Traumatic appendicitis: Is it a fairy tale? A literature review

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Abstract
Acute appendicitis is the most common surgical condition in patients presenting to emergency departments worldwide. It was only in the early 1930s that the relationship between blunt trauma and acute appendicitis was reported. Searches on the terms “traumatic appendicitis” and “appendicitis post blunt trauma” in PubMed, Google, and Medline yielded 23 full-text articles about traumatic appendicitis. The articles reported on acute post-traumatic appendicitis. Nevertheless, the relationship between acute appendicitis and trauma is still controversial. A few theories have attempted to explain the relationship; however, a definitive cause has not yet been identified. A patient presenting with right iliac fossa or diffuse abdominal pain after a traumatic event should be investigated, and acute appendicitis should be included in a differential diagnosis.

Keywords: Appendicitis, fairy tale, worldwide

Introduction
Acute appendicitis is the most common surgical condition in patients presenting to emergency departments worldwide. The mechanisms behind acute appendicitis have been explained by obstructions of the appendix lumen by fecaliths or foreign bodies [1, 2]. It was only in the early 1930s that the relationship between blunt trauma and acute appendicitis was reported [3, 4, 1]. The most famous figure who was speculated to have died from acute appendicitis after multiple blows to the abdomen was the magician Houdini in 1926 [2]. Whether acute appendicitis in a trauma setting is an incidental or casual finding is unclear. The aim of this literature review was to seek evidence about the possibility of the implementation of a traumatic appendicitis diagnosis.

Methods
Searches on the terms “traumatic appendicitis,” “appendicitis post trauma,” and “appendix injury” were performed in PubMed, Google, and Medline between August and October 2019. The inclusion criterion was full-text English-language articles. The exclusion criteria were articles with only abstracts or summaries. Twenty-three full-text published articles on traumatic or post-traumatic appendicitis were found.

Results
The total number of patients reported in the articles was 39: 36 males and 3 females [5, 6]. Each had been healthy prior to experiencing a traumatic event in the preceding 1–48 hours. Three cases were described as appendix injury or post-traumatic perforation [7–9]. One case was caused by a penetrating stab wound in the right lower abdomen [10]. The search results are summarized in Table 1. All the patients had been exposed to abdominal trauma, such as seat belt injuries, blows to the abdomen, assaults, and bicycle injuries. The age range was 5–65 years. The applied diagnostic modules were ultrasonography and computed tomography of the abdomen (Table 2). Some articles provided no documentation on the diagnostic modules [1, 3, 5, 7]. One article did not specify the diagnostic investigations that were performed [5]. Fowler published a report on 48 cases that had been diagnosed as acute appendicitis caused by external trauma in industrial accidents; however, details were not provided [3]. He emphasized the lack of proper documentation of traumatic events and their times of occurrence.
This was attributed to the patients’ manipulation of the period between trauma and injury to benefit from the compensation laws [3]. For linkage, most experts at that historical period set an interval of 48 hours between the clinical symptoms and the traumatic event [3]. A period of more than 48 hours between symptoms and a traumatic event would rule out a relationship [3]. Fowler stated that some cases were diagnosed intraoperatively as acute appendicitis; however, the results of histological examinations indicated otherwise [3].

| Author             | Publication year | Number of cases |
|--------------------|------------------|-----------------|
| Thomas [7]         | 1978             | 1               |
| Hennington [1]     | 1990             | 2               |
| Ciftci [9]         | 1996             | 5               |
| Hagger [11]        | 2002             | 1               |
| Ramesh [11]        | 2002             | 1               |
| Karavokyros [13]   | 2004             | 1               |
| Etensel [14]       | 2005             | 5               |
| Touni [15]         | 2010             | 1               |
| Torres-Grau [16]   | 2012             | 1               |
| Wani [5]           | 2013             | 8               |
| Bouassria [10]     | 2013             | 1               |
| Moslemi [8]        | 2013             | 1               |
| Ahmed [17]         | 2014             | 1               |
| Gupta [18]         | 2016             | 2               |
| Seung [9]          | 2016             | 1               |
| Jensen [19]        | 2016             | 1               |
| Khalji [2]         | 2017             | 1               |
| Siddiqui [4]       | 2018             | 1               |
| Singh [10]         | 2018             | 1               |
| AlJaberi [21]      | 2018             | 1               |
| Çağlar [22]        | 2018             | 1               |
| O’Kelly [23]       | 2019             | 1               |
| **Total**          |                  | **39**          |

