REVIEW ARTICLE
MECHANICAL SMALL BOWEL OBSTRUCTION BY AN INFLAMED APPENDIX: AN UNCOMMON MANIFESTATION OF A COMMON CONDITION. CASE REPORT AND REVIEW OF LITERATURE.

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ABSTRACT

Appendicitis is the commonest cause of acute abdomen. Common complications include perforation, mass formation, abscess, peritonitis and sepsis. Intestinal obstruction is also common in the General Surgeon's emergency case mix with the commonest causes being external herniae and post operative adhesions. Mechanical small bowel obstruction from appendicitis with the inflamed appendix acting as the physical obstructing agent is rare with only a few cases reported. We share our case of small bowel obstruction from an inflamed appendix and review similar cases in the literature.

Our patient presented with symptoms of intestinal obstruction, anorexia and fever. She was dehydrated and her abdomen was centrally distended with increased bowel sounds. Plain x-rays showed features of small bowel obstruction. She had an emergency laparotomy via a midline incision and the findings were an inflamed, ruptured appendix, lying across and constricting the terminal ileum with tip attached to posterior peritoneum. Adhesiolysis and appendicectomy were performed. She was discharged on the 8th day post surgery. Histopathology revealed ruptured, gangrenous appendicitis.

A literature search was conducted of the PubMed and Google Scholar databases. All articles from 2000 to 2019 in which the inflamed appendix was implicated as the obstructing agent were included. Data was extracted and analyzed using simple percentages and ratios.

Thirty one case reports were reviewed. There were 25 males and 6 females with a ratio of 4:1. The age range was 21 days to 83 years with an average of 46.1 years. Twenty three patients (76.7%) had predominantly obstructive features while three (10%) and four (13.3%) had predominantly appendicitis and mixed symptoms (obstructive and appendicitis) respectively. All cases were treated surgically, 93.3% by laparotomy and 6.67% laparoscopically. Appendicectomy and adhesiolysis was the commonest procedure performed (76.7%). Others were ileocaecal resection (6.7%), right hemicolectomy (6.7%) and ileal resection (10%).

Mechanical small bowel obstruction from an inflamed appendix is rare. It is commoner in males and affects all age groups. Obstructive features usually obscure the symptoms of appendicitis. Patients should be treated surgically with a midline laparotomy being the preferred approach. Appendicectomy and adhesiolysis will suffice in most cases. General Surgeons should have a high index of suspicion of this interesting condition.

KEYWORDS; *appendicitis, small bowel obstruction, appendiceal tourniquet, band, knot and tie*

INTRODUCTION

Acute appendicitis is the commonest cause of acute abdomen in our environment. It is also the commonest indication for emergency abdominal surgery[i]. It is a disease of the young with a peak age of occurrence in the 21 to 30 age group . The complications of acute appendicitis are well documented and include perforation/rupture, gangrene, appendix mass, appendix abscess, generalized peritonitis, sepsis and portal pyemia.

Intestinal obstruction as an entity is also a common feature of the General Surgeon's emergency cases. The commonest causes of small bowel obstruction in our environment are postoperative adhesions and external herniae. Complications of SBO include dehydration, electrolyte imbalance, bowel gangrene and perforation, sepsis, shock (hypovolemic and septic) and multiple organ failure. Previous abdominal surgery including appendicectomies are known to cause intestinal obstruction from adhesion formation which could be early (fibrinous or "bread and butter adhesions) or late (fibrous or band adhesions). Also paralytic ileus as a form of an adynamic intestinal obstruction is common in intraabdominal infective pathologies including appendicitis. These are separate entities distinct from the case we are highlighting which is mechanical obstruction caused directly by the inflamed vermiform appendix as the obstructing agent. This is a rare phenomenon. In a patient with appendicitis and small bowel obstruction, the sum of the complications of both conditions is likely to be exponential leading to increased morbidity and mortality thus the need for a high index of suspicion and timely and expert intervention.

