

Systematic review of blunt abdominal trauma as a cause of acute appendicitis

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ABSTRACT

INTRODUCTION Acute appendicitis commonly presents as an acute abdomen. Cases of acute appendicitis caused by blunt abdominal trauma are rare. We present a systematic review of appendicitis following blunt abdominal trauma. The aim of this review was to collate and report the clinical presentations and experience of such cases.

SUBJECTS AND METHODS A literature review was performed using PubMed, Embase and Medline and the keywords 'appendicitis', 'abdominal' and 'trauma'.

RESULTS The initial search returned 381 papers, of which 17 articles were included. We found 28 cases of acute appendicitis secondary to blunt abdominal trauma reported in the literature between 1991 and 2009. Mechanisms of injury included road-traffic accidents, falls, assaults and accidents. Presenting symptoms invariably included abdominal pain, but also nausea, vomiting and anorexia. Only 12 patients had computed tomography scans and 10 patients had ultrasonography. All reported treatment was surgical and positive for appendicitis.

CONCLUSIONS Although rare, the diagnosis of acute appendicitis must be considered following direct abdominal trauma especially if the patient complains of abdominal right lower quadrant pain, nausea and anorexia. Haemodynamically stable patients who present shortly after blunt abdominal trauma with right lower quadrant pain and tenderness should undergo urgent imaging with a plan to proceed to appendicectomy if the imaging suggested an inflammatory process within the right iliac fossa.

KEYWORDS

Trauma – Appendicitis

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Appendicitis is a very common surgical condition. Approximately 7% of people in Western countries have appendicitis at some time during their lives. Obstruction of the proximal lumen of the appendix has long been considered to be the major cause of acute appendicitis. In many cases, the cause of obstruction is unknown. The evidence from temporal and geographical clustering of cases suggests primary infectious aetiology.¹ Trauma has been known to be a rare cause of appendicitis for a long time.² However, several current textbooks omit trauma as a cause of appendicitis. Cases of acute appendicitis caused by blunt abdominal trauma are rare, but have been reported sporadically in the literature. The aim of this systematic review was to collate and report the clinical presentations and experience of such cases. The systematic review was initiated after we were presented with a case of acute appendicitis following blunt trauma which we present briefly first.

Case history

An 11-year-old boy presented with right iliac fossa (RIF) pain after direct trauma to the right lower quadrant of his abdomen. While lying on a trampoline, his brother landed with his elbow on the patient's abdominal right lower quadrant after a high jump. His abdominal pain started immediately. Apart from the pain; he had nausea, vomiting and anorexia. Symptoms persisted until his admission 3 days later. He was previously fit and well and he did not have similar symptoms prior to the traumatic incident. The patient was pyrexial, tachycardic but normotensive. His abdomen was soft but tender in the right lower quadrant and right flank. A chest X-ray showed no free intraperitoneal gas, urinalysis showed only a trace of blood and haematological and biochemical investigations showed raised inflammatory markers. A computed tomography (CT) scan was performed which showed appendicitis with



Figure 1 Computed tomography image of right iliac fossa collection (arrowed) as seen in our case.

an adjacent collection (Fig. 1). Subsequently, an appendicectomy was performed. The retrocaecal appendix was grossly inflamed and necrotic. Histology confirmed acute suppurative appendicitis with serositis. The patient was discharged on postoperative day 4 after making a full recovery.

Subjects and Materials

A computerised search of all the English literature cited in the PubMed, Embase and Medline databases from 1991 to 2009 was performed using the search words 'appendicitis' and either 'abdominal' or 'trauma' with no logic operators which returned 381 papers. Of these, non-relevant papers, reviews and non-English articles were excluded. Twenty-eight case reports (including our case) from 17 papers were included in this review, and data (including patient characteristics, investigations, treatment and outcome) were extracted from each report.

Results

Between 1991 and 2009, we found 28 cases of acute appendicitis caused by blunt abdominal trauma reported in the literature (Table 1). The age of patients ranged from 4–60 years (median, 11.5 years), and only three patients were female (10.7%). Mechanisms of injury ranged from road-traffic accidents (11 cases, two being pedestrians, one passenger and two due to seatbelt injuries, one bike-related and five unspecified), to falls (eight cases), assaults (five cases) and other accidents (three cases related to objects falling on the abdomen). One case presented following a colonoscopy. Presenting symptoms invariably included abdominal pain (17 with diffuse abdominal pain, only nine complained of localised RIF pain). Patients also experienced nausea (nine cases), vomiting (six cases) and anorexia (three cases). Patients presented 0.25–168 h (median, 12 h) after the traumatic event (Table 2). The

mean temperature of patients was $37.9 \pm 0.91^\circ\text{C}$. The mean white cell count was $13.7 \pm 5.0 \times 10^5/\text{mm}^3$. Only 12 patients had computed tomography (CT) scans and 10 patients had ultrasound scans (Table 2).