| Author    | CT scan abdomen                          | Ultrasonography of the abdomen                        |
|-----------|------------------------------------------|-------------------------------------------------------|
| Thomas [5]| Not done                                  | Not done                                              |
| Hennington [1] | Not done                          | Not done                                              |
| Hennington [1] | Not done                          | Not done                                              |
| Ciftci [9] | Not done                                  | Not done                                              |
| Ciftci [9] | Not done                                  | Not done                                              |
| Ciftci [9] | Not done                                  | Not done                                              |
| Ciftci [9] | Not done                                  | Not done                                              |
| Ciftci [9] | Not done                                  | Not done                                              |
| Ciftci [9] | Not done                                  | Dilated bowel loops                                    |
| Ciftci [9] | Not done                                  | Dilated bowel loops                                    |
| Hagger [11]| Dilated loops of small bowel, incarceration of edematous bowel in a right inguinal hernia, and edematous changes in the right perirenal tissues | Not done                                              |
| Ramesh [12]| Not done                                  | Bilateral iliac fossa fluid collection.               |
| Karavokyros [13]| Not done                              | Free peritoneal fluid mainly around the liver          |
| Etensel [14]| Not done                                  | Large abdo fluid, hepatic lacerations                 |
| Etensel [14]| Not done                                  | Large hepatic laceration, free fluid and retroperitoneal hematoma |
| Etensel [14]| Not done                                  | Retroperitoneal hematoma                               |
| Etensel [14]| Free air                                  | Free air                                              |
| Etensel [14]| Splenic laceration, free fluid (large volume), pneumomediastinum, left hemidiaphragm and left ureteropelvic junction and urinoma | Not done                                              |
| Toumi [15]| Appendicitis with an adjacent collection | Normal liver, gallbladder, spleen and kidneys, with no evidence of presence of free fluids |
| Torres-Grau [16]| Not done                                  | Normal liver, gallbladder, spleen and kidneys, with no evidence of presence of free fluids |
| Wani [5]| Used but no specifications                | Used but no specifications                            |
| Wani [5]| Used but no specifications                | Used but no specifications                            |
| Wani [5]| Used but no specifications                | Used but no specifications                            |
| Wani [5]| Used but no specifications                | Used but no specifications                            |
| Wani [5]| Used but no specifications                | Used but no specifications                            |
| Wani [5]| Used but no specifications                | Used but no specifications                            |
| Wani [5]| Used but no specifications                | Used but no specifications                            |
| Wani [5]| Used but no specifications                | Used but no specifications                            |
| Wani [5]| Used but no specifications                | Used but no specifications                            |

Table 1: Searched articles with number of cases

Table 2: Diagnostic investigations
Table 3: Initial symptoms and time interval between trauma and symptoms

| Author          | Time interval between trauma and symptoms | Initial symptoms                                      |
|-----------------|------------------------------------------|-------------------------------------------------------|
| Thomas [7]      | 4–6 hours                                 | Tenderness in lower abdomen                            |
| Hennington [1]  | 1<sup>st</sup> case: 48 hours, 2<sup>nd</sup> case: 12 hours | Severe pain in lower abdomen                          |
| Ciftci [6]      | Not mentioned                             | Not mentioned                                         |
| Hagger [11]     | 72 hours                                  | Right lower quadrant pain; worse on movement          |
| Ramesh [12]     | 48 hours                                  | Persistent abdominal pain, nausea and vomiting        |
| Karavokyros [13] | 12 hours presumably                      | Vague abdominal pain and dysuria without concomitant diarrhea or vomiting |
| Ectensel [14]   | 1<sup>st</sup> case: 4 hours, 2<sup>nd</sup> case: 1 hour, 3<sup>rd</sup> case: 1 hour, 4<sup>th</sup> case: 1 hour, 5<sup>th</sup> case: 15 mins | All with lower abdomen pain with or without abrasions |
| Toumi [15]      | Immediately                               | Severe lower abdomen pain                             |
| Torres-Grau [16] | 6 hours                                   | Sever right sided abdominal pain                      |
| Wani [3]        | 24 hours–4 days                           | Lower abdomen pain                                    |
| Bouassria [19]  | 24 hours                                  | Right iliac fossa pain post stab                      |
| Moslemi [4]     | 6 hours                                   | Diffuse abdominal pain with fever                     |
| Ahmed [17]      | 48 hours                                  | Right lower abdominal pain                            |
| Gupta [18]      | 1<sup>st</sup> case: 96 hours, 2<sup>nd</sup> case: 72 hours | Severe abdominal pain in both cases                  |
| Seung [9]       | 8 hours                                   | Pain in the periumbilical area as well as the lower abdomen |
| Jensen [19]     | 6 hours                                   | Acute abdominal pain and nausea                       |
| Khilji [2]      | 2 hours                                   | Abdominal pain                                        |
| Siddiqui [4]    | 1 hour                                    | Right shoulder and lateral right hip                  |
| Singh [20]      | 48 hours                                  | Abdominal pain                                        |
| AlJaberi [21]   | 30 minutes                                | Right flank pain                                      |
| Çağlar [22]     | 24 hours                                  | Abdominal pain                                        |
| O’Kelly [23]    | 24 hours                                  | Sudden progressive right lower quadrant pain          |

