 1,167 patients with suspected appendicitis. The system uses nine clinical and one laboratory variable to form a score. Each variable is given a weight between -15 and $+15$ (Fenyo et al. 1997). The authors initially reported a reduction in the rate of negative laparotomies associated with the use of the score.

3.3 Pediatric Appendicitis Score (Samuel Score)

The Pediatric Appendicitis Score (PAS) was first described by Madan Samuel in 2002. It was based on an analysis of a prospectively collected cohort of 1,170 children aged 4–15 years (Samuel 2002). The symptoms, signs and laboratory findings were evaluated for sensitivity, specificity, predictive value and joint probability. A diagnostic index/weight for each clinical feature and investigation was calculated. A stepwise multiple linear regression analysis was then performed on the best independent predictors to develop a scoring system based on eight variables. The variables were given a score of one except for physical signs which were assigned a score of 2 to give a total score of 10. The variables in order of diagnostic index are, cough/percussion/hopping tenderness in the right lower quadrant of the abdomen, anorexia, pyrexia, nausea and emesis, tenderness over the right iliac fossa, leukocytosis, polymorphonuclear neutrophilia and migration of pain. The score was then validated on the cases and was found to have a sensitivity of 1, specificity of 0.92, positive predicted value of 0.96 and negative predictive value of 0.99.

The PAS has been evaluated in other cohorts of paediatric patients. It has been suggested that it is useful in stratifying the clinical risk of acute appendicitis in those children presenting to the emergency department with abdominal pain and classifying them as low, medium and high risk of acute appendicitis (Goldman et al. 2008). A score of less than or equal to 2 was found to have a high validity of ruling out acute appendicitis while a score greater than or equal to 7 was found to have a high validity of predicting acute

appendicitis. In two prospectively collected cohorts of 588 and 287 paediatric patients evaluated for acute appendicitis a PAS score of 6 or more had a sensitivity of 77–88% and a specificity of 65–50%, respectively (Schneider et al. 2007; Mandeville et al. 2010). Following both evaluations the authors concluded that neither the Alvarado nor PAS could be used in isolation to diagnose acute appendicitis.

3.4 Scoring Systems and the Use of Radiological Investigations

None of the scoring systems described have been able to replace the clinical diagnosis of acute appendicitis, however, they do act as an adjunct to diagnosis. Several studies have detailed their possible use in determining the need for further investigation in patients with abdominal pain. The authors of a prospective evaluation of 849 children with abdominal pain suggested that those with a PAS score of between 3 and 6 should go on to have further investigation such as ultrasound or computed tomography or a period of further evaluation (Goldman et al. 2008). A second prospective review of 246 children concluded that a PAS score of 5–7 may indicate the need for further investigation (Bhatt et al. 2009). A further retrospective review of 150 patients aged over 7 years presenting with abdominal pain concluded that those with an Alvarado score between 3 and 6 should undergo a CT scan of the abdomen with a sensitivity of CT of 90.4% and specificity of 95% (McKay and Shepherd 2007). A randomized controlled trial of graded ultrasonography and Alvarado scoring compared to standard clinical diagnosis demonstrated a significant decrease in time to surgery in the intervention group without a decrease in hospital stay or perforation rates (Douglas et al. 2000). The scoring, however, was carried out by just one observer and the intervention arm had three non-diagnosed cases of perforation which was worse than the control arm of the study.

The evidence, therefore, suggests that these scoring systems when equivocal may indicate the need for further investigation or a period of observation with serial physical examinations (Pouget-Baudry et al. 2010). None of the systems allow a definitive diagnosis of acute appendicitis or have the ability to accurately predict the need for further investigation. Therefore, clinical

diagnosis and clinical judgment should still be the main guides to further investigation in those patients in whom the diagnosis of appendicitis is unclear.

4 Difficult Diagnostic Areas

4.1 Abscess

Patients with an appendix abscess present with a swinging pyrexia associated with a tender mass in the right lower quadrant and a leucocytosis. The abscess is most often located in the lateral aspect of the right iliac fossa although a pelvic abscess may be palpable per rectum. The diagnosis is often confirmed on ultrasound or using computed tomography. The abscess can be drained percutaneously but open drainage allows appendicectomy to be performed (Humes and Simpson 2006).