All reported treatment was surgical (Table 3). Many cases were treated with an appendicectomy (16, including two laparoscopic cases) and the remaining with exploratory laparotomy. All cases were positive for appendicitis, either by examination of the gross specimen, by histological analysis or both. There was no mortality reported in any of the cases. The mean hospital stay was 11.0 days.

Discussion

Acute appendicitis following blunt abdominal trauma has been reported sporadically over the past century. The most famous case is perhaps that of the Hungarian escapologist and stunt performer, Harry Houdini, who died in 1926 aged 52 years following a ruptured appendix after being punched several times (with permission) in the abdomen by student Gordon Whitehead. The reported incidence of acute appendicitis following trauma remains low. In 1938, Fowler² reported only 48 cases out of 13,496 cases of appendicitis (0.3%) with a history of trauma. Ciftci *et al.*⁵ reported only five cases of appendicitis out of 554 patients (0.9%) following blunt abdominal trauma.

There has been much debate as to whether acute appendicitis following trauma is coincidental or causal. For genuine cases, Fowler² stated the following conditions must be met:

1. No history of previous attacks of appendicitis.
2. The cause of the trauma and mechanism of injury must create a force which is capable of reaching the appendix.
3. The effects of the trauma must be experienced immediately, and merges into that of acute appendicitis.
4. True traumatic lesions of the appendix must be operatively demonstrated.
5. There must be a superimposed acute inflammation of the appendix.

We found 28 cases in the literature (Table 1), with different mechanisms of trauma. Our case is the first case of trampoline-related appendicitis.

The presentation of appendicitis secondary to trauma is generally similar to non-traumatic appendicitis. The difficulty lies with the unfamiliarity of clinicians with the possibility of appendicitis and the extensive differential diagnosis of abdominal pain after blunt abdominal trauma. Due to rarity of the diagnosis, further investigations might be required in stable patients. These investigations are essentially required to confirm the diagnosis of appendicitis, rule

Table 1 Summary of cases: patient characteristics, mechanism of injury and presenting symptoms

Reference	Age	Sex	Mechanism of injury	Time of presentation (h)	Presenting symptoms		Fever	Nausea	Vomiting	Anorexia	Other
					Diffuse abdominal pain	RIF abdominal pain					
Amir (2009) ³	10	M	Fall	2	Groin pain	x	x	x	x	x	x
Bangs (1991) ⁴	20	M	RTA (motorcyclist)	-	Admitted to ITU with closed head injury and decerebrate posturing	x	√	x	x	x	x
Ciftci (1996) ⁵	8	M	RTA (pedestrian)	2	√	x	√	x	x	x	x
Ciftci (1996) ⁵	5	F	Fall	6	√	x	x	x	x	x	x
Ciftci (1996) ⁵	13	F	Accident (ball)	12	x	x	√	x	x	x	x
Ciftci (1996) ⁵	14	M	RTA	4	√	x	√	√	√	x	x
Ciftci (1996) ⁵	7	M	Assault	12	√	x	x	x	x	x	x
Derr (2009) ⁶	41	M	Fall	-	Epigastric	√	x	x	√	x	x
Etensel (2005) ⁷	5	M	RTA	4	√	x	x	x	x	x	x
Etensel (2005) ⁷	8	M	RTA	1	√	x	√	x	x	x	x
Etensel (2005) ⁷	14	M	RTA	1	x	√	x	x	x	x	x
Etensel (2005) ⁷	9	M	Fall	1	√	x	x	x	x	Confusion	x
Etensel (2005) ⁷	13	M	RTA (pedestrian)	0.25	√	x	x	x	x	x	x
Hagger (2002) ⁸	60	M	Fall	72	x	√	x	x	x	x	Right inguinal mass
Hennington (1991) ⁹	46	M	Accident	48	√	x	√	x	x	√	x
Hennington (1991) ⁹	12	M	Fall	12	√	x	√	x	x	√	x
Houry (2001) ¹⁰	5	M	Fall	1	√	x	√	√	x	x	x
Karakyros (2004) ¹¹	21	M	Assault	'Several hours'	√	√	√	x	x	x	x
Musemeche (1995) ¹²	4	M	RTA (passenger)	'Within hours'	√	√	√	x	x	x	x
Osterhoudt (2000) ¹³	9	M	RTA	'Few hours'	x	√	x	x	x	x	x
Ramesh (2002) ¹⁴	11	M	Accident (bike)	48	√	x	√	√	√	x	Diarrhoea
Ramsook (2001) ¹⁵	12	M	Assault	18	x	√	√	x	x	x	x
Serour (1996) ¹⁶	11	M	Assault	18	√	√	x	x	√	√	x
Serour (1996) ¹⁶	8	M	Fall	3	√	x	√	√	x	x	x
Serour (1996) ¹⁶	7	M	Assault	168	x	√	√	x	√	x	x
Stephenson (1995) ¹⁷	32	F	RTA, seat belt	120	'Signs of acute appendicitis'	√	√	x	√	x	x
Takagi (2000) ¹⁸	45	M	RTA, seat belt	24	√	x	x	x	x	x	x
Volchok (2006) ¹⁹	60	M	Colonoscopy	60	x	√	√	√	√	x	x
This study	11	M	Accident (trampoline -related)	72	x	√	√	√	√	√	√