Table 4: Trauma mechanisms, surgical intervention, intraoperative findings, and histology

| Author          | Mechanism of trauma                                                                 | Procedure                             | Intra-operative findings                                                                 | Histology                                      |
|-----------------|--------------------------------------------------------------------------------------|---------------------------------------|------------------------------------------------------------------------------------------|------------------------------------------------|
| Thomas [5]      | Low-velocity crush injury; patient was trapped between stationary and slow-moving vehicles | Open appendectomy via right paramedian incision | Torn mesoappendix; the appendix itself was completely severed at the junction of its proximal third and distal two-thirds | The appendix showed a small fecalith in the severed portion and mild but definite inflammatory changes confined to the mucosa of both portions. |
| Hennington [1]  | Engine transmission (200 lb) fell on patient’s abdomen                                 | Open appendectomy                      | Gangrenous appendix                                                                      | Not mentioned                                  |
| Hennington [1]  | Bicycle handlebar injury to his lower abdomen.                                        | Open appendectomy                      | Acute suppurative appendicitis                                                           | Not mentioned                                  |
| Ciftci [6] | Patient fell from approximately 6 feet and landed prone on the rungs of the ladder | Open appendectomy | Gangrenous appendix with free pus | Not mentioned |
| Karavokyros [13] | Bicycle handlebar injury to patient’s lower abdomen. | Laparotomy with appendectomy | Infamed appendix, a few enlarged mesenteric lymph nodes and free peritoneal fluid | Confirmed appendicitis |
| Etensel [14] | RTA | Laparotomy + appendectomy | Hyperemic, edematous, thickened appendix | Confirmed appendicitis |
| Etensel [14] | RTA | Laparotomy + appendectomy | Hyperemic, inflamed appendix | Confirmed appendicitis |
| Touni [15] | Fall and blow to abdomen | Open appendectomy | Retrocecal appendix was grossly inflamed and necrotic | Acute suppurrative appendicitis with serositis |
| Wani [5] | Fall | Open appendectomy | Features of appendicitis | Confirmed appendicitis |
| Wani [5] | Fall | Open appendectomy | Features of appendicitis | Confirmed appendicitis |
| Wani [5] | Kicked in the abdomen | Open appendectomy | Features of appendicitis | Confirmed appendicitis |
| Wani [5] | Kicked in the abdomen | Open appendectomy | Features of appendicitis | Confirmed appendicitis |
| Wani [5] | Kicked in the abdomen | Open appendectomy | Features of appendicitis | Confirmed appendicitis |
| Wani [5] | Compression on the right lower abdomen by a bicycle handlebar | Open appendectomy | Features of appendicitis | Confirmed appendicitis |
| Bouassria [10] | Penetrating stab wound to the abdomen | Laparotomy + appendectomy | Appendix was hyperemic and edematous | Confirmed diagnosis of acute appendicitis |
| Moslemi [9] | Bicycle handlebar injury to the lower abdomen | Exploratory laparotomy + appendectomy | Transection of the appendix from its distal half | Acute appendicitis |
| Ahmed [17] | Blunt trauma to the right lower abdomen from a desk corner | Exploratory laparotomy + appendectomy | Perforated appendix | Acute appendicitis |
| Gupta [18] | Bicycle handlebar injury | Open appendectomy | Appendix was perforated and fecalith | Appendicitis with appendicolith |
| Gupta [18] | Fall | Exploratory laparotomy + appendectomy | Appendicular lump with a perforated appendix | Perforated appendix with inflammation involving all layers of the appendix |
| Seung [9] | Motor vehicle collision | Exploratory laparotomy + appendectomy | Appendix was transected completely at its proximal portion, and the free distal portion of the transected appendix was found in the pelvic cavity (Fig. 4) | Not mentioned |
| Jensen [19] | Bicycle handlebar injury | Diagnostic laparoscopy + appendectomy | Appendix was traumatically amputated 1.5 cm above the base | Confirmed ruptured appendix |
| Siddiqui [4] | Fall from a ladder | Diagnostic laparoscopy + appendectomy | Inflamed retrocecal appendix consistent with acute appendicitis | Active inflammatory changes consistent with acute appendicitis |
| Singh [19] | Bicycle handlebar injury | Exploratory laparotomy + appendectomy + perforation repair | Jejunal perforation with appendicitis | Acute appendicitis |
| AlJaberi [20] | Motor vehicle collision | Lower midline | Free fluid in the abdomen; a | Not mentioned |
The pathophysiological mechanism is still unclear. Several theories have been formulated; however, a definitive cause has not been found. Hennington proposed that trauma that indirectly causes eecum contusion, mesenteric disruption, and enlarged lymph nodes could lead to the obstruction of appendiceal lumen, and this could lead to bacterial infection \[1\]. The bacterial infection would lead to the cycle, which eventually could lead to perforation \[1\]. A second theory has suggested that the position of the appendix could be a cause of traumatic appendicitis \[15\]. Post-traumatic appendicitis is unlikely to develop in a retrocecal appendix because of the protection from the eecum against the increased intra-abdominal pressure caused by trauma. However, it is more likely to occur in a pelvic appendix or appendix in the inguinal hernia (Amyand’s hernia) \[15\]. A third theory has posited that the sudden increase of intra-abdominal pressure on the appendix could lead to inflammation, edema, and lumen obstruction \[20\]. A fourth theory is that the combination of appendicular fecalith and eecum trauma could cause an appendix lumen obstruction and infection \[20\].