The aim of this study is to share our experience with a case of small bowel obstruction due to an inflamed appendix, to highlight the pathogenesis and pathophysiology of this condition and to review similar cases in the literature.

CASE REPORT

Miss J.V., an 18 year old lady presented to the emergency room with a 4 day history of severe colicky abdominal pain, copious bilious vomiting, abdominal distension and constipation. There was associated anorexia and fever. A history of recurrent right sided lower abdominal pain was not sought in this patient. She has not had any surgeries in the past. She was dehydrated and warm to touch with a temperature of 37.8 degrees Celsius. Her pulse was 102 beats per minute. Her abdomen was distended centrally and moved with respiration. She had no inguinal herniae. There was lower abdominal tenderness with guarding. Bowel sounds were present and reduced. The rectum was empty on digital exam. Plain abdominal x-rays showed features of small bowel obstruction. There was leukocytosis of $18*10^{9}$/L with neutrophilia of 79%. Her haemolobin concentration was 12g/dl and platelet count was $200*10^{9}$/L. The electrolytes, urea and creatinine parameters were within normal limits, (Na=146 mmol/l, K=4 mmol/l, Cl=95mmol/l urea=6mmol/l, creatinine=63 micromol/l). A diagnosis of intestinal obstruction with possible bowel gangrene was made and she had an exploratory laparotomy after adequate resuscitation. Access was via a midline incision and the findings were an inflamed, ruptured appendix lying across and constricting a loop of terminal ileum with its tip attached to the posterior peritoneum. The bowel proximal to this point was grossly dilated. There was also a closed loop obstruction in the terminal ileum constricted by the appendix with strangulation. On adhesiolysis and relief of the obstruction the strangulated bowel regained its luster and motility and so no resection was required. Appendicectomy with copious lavage was done. The excised appendix measured 10cm. The post-operative period was complicated by ileus. She was discharged on the 8th day post operation. The histopathological diagnosis was ruptured, gangrenous appendicitis.

METHODOLOGY

A search of the PubMed and Google scholar databases was carried out using the key words appendicitis, intestinal obstruction, appendiceal band, appendiceal tourniquet, appendiceal knot and appendiceal tie.

The inclusion criteria were case reports and series in which an inflamed appendix mechanically caused small bowel obstruction. All articles from the year 2000 to 2019 were reviewed. They included full length papers and abstracts that contained all the variables that were to be measured. We included the case in our study as it met the

inclusion criteria. Cross referencing of selected articles was done.
Exclusion criteria were articles reporting small bowel obstruction due to paralytic ileus, appendix mass or abscess and due to post appendicectomy adhesions. Also excluded were abstracts with incomplete data and systematic reviews and meta analyses.
Data extracted included names of authors, country and year of study, age and sex of patient, clinical features, use of imaging. Others include type of incision used, intraoperative findings, surgery done and the histology of excised appendix.
Data was analyzed using SPSS version 2.0 (Inc. Chicago)

RESULTS

Using the phrase appendicitis with small bowel obstruction yielded 391 articles on Google scholar and 359 on pubmed. This was pruned down to 30 case reports which met the inclusion criteria.
The 31 cases were from 17 countries with 18 from Asia, seven form Africa and four and two from Europe and Australia respectively.
Table 1.