RTA, road traffic accident.

Table 2 Investigations during admission

Author	Computed tomography	Ultrasonography
Amir	Free fluid and distended appendix	Atonic bowel loops, retrovesicular mass
Bangs	Initially showed no visceral injury	Not done
Ciftci	Not done	Not done
Ciftci	Not done	Not done
Ciftci	Not done	Not done
Ciftci	Not done	Dilated loops (minimal intraperitoneal fluid)
Ciftci	Not done	Dilated loops (minimal intraperitoneal fluid)
Derr	Not done	Non-compressible app + 'target' appearance
Etensel	Not done	Large abdo fluid, hepatic lacerations
Etensel	Not done	Large hepatic laceration, free fluid and retroperitoneal haematoma
Etensel	Not done	Retroperitoneal haematoma
Etensel	Free air	Free air
Etensel	Splenic laceration, free fluid (large volume), pneumomediastinum, left hemidiaphragm and left ureteropelvic junction and urinoma	Not done
Hagger	Dilated loops of small bowel, incarceration of oedematous bowel in a right inguinal hernia, and oedematous changes in the right perirenal tissues	Not done
Hennington	Not done	Not done
Hennington	Not done	Not done
Houry	Pelvic free fluid, inflammation in the appendix and right colon	Not done
Karavokyros	Not done	Free peritoneal fluid around liver
Musemeche	Multiple contused and lacerated spleen, liver contusions and moderate oedema around pancreas	Not done
Osterhoudt	Normal CT	Not done
Ramesh	Not done	Bilateral iliac fossa fluid collection
Ramsook	Thick walled loop of bowel (RLQ), free pelvic fluid	Not done
Serour	RIF haziness, calc faecolith, prerectal fluid	Not done
Serour	Not done	Not done
Serour	RLQ Abscess	Not done
Stephenson	Not done	Not done
Takagi	Not done	Not done
Volchoh	Retrocaecal appendix with appendicolith, wall thickening and peri-appendiceal inflammation	Not done
This study	Appendicitis with adjacent collection	Not done

out other diagnoses and aid in planning the management of such patients. The rarity of the diagnosis and the long list of differential diagnoses made us reluctant to operate on our patient without CT confirmation of the diagnosis.

From our review, routine haematological and biochemical investigations are not very useful. Even if inflammatory markers are raised, that would not confirm the diagnosis. DPL was reported only once to have been used to diagnose a post traumatic abdominal inflammatory process which led to laparotomy and diagnosis of appendicitis.⁴

The diagnosis is likely to require imaging for confirmation. Ultrasonography in the diagnosis of appendicitis following blunt trauma has been shown to be useful as a diagnostic tool if done by experts.⁶ Some authors advocate a trauma eFAST scan (extended focused assessment with sonography in trauma) to include the appendix.⁶ CT scanning has proven useful in many of the cases presented here. CT was normal in one case on admission.⁴

The pathological process of the development of acute appendicitis has been attributed to different mechanisms.