4.2 Mass

Delayed presentation of appendicitis can be associated with presentation with a tender mass in the right iliac fossa. The mass can be confirmed using radiological imaging and patients who are clinically well are treated with intravenous antibiotics. In the majority of cases the mass will resolve and if indicated an interval appendicectomy can be performed. In elderly patients, the possibility of an underlying malignancy must be excluded. Careful clinical review is required to ensure resolution of the inflammatory process.

4.3 Pregnancy

Displacement of the appendix by the gravid uterus results in an atypical presentation of appendicitis in this group of patients. Nausea and vomiting may be present with tenderness located at any point on the right side of the abdomen. Acute appendicitis is the most common non-obstetric emergency requiring surgery in pregnancy with an incidence of 0.15–2.1 per 1,000 pregnancies (Guttman et al. 2004). The diagnosis may require specialist investigation with magnetic resonance imaging or ultrasound. A high index of suspicion is required as a delay in diagnosis results in an increase in both maternal (<1–4%) and fetal (1.5–35%) mortality associated with perforation (Guttman et al. 2004).

4.4 Chronic or Neuroimmune Appendicitis

A small number of patients present with recurrent episodes of right lower quadrant abdominal pain with no associated inflammatory changes (Barber et al. 1997). These patients are often difficult to diagnose and treat. Due to their small numbers only a few studies have attempted to define these cases in more detail. There appears to be two distinct groups of patients those with recurrent episodes of abdominal pain who ultimately have a chronically inflamed appendix removed reported as 6.5% of patients presenting with appendicitis in one study (Barber et al. 1997) and those in whom a histologically normal appendix is removed. Characteristics of these patients with recurrent episodes of pain are the presence of chronic inflammatory changes at the time of appendectomy (Mattei et al. 1994), and the presence of appendicolith on CT scan with a thickened appendix greater than 9 mm in width (Giuliano et al. 2006). In those with a normal appendix neuroimmune changes with an increased expression of substance P and vasoactive intestinal peptide (VIP) containing nerves have been demonstrated suggesting a possible neuroimmune explanation for symptoms other than acute inflammation (Di Sebastiano et al. 1999). There is no current standardized strategy for the management of these patients who must be dealt with on an individual basis. “[Spontaneously Resolving and Chronic Appendicitis](#)” is further discussed by LP Cobben.

5 Conclusion

The diagnosis of acute appendicitis is clinical and specialist investigations should only be requested in those patients in whom the clinical diagnosis is uncertain. The Alvarado and other scoring systems are still only an aid to clinical diagnosis and may aid in the clinicians judgment of how to manage patients.