Appendiceal transections have been reported after seat belt injuries and bicycle handlebar injuries to the abdomen \[8, 9, 19, 21\]. In these cases, a transection of the appendix was identified intraoperatively \[8, 9, 19, 21\]. The causes were crush or deceleration injuries \[8, 9\]. In one case, acute appendicitis was reported after a penetrating abdominal stab wound \[10\]. A right paracolic retroperitoneal hematoma was found with cecal and appendiceal wall hematomas intraoperatively. This might have led to compression on the cecum and appendix and the subsequent obstruction of the appendix lumen \[10\].

Blunt abdominal trauma from handlebar injuries or kicks directly to the abdomen in children should raise the index of suspicion of possible internal organ injury \[12\]. Abdominal ultrasonography could assist in the diagnosis of appendicitis in children \[12\]. In adults for whom traumatic appendicitis might be caused by seat belt trauma, road traffic accidents (including those involving motor vehicles), assaults, or falls from ladders \[11, 9, 5, 14, 16, 15\], abdominal ultrasonography and computed tomography of the abdomen are helpful tools in diagnostic confirmation \[2\].

**Conclusion**

Acute appendicitis after abdominal trauma is rare and controversial. Several theories have attempted to explain the relationship between trauma and appendicitis; however, no definitive cause has been found. For abdominal pain presentation after trauma, emergency physicians should consider appendicitis in the differential diagnosis.

**Conflicts of interest**

The authors have no conflicts to declare.

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**Discussion**

Traumatic appendicitis and post-traumatic appendicitis are controversial terms. Fowler \(^{[3]}\) listed three criteria for using the term traumatic appendicitis: (1) The patient should be previously healthy with no history of pain attacks prior to the trauma; (2) the force of the trauma should be directed to the abdomen; and (3) the effects of the trauma must progress to appendicitis symptoms, such as pain. The time interval between the trauma and presenting symptoms is 1–72 hours \[^6, 11-14\]. All the cases presented with diffuse abdominal or right iliac fossa pain \[^5, 14, 15, 22\].

| ÇÇlar \[^{[21]}\] | Fall from a swing | exploratory laparotomy | Not mentioned | Inflamed and perforated appendix | Acute appendicitis |
|----------------------------|------------------|------------------------|---------------|-------------------------------|------------------|
| O’Kelly \[^{[22]}\] | Kick to the abdomen during a soccer game | Lower midline exploratory laparotomy | Disintegrated perforated appendix | Evidence of a dense inflammatory infiltrate and necrotic fragments | |

**RTA: Road Traffic Accident**
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