Table 3 Summary of treatment for appendicitis, histology results and outcome

Author	Treatment	Gross histology	Histology	Outcome
Amir	–	Inflamed appendix (+ fibrin)	Appendicitis	Recovered
Bangs	Laparotomy	–	–	–
Ciftci	Appendicectomy	Perforated appendix	Appendicitis	6.4 ± 1.5 days hospital stay
Ciftci	Appendicectomy	Acute appendicitis	Appendicitis	
Ciftci	Appendicectomy	Acute appendicitis	Appendicitis	
Ciftci	Appendicectomy	Perforated appendix	Appendicitis	
Ciftci	Appendicectomy	Acute appendicitis	Appendicitis	
Derr	Laparoscopic appendicectomy	No perforation	–	Recovered
Etensel	Laparotomy	Hep lacerations + appendicitis	Confirmed appendicitis	15-day stay
Etensel	Laparotomy	Hyperaemic, oedematous, thickened	Confirmed appendicitis	19-day stay
Etensel	Laparotomy	Hyperaemic, inflamed	Confirmed appendicitis	15-day stay
Etensel	Laparotomy	Hyperaemic, oedematous, inflamed	Confirmed appendicitis	10-day stay
Etensel	Laparotomy	Hyperaemic, oedematous, thickened	Confirmed appendicitis	21-day stay
Hagger	–	Gangrenous appendix inside hernia	–	Full recovery by 6 weeks
Hennington	Midline celiotomy	Gangrenous appendix	–	3-day stay
Hennington	Appendicectomy	Acute suppurative appendicitis	–	2-day stay
Houry	Exploratory laparotomy	Acutely inflamed, perforated	–	7-day stay
Karavokyros	Antibiotics, then laparotomy	Inflamed appendix	Confirmed appendicitis, lymph node enlarged	7-day stay
Musemeche	Appendicectomy	Acute appendicitis with perforation	–	19-day stay
Osterhoudt	Appendicectomy	Gangrenous appendix	Gangrenous appendix	Full recovery
Ramesh	Laparotomy	Perforated appendix	Suppurative appendicitis	5-day stay
Ramsook	Appendicectomy/lavage	Acutely inflamed, retrocaecal	Inflammation, full thickness perforation	–
Serour	Laparotomy	Gangrenous appendix	Confirmed, with peri-appendicitis	–
Serour	Appendicectomy	Phlegmonous appendix	Confirmed, with peri-appendicitis	–
Serour	Appendicectomy/drainage	Acute, gangrenous, perforated	–	–
Stephenson	Appendicectomy	Acutely inflamed appendix	–	Full recovery
Takagi	Appendicectomy	Acutely inflamed appendix	Phlegmonous appendix + peri-appendicitis	Uncomplicated
Volchok	Laparoscopic appendicectomy	Grossly inflamed appendix + fecalith	–	1-day stay
This study	Appendicectomy	Retrocaecal, inflamed and necrotic appendix	Acute suppurative appendicitis with serositis	4-day stay

The first proposed mechanism is increased intra-abdominal pressure in direct injury.² Pressure within the appendix may be increased by any force which decreases intra-abdominal space.² This force must be suddenly exerted.² The second explanation is that blunt trauma might have a direct effect on the appendix with subsequent appendiceal oedema, inflammation, and/or hyperplasia of intrinsic lymphoid tissues, all of which could result in obstruction of the appendiceal lumen.⁷ The third mechanism is explained by a combination of appendiceal faecolith and caecal trauma. In the presence of faecolith, a direct blow or crushing injury deliv-

ered over the caecum may cause a true traumatic lesion or forcible expulsion of gas and faecal contents into the organ. That increases luminal pressure. Minute fissures in the mucosa or lacerations may occur permitting invasion of bacteria into the submucous coat. This leads to complete obstruction, inadequate drainage, defective circulation and (subsequently) gangrene (as in our case) and spontaneous perforation.² The fourth explanation states that stretching of the appendiceal orifice is the cause of appendicitis. The caecum, as the widest part of the colon, is most susceptible to distension with increases in intracolonic pressure. This

leads to stretching of the appendiceal orifice. Subsequent acute inflammation in response to this stretching trauma may have led to the development of an obstructive appendicitis.²⁰ Indirect trauma might also cause appendicitis. This is either caused by increased intra-abdominal pressure⁷ or irritation caused by muscle contractions. Power contractions of the iliopsoas might irritate the appendix causing adhesions, bands, angulations, kinks or obstructions.² Some authors attribute appendicitis secondary to direct and indirect trauma to hypoperfusion with subsequent mucosal oedema and appendicitis.

Conclusions

Although rare, the diagnosis of acute appendicitis must be considered following direct abdominal trauma especially if the patient complained of abdominal right lower quadrant (RLQ) pain, nausea and anorexia. Appendicitis can be reasonably attributed to trauma if the presentation was early after the traumatic event and the patient has not suffered from suggestive symptoms prior to trauma. Attributing appendicitis to trauma might be more difficult in other cases. Haemodynamically stable patients who present shortly after blunt abdominal trauma with RLQ pain and tenderness should undergo immediate imaging with a plan to proceed to appendicectomy if the imaging suggested an inflammatory process within the RIF.

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