S/N	AUTHOR	TITLE	COUNTRY	YEAR	AGE	SEX
1	Chowdary et al[1]	Appendicular tourniquet: A Cause of intestinal obstruction	India	2016	73	M
2	Kifle et al[2]	Appendico ilial knotting: a rare cause of small bowel obstruction	Ethiopia	2018	46	F
3	Awale et al[3]	Appendiceal tie syndrome: a very rare complication of a common disease.	Nepal	2015	20	M
4	O'Donnell et al[4]	Small bowel obstruction secondary to an appendiceal tourniquet	Ireland	2008	83	F
5	Al Shahbazi et al[5]	Strangulated small bowel gangrene due to torsioned gangrenous appendix in an old man: a case report	Iran	2016	83	M
6	Ranjan et al[6]	Acute small bowel obstruction as a result of an appendicular knot encircling the terminal ileum: an exceptionally rare case report	India	2014	65	M
7	Al Qallaf et al[7]	Acute appendicitis as a rare cause of mechanical small bowel obstruction case report	Kuwait	2016	53	M
8	Ajiboye et al[8]	Small bowel gangrene due to inflamed appendicular band: a case report.	Nigeria	2017	44	M
9	Ali et al[9]	Inflamed appendicular tourniquet causing mechanical ileal obstruction	India	2013	78	M
10	Yang and Lee[10]	Appendico-ileal knotting resulting in closed -loop obstruction in a child.	China	2002	19 mo	M
11	Soo and Tsegha[11]	Appendicular knot causing closed-loop obstruction, volvulus and strangulation of ileum in a 9 -year-old: a case report	Nigeria	2016	9	M

12	Lin et al[12]	Intestinal obstruction caused by appendiceal knot	Taiwan	2017	4	M
13	Chatterjee and Dash[13]	Appendiceal knotting causing small bowel strangulation	India	2014	26	M
14	Bhandari and Mohandas[14]	Appendicitis as a cause of intestinal strangulation: a case report and review.	India	2009	24	M
15	Pangayoman et al[1]	A Case Report: Intestinal Obstruction Due to Acute Appendicitis	Indonesia	2010	28	M
16	Niranjan et al[2]	Ileal obstruction: a rare complication due to appendiceal band	India	2010	50	M
17	Maly and Palal[3]	Appendicitis as a rare cause of mechanical small -bowel obstruction: A literature review of case reports	Czech republic	2013	62	F
18	Lukong et al[4]	Appendiceal Knotting: A Rare Complication Causing Intestinal Obstruction in a Child.	Nigeria	2009	10	M
19	Assenza et al[5]	Mechanical small bowel obstruction due to an inflamed appendix wrapping around the last loop of ileum	Italy	2005	78	F
20	Pierrot Sakis[6]	Perforated appendicitis in a neonate presenting with intestinal obstruction	UAE	2013	21 days	M
21	Bali et al[7]	Appendiceal duplication with simultaneous acute appendicitis and appendicular perforation causing small bowel obstruction	India	2011	40	M
22	Okello et al[8]	Appendico-ileal knotting mimicking adhesive bowel disease	Uganda	2016	59	F
23	Yee et al[9]	Appendiceal-tie syndrome: acute appendicitis causing mechanical small bowel obstruction managed laparoscopically	Singapore	2018s	25	M
24	Menon et al[10]	Appendiceal tie syndrome	Australia	2007	81	M
25	Deshmukh et al[11]	Small bowel obstruction caused by appendiceal tourniquet.	India	2011	79	M
26	Otaghoor et al[12]	Mechanical small bowel obstruction after gangrenous appendicitis	Iran	2014	20	M

27	Chintamani and Khanna[13]	Appendicular knot - An exceptionally rare "Two in one case" of Acute Abdomen.	India	2011	25	M
28	Deshpande et al[14]	Appendicular band syndrome mimicking appendicular mass in an adult	India	2015	28	M
29	Riley and Martin[1]	Appendiceal tourniquet	Australia	2009	81	M
30	Makama et al[34]	Strangulated intestinal obstruction due to appendiceal tourniquet	Nigeria	2017	28	M

There were 24 males and 6 females with a male to female ratio of 4:1.
The age range was 19 days to 83 years with an average of 43.5 years and a Standard Deviation of 27.3years.
sTwenty three patients had predominantly symptoms of intestinal obstruction (76.7%), three (10%) had predominantly features of appendicitis while four (13.3%) had mixed features (both appendicitis and intestinal obstruction).
All the cases had surgery. The vast majority had laparotomy via a midline incision (90%). The approach in one patient (3.33%) was via a paramedian incision. Two patients (6.67%) were treated laparoscopically.
Table 2; types of surgeries performed

TYPE OF SURGERY	NUMBER OF CASES	%
Apendicectomy and adhesiolysis	24	77.4%
Limited ileocaecal resection and ileo-ascending anastomosis	2	6.5%
Right hemicolectomy and ileo -transverse anastomosis	2	6.5%
Ileal resection and anastomosis	3	9.6%

Table 3; intraoperative findings/ obstructing mechanisms in various studies.