References

- Addiss D et al (1990) The epidemiology of appendicitis and appendectomy in the United States. *Am J Epidemiol* 132(5):910–925
- Alvarado A (1986) A practical score for the early diagnosis of acute appendicitis. *Ann Emerg Med* 15(5):557–564
- Andersson R (2004) Meta-analysis of the clinical and laboratory diagnosis of appendicitis. *Br J Surg* 91(1):28–37
- Andersson M, Andersson R (2008) The appendicitis inflammatory response score: a tool for the diagnosis of acute appendicitis that outperforms the Alvarado score. *World J Surg* 32(8):1843–1849
- Attard AR et al (1992) Safety of early pain relief for acute abdominal pain. *BMJ* 305(6853):554–556
- Barber MD, McLaren J, Rainey JB (1997) Recurrent appendicitis. *Br J Surg* 84(1):110–112
- Beltrán MA et al (2007) Predictive value of white blood cell count and C-reactive protein in children with appendicitis. *J Pediatr Surg* 42(7):1208–1214
- Bhatt M et al (2009) Prospective validation of the pediatric appendicitis score in a canadian pediatric emergency department. *Acad Emerg Med* 16(7):591–596
- Bickell NA et al (2006) How time affects the risk of rupture in appendicitis. *J Am Coll Surg* 202(3):401–406
- Blomqvist PG et al (2001) Mortality after appendectomy in Sweden, 1987–1996. *Ann Surg* 233(4):455–460
- Caglayan F et al (2003) Plasma D-lactate levels in diagnosis of appendicitis. *J Invest Surg* 16(4):233–237
- Coleman C et al (1998) White blood cell count is a poor predictor of severity of disease in the diagnosis of appendicitis. *Am Surg* 64(10):983–985
- Cope Z (2000) *Early diagnosis of the acute abdomen*. 20th Edn. Oxford University Press
- De Dombal FT et al (1974) Human and computer-aided diagnosis of abdominal pain: further report with emphasis on performance of clinicians. *Br Med J* 1(5904):376–380
- Demircan M et al (2004) Plasma D-Lactic acid level: a useful marker to distinguish perforated from acute simple appendicitis. *Asian J Surg* 27(4):303–305
- Di Sebastiano P et al (1999) Neuroimmune appendicitis. *The Lancet* 354(9177):p 461
- Dixon JM et al (1991) Rectal examination in patients with pain in the right lower quadrant of the abdomen. *BMJ* 302(6773):386–388
- Douglas CD et al (2000) Randomised controlled trial of ultrasonography in diagnosis of acute appendicitis, incorporating the Alvarado score. *BMJ* 321(7266):919
- Dueholm S, Bagi P, and Bud M (1989) Laboratory aid in the diagnosis of acute appendicitis. A blinded, prospective trial concerning diagnostic value of leukocyte count, neutrophil differential count, and C-reactive protein. *Dis Colon Rectum* 32(10):855–859
- Duzgun AP et al (2007) Serum D-lactate: a useful diagnostic marker for acute appendicitis. *Hepatogastroenterology* 54(77):1483–1486
- Eriksson S, Granstrom L, Carlstrom A (1994) The diagnostic value of repetitive preoperative analyses of C-reactive protein and total leucocyte count in patients with suspected acute appendicitis. *Scand J Gastroenterol* 29(12):1145–1149
- Estrada J et al (2007) Hyperbilirubinemia in appendicitis: a new predictor of perforation. *J Gastrointest Surg* 11(6):714–718
- Fenyo G et al (1997) Diagnostic decision support in suspected acute appendicitis: validation of a simplified scoring system. *Eur J Surg* 163(11):831–838
- Flum DR, Koepsell T (2002) The clinical and economic correlates of misdiagnosed appendicitis: Nationwide analysis. *Arch Surg* 137(7):799–804