	INTRAOPERATIVE FINDING	AUTHORS	NUMBER OF STUDIES	%
1	Appendix laid across loops of bowel bound down by adhesions	Chowdary, O'Donnell, Ajiboye, Ali K, Pangayoman, Niranjan, Assenza, Men on, Otaghoor, Riley and Martin. Bail et al, Koroye et al, Makama	13	42%
2	Herniation through a ring formed by infolding and attachment of appendix to caecum, abdominal wall, ileum or the mesentry	Awale, Ranjan, Chatterjee and Dash, Bhandari and Mohandas , Maly and Paral, Lukong, Sakis P, Yee, Deshmuk, Chintamani, Deshpande	11	35.5%

3	Appendix tip attached to bowel causing torsion	Al Qallaf et al, Lin et al	2	6.4%
4	Complex knotting	Kifle, Al Shahbazi, Yang and Lee, Soo and Tsegha, Okello	5	16.1%

DISCUSSION

Mechanical small bowel obstruction (SBO) caused directly by an inflamed appendix goes by many sobriquets and these include appendiceal knot[10,15,16,18], appendiceal tie[27,28], appendiceal band[12] and appendiceal tourniquet[5,29]. It is a rare condition with only a few cases reported worldwide. Only four articles on this topic are in the literature from our locality[12,15,22,]. This phenomenon was first described by Lucius Hotchkiss in 1901 when he reported 3 cases he successfully managed. Makama et al in a systematic review identified the risk factors for this condition to include the mobility and length of the appendix, intestinal malrotation, preileal position of the appendix and recurrent attacks of appendicitis. The longer and more mobile the appendix, the more likely it is to ensnsare the bowel as is an appendix in the preileal position. A retrocaecal, subserosal appendix is most unlikely to do so. In the index patient, the appendix was preileal and was relatively long. When retrospectively asked of previous episodes of right sided lower abdominal pain suggestive of appendicitis, our patient answered in the affirmative. In patients with intestinal malrotation, cases of duodenal obstruction from acute appendicitis and appendiceal bands have been reported'

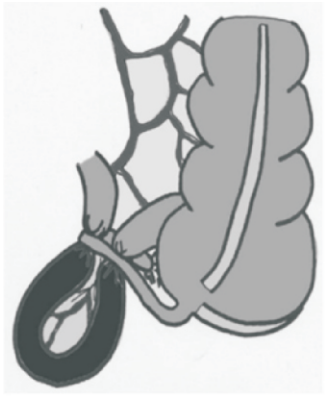
There are a number of related conditions which should be distinguished from this rare pathology we are highlighting. These include post appendicectomy intestinal obstruction, paralytic ileus and obstruction from the pressure effect of a mass or abscess. Forbes Hawkes in the early 20th century described post-appendicectomy intestinal obstruction and how it can be prevented[4] .He divided the causes into mechanical from adhesions, septic or a combination of both[4]. Paralytic ileus is caused by spreading infection and inflammation to adjacent bowel.

Intestinal obstruction related to appendicitis can also occur as the result of the effect of a mass or abscess or both. Kurguzov reported a case of SBO due to a twist of the intestinal loop matted to an appendicular abscess. Kareem et al also reported a case of SBO due to an appendix mass. Histological diagnosis was perforated appendix with colon and ileal ulceration[40]. Miehsler et al reported a similar case.

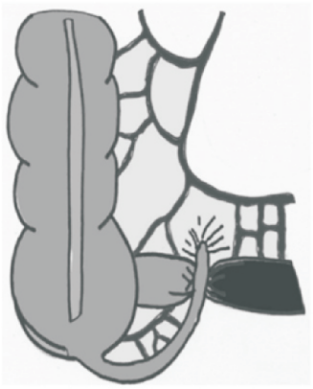
There are several mechanisms by which the inflamed appendix can physically occlude the small bowel. Makama et al in their systematic review grouped the mechanisms by which the inflamed appendix caused SBO broadly into 5 categories.[36] They include;

1. Appendix laid across loops of bowel bound down by adhesions
2. Herniation through a ring formed by the attachment of the appendix to its base
3. Appendix tip attached to the bowel causing torsion
4. Kinking of the bowel
5. Complex knotting

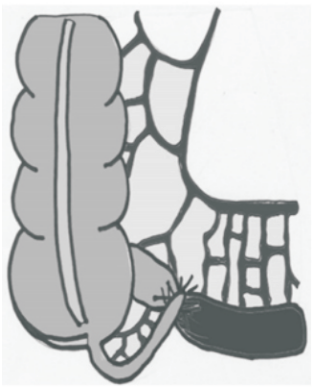
Assenza et al in their study aptly captured the mechanisms above in their diagrams as shown in Figure 1 below.[23]



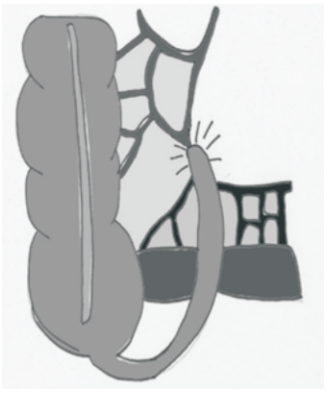
a - Our case: mechanical small bowel obstruction due to an inflamed appendix wrapping around the last loop of ileum



b- The tip of the inflamed appendix adheres to posterior peritoneum across the ileum.



c - The tip of the inflamed appendix adheres to the bowel wall directly.



d - The tip of the inflamed appendix adheres to the mesentery near ileocolic artery.

These attachments of the appendix to the small bowel, caecum, mesentery, posterior peritoneum or even the base of the appendix are adhesions. In acute appendicitis there is a fibrin rich inflammatory exudate in response to the infective process. This exudate may cause loops of bowel to stick to each other. These are fibrinous adhesions, the so called "bread and butter adhesions". With treatment or resolution of an attack of acute appendicitis these flimsy adhesions may be absorbed with fibrinolysis. They may persist however and form a template for fibroblasts to lay collagen on leading to the formation of fibrous or band adhesions. The entrapment of the small bowel by the appendix causes a gradual narrowing of the bowel lumen. With complete narrowing there is accumulation of intestinal secretions and gas above leading to a third space loss and vomiting which lead to profound fluid and electrolyte disturbances. The blood supply to the trapped small intestine may become compromised causing strangulation and eventually ischemia and gangrene. Without prompt intervention, gangrene causes sepsis, septic shock and death. Combined with the effects and complications of acute appendicitis, these effects may be amplified.

In our patient the 1st mechanism (Fig.1a) in the list above was responsible for her pathology. In our review, this mechanism was the commonest (40%) by which the inflamed appendix caused intestinal obstruction. In one of the cases reviewed, there was appendiceal duplication with simultaneous appencicitis with one of them entrapping the ileum.[25] The other appendix was retrocaecal and perforated.[25]

SBO due to appendiceal tourniquet or band occurs in all age groups. In the study by Makama et al, the ages ranged from 3 to 82 with a mode of 36 years.[36] It has been reported in neonates, infants, older children and the elderly.[24,28,5,23,4.] Similar results are seen in our review with an age range of 21 days to 83 years (Table 1) and an average of 46 years.