- Flum DR et al (2001) Has misdiagnosis of appendicitis decreased over time? A population-based analysis. *JAMA* 286(14):1748–1753
- Giuliano V et al (2006) Chronic appendicitis “syndrome” manifested by an appendicolith and thickened appendix presenting as chronic right lower abdominal pain in adults. *Emerg Radiol* 12(3):96–98
- Goldman RD et al (2008) Prospective validation of the pediatric appendicitis score. *J Pediatr* 153(2):278–282
- Goodwin AT et al (1997) Can serum interleukin-6 levels predict the outcome of patients with right iliac fossa pain? *Ann R Coll Surg Engl* 79(2):130–133
- Green R et al (2005) Early analgesia for children with acute abdominal pain. *Pediatrics* 116(4):978–983
- Grönroos JM, Grönroos P (1999) Leucocyte count and C-reactive protein in the diagnosis of acute appendicitis. *Br J Surg* 86(4):501–504
- Gurleyik E, Gurleyik G, Unalmiser S (1995) Accuracy of serum C-reactive protein measurements in diagnosis of acute appendicitis compared with surgeon’s clinical impression. *Dis Colon Rectum* 38(12):1270–1274
- Gurleyik G et al (2002) Serum interleukin-6 measurement in the diagnosis of acute appendicitis. *ANZ J Surg* 72:665–667
- Guttman R, Goldman RD, Koren G (2004) Appendicitis during pregnancy. *Can Fam Physician* 50:355–357
- Hallan S, Asberg A, Edna T (1997) Additional value of biochemical tests in suspected acute appendicitis. *Eur J Surg* 163:533–538
- Hsieh C-H et al (2011) Novel solutions for an old disease: Diagnosis of acute appendicitis with random forest, support vector machines, and artificial neural networks. *Surgery* 149(1):87–93
- Humes DJ, Simpson J (2006) Acute appendicitis. *BMJ* 333(7567):530–534
- Käser SA et al (2010) C-reactive protein is superior to bilirubin for anticipation of perforation in acute appendicitis. *Scand J Gastroenterol* 45(7–8):885–892
- Korner H, Soreide J, Sondenaa K (1999) Diagnostic accuracy of inflammatory markers in patients operated on for suspected acute appendicitis: a receiver operating characteristic curve analysis. *Eur J Surg* 165:679–685
- Kremer K et al (1998) The diagnostic value of rectal examination of patients with acute appendicitis. *Langenbecks Arch Chir Suppl Kongressbd* 115:1120–1122
- Kwan KY, Nager AL (2010) Diagnosing pediatric appendicitis: usefulness of laboratory markers. *Am J Emerg Med* 28(9):1009–1015
- Lintula H (2010) Diagnostic score in acute appendicitis. Validation of a diagnostic score (Lintula score) for adults with suspected appendicitis. *Langenbeck’s Arch Surg* 395(5):495–500
- Lintula H et al (2005) A diagnostic score for children with suspected appendicitis. *Langenbeck’s Arch Surg* 390(2):164–170
- Mandeville K, Pottker T, and Bulloch B (2010) Using appendicitis scores in the pediatric ED. *Am J Emerg Med*. 2010 Jul 30, Epub ahead of print
- Mattei P, Sola JE, Yeo CJ (1994) Chronic and recurrent appendicitis are uncommon entities often misdiagnosed. *J Am Coll Surg* 178(4):385–389
- McBurney C (1889) Experiences with early operative interference in cases of diseases of the vermiform appendix. *NY Med J* 50:676–684
- McKay R, Shepherd J (2007) The use of the clinical scoring system by Alvarado in the decision to perform computed tomography for acute appendicitis in the ED. *Am J Emerg Med* 25(5):489–493
- Murphy J (1904) Two thousand operations for appendicitis with deductions from his personal experience. *Am J Med Sci* 128:187–211
- Ohmann C, Yang Q, Franke C (1995) Diagnostic scores for acute appendicitis. *Abdom Pain Study Group. Eur J Surg* 161(4):273–281
- Paajanen H et al (2002) Novel serum inflammatory markers in acute appendicitis. *Scand J Clin Lab Invest* 62:579–584
- Paulson EK, Kalady MF, Pappas TN (2003) Suspected appendicitis. *N Engl J Med* 348(3):236–242
- Pouget-Baudry Y et al (2010) The use of the Alvarado score in the management of right lower quadrant abdominal pain in the adult. *Journal of Visceral Surgery* 147(2):e40–e44
- Prabhudesai S et al (2008) Artificial Neural Networks: Useful Aid in Diagnosing Acute Appendicitis. *World J Surg* 32(2):305–309
- Puskar D et al (1995) Urinalysis, ultrasound analysis, and renal dynamic scintigraphy in acute appendicitis. *Urology* 45(1):108–112
- Rusnak RA, Borer JM FJS (1994) Misdiagnosis of acute appendicitis: common features discovered in cases after litigation. *Am J Emerg Med* 12(4):397–402
- Sack U et al (2006) Diagnostic value of blood inflammatory markers for detection of acute appendicitis in children. *BMC Surgery* 6(1):15
- Samuel M (2002) Pediatric appendicitis score. *J Pediatr Surg* 37(6):877–881
- Scarlett PY et al (1986) Computer aided diagnosis of acute abdominal pain at Middlesbrough General Hospital. *Ann R Coll Surg Engl* 68(4):179–181
- Scheinfeld M et al (2010) Can lab data be used to reduce abdominal computed tomography (CT) usage in young adults presenting to the emergency department with nontraumatic abdominal pain? *Emerg Radiol* 17(5):353–360
- Schneider C, Kharbanda A and Bachur R (2007) Evaluating Appendicitis Scoring Systems Using a Prospective Pediatric Cohort. *Annals of Emergency Medicine* 49(6):778–784.e1
- Thompson MM et al (1992) Role of sequential leucocyte counts and C-reactive protein measurements in acute appendicitis. *Br J Surg* 79(8):822–824
- Thuijls G et al (2011) A pilot study on potential new plasma markers for diagnosis of acute appendicitis. *Am J Emerg Med* 29(3):256–260
- Tzanakis N et al (2005) A new approach to accurate diagnosis of acute appendicitis. *World J Surg* 29(9):1151–1156
- Wagner JM, McKinney WP, Carpenter JL (1996) Does this patient have appendicitis? *Jama* 276(19):1589–1594
- Wellwood J, Johannessen S, Spiegelhalter DJ (1992) How does computer-aided diagnosis improve the management of acute abdominal pain? *Ann R Coll Surg Engl* 74(1):40–46
- Yang H-R et al (2006) Laboratory tests in patients with acute appendicitis. *ANZ J Surg* 76(1–2):71–74

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