In two seperate reviews by Makama et al[36] and Maly et al[21] on the subject, there were 22 males out of 30 and 11 males out of 17 respectively who had SBO secondary to appendicitis. This raises a question as to a sex predisposition to this condition. The preponderance was seen in our study with a male to female ratio of 4 to 1.

The clinical features of this condition can be predominantly of obstruction, appendicitis or mixed occurring in 51.6%, 35.6% and 13.3% of cases respectively.[36] in this review obstructive symptoms were seen in 75% of the patients. In a particular study, a patient developed obstructive symptoms 2 days after appendicectomy via a Lanz incision which revealed an inflamed appendix wrapping the ileum. On exploration 6 days later for persistence of the obstruction, a stenotic portion in the ileum 60cm from the ileocecal junction was seen. Perhaps if there had been a delay in the appendicectomy, the obstructive symptoms would have obscured those due to appendicitis. In another study a 73 year old man with a prior history of drainage of an appendix abscess, presented with obstructive symptoms due to an appendiceal tourniquet.[5]

In most of the studies reviewed including ours, only plain abdominal X-rays and abdominal ultrasound scans were done for the patients. In the studies in which computerized tomography (CT) of the abdomen was done, it did not clinch the diagnosis except for one case.[11] CT diagnosis of appendicitis depends on the stage, being more sensitive in the acute phase.[18] Some studies suggest that an experienced radiologist may view the appendiceal tourniquet in the transition zone of the obstruction[5] and this was confirmed by Al-Qallaf et al[11]. It is pertinent to state that a preoperative diagnosis of SBO secondary to an appendiceal band or tourniquet is extremely rare. A CT can diagnose SBO which can also be done comfortably clinically augmented by plain x-rays. In our environment, CT is not readily available and is expensive. CT findings will also have no influence on the management of these patients which remains an urgent laparotomy. In the authors' opinion CT should be used where available but when unavailable or there are financial constraints, it should not unduly delay intervention.

Complications of SBO include strangulation and gangrene. Some of the cases in this review developed bowel gangrene.[9,12,13,23,28] The presence of bowel gangrene necessitating resection portends a poor prognosis with increased morbidity and mortality[v]. Our patient had ileal strangulation but fortunately it hadn't progressed to gangrene. Prompt intervention will help reduce this

complication. One death has been reported in the literature from this "two in one" pathology. A 23 month old girl who died before intervention for acute abdomen at autopsy was found to have strangulation and torsion of a 70cm length of jejunum and ileum that herniated through an appendicular knot caused by attachment of the tip of the inflamed appendix to the ileum.[46]

Most of the patients were treated with an exploratory laparotomy with the midline incision being the most used. In younger children, a lower transverse incision will suffice. This approach (laparotomy) is advised even in the unlikely event that the diagnosis is known preoperatively. Appendicectomies were performed in all the patients and any further procedures depended on the intraop findings especially bowel gangrene. Additional procedures include adhesiolysis, segmental resections, ileocaecectomy, right hemicolectomy and ileostomy.

With laparoscopic surgery rapidly expanding in horizon and evolving perpetually, studies have shown promising results in the laparoscopic management of acute mechanical bowel obstruction especially the variety caused by post op adhesions". Two of the cases reviewed were managed successfully laparoscopically.[11,27] However this should be performed only by experienced and specialized laparoscopic surgeons after careful patient selection.

CONCLUSION

Mechanical SBO due to acute appendicitis is rare. It is also known as appendiceal tourniquet, band or knot. It is commoner in males and this phenomenon occurs in all age groups. The obstructive symptoms usually obscure the symptoms of appendicitis and a past history should be sought for. Advanced imaging may not be necessary as the diagnosis is seldom made preoperatively and it does not influence the course of management. A midline laparotomy is the preferred approach to treatment. Simple appendicectomy and adhesiolysis will suffice as treatment in most cases but if gangrene has set in resection and anastomosis is indicated. The presence of gangrenous bowel greatly increases the morbidity and mortality thus surgeons should have a high index of suspicion of this interesting condition.

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