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Diagnosis of acute appendicitis in infants and children

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THE DIAGNOSIS OF ACUTE APPENDICITIS IN INFANTS AND CHILDREN

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Introduction

"Anatomically, the appendix was described in the six-teenth century; pathologically, it was recognized in the eighteenth century; clinically, it belongs in the nineteenth century; and, therapeutically, it is the challange of the twentieth century" (118).

Although there has been a reduction in the mortality in acute appendicitis in the past half century, there still remains a comparatively high ieath rate in this disease in infants and children. The great advances in technical and therapeutic procedures have obscured the importance of early diagnosis (27). The purpose of this paper is to discuss some of the problems in the diagnosis of acute appendicitis in infants and children.

Appendicitis is extremely rare in the first year of life, less rare, but still infrequent in the second year. There is an increasing frequency during the third year; and, from three years onward, it becomes the most common surgical disease of childhood (108).

Physical Differences

Although the course of appendicitis may be insidious in adults, it generally presents a typical syndrome when compared with that seen in children. It is, therefore, one of the dis-eases in which a tragic error may be made by thinking the "child is but a small adult."

Among important differences, are such considerations as the obvious inability of the child to communicate with little more than a cry so that the whole gamut of expression is conveyed by one device. Moreover, children cry, not so much because of associated pain, but because of fear of what is going to happen to them. They quickly learn to relate the universal needle and shots to the doctor or the white uniform. Further, the child may be crying less for pain and more for the endear-ing effect it has on solicitous parents. Incidentally, Potts (1) suggests that a reciprocal fear may be operative with the examiner at the loss when confronted with the infant who just screams.

It is of value to consider in what respects the child's appendix differs from that of the adult. Because of the elevation of the pelvic floor, there is a corresponding alteration in the normal position of the viscera. Not only does the cecum lie higher up in the abdomen than the adult cecum, but

the appendix is also less retrocecal (2). This change in position has the added significance of the possibility of more widespread peritonitis in the event of appendicial perforation. The size and form of the appendix is also different in the infant. Treves (3), in 1885, was among the first to describe the fetal type of cecum with a dependent, funnel-shaped appendix. Synder and Chaffin (4) substantiated Treves and further suggest that if obstruction is the basic cause of appendicitis, the fetal type of appendix is less likely to obstruct. This latter fact offers an explanation for the increasing incidence of appendicitis as the cecum matures throughout childhood. Carson (2) points out that the proportionately large appendix in the child together with a smoother lining membrane favor the entrance of material which might cause infection. Further, the structure of the appendix in children is more delicate than in the adult and allows for more rapid extension of the inflammation once the process is initiated (2)(5). The increasing amount of lymphoid tissue found in the appendix wall during the first ten years of life has been suggested as another important factor in the development and spread of appendicial infection in the child (5)(6)(9). The omentum is less developed in the child and hence affords a less effective protective influence (5)(7).

Even the slight quantity of subperitoneal fat has been suggested as playing an important role (76). Because of the relatively longer meso-cecum, the cecum and appendix are more freely movable in the child (8). This motility has been the explanation for cases which have described the tip of the appendix as being fixed to the spleen, the left kidney, and up under the liver (10).

Etiology

We are still ignorant about the exact cause of acute appendicitis, however, several factors have been blamed for initiating the attack. Important among these is the already mentioned feature of the anatomical change from a fetal-type cecum and appendix with a funnel-shaped opening to the adult form having a narrowed connection into the cecum. This would provide a physical basis for obstruction (4).

Mention has also been made of the relatively greater amount of lymphoid tissue present in the appendix in the first decade of life (5). Whitney (11) has shown that the lymphoid tissue in general reaches its relative maximum during the age span from two to five. Several factors seem to stimulate the lymphoid tissue. The most frequently emphasized is infection, against which the tissue constitutes a defense mechanism for the body (12). The most characteristic response of lymphoid tissue to any agent is hyperplasia. This response may result not only

from toxic and physical agents, but from physiologic activity. Frequent swelling of the lymph tissue of an insidious nature come and go without an obvious etiologic agent. Enlargement of the solitary and aggregated collections of lymph tissue of the intestinal tract is commonly an accompaniment of marantic conditions in infants. This is probably related to the almost constant intestinal indigestion which is present and which in turn has important relations to bacterial activity in the intestinal canal (13). The presence of extra-ordinary aggregations of lymph tissue at the upper end of the alimentary canal and the terminal part of the small intestine where bacterial activity either commences or is reenforced or reactivated, suggests that these are strategic points and the lymph tissue is an important combatant of bacterial activity. The list of agents which can cause generalized lymphadenopathy is long, but important in consideration of childhood diseases are the infections of the upper respiratory tract, exanthems, and intestinal inflammation. Allergy has even been suggested as a causative agent (14). Since the child, in part because of undeveloped resistance, is subject to frequent upper respiratory infections, the exanthemas, intestinal infections either from dietary changes or allergies, the relationship between the resultant lymphoid hyperplasia and the frequency of appendicitis seems clear. In the various exanthems,

The rash commonly spreads from the external layers of the skin and appears in the mucous membranes of the alimentary canal. The characteristic cervical lymphadenopathy is frequently matched by abdominal lymphadenopathy and, in many cases, the disease is ushered in with gastrointestinal symptoms (13)(15). Davidsohn and Mora (109) believe that appendicial symptoms during the course of measles should not be lightly dismissed, since they may indicate suppurative disease requiring appendectomy. In the study by Malloy et al (57), they found that cases in which lymphoid hyperplasia was a prominent feature were characterized by a history of an upper respiratory infection or gastrointestinal upset for a few days to a week and gradually or suddenly had developed colicky abdominal pains. Gray and Heifetz (58) expressed the belief that the lymphoid hyperplasia in the appendix results in stasis of the mucosal crypts with inflammation soon following in the form of acute appendicitis.

Although a great variation has been reported in the incidence of parasites found within the appendix (16)(122), it should be kept in mind that children notoriously harbor parasites of one kind or another in the intestinal contents. Whether the appendicitis results solely from obstruction or from local erosive trauma and subsequent lymphadenopathy seems of academic interest, for the injured mucosa becomes the site of secondary infection

through which micro-organisms initiate an intramural infection (13)(18).

Fraser (5) suggests that there is also an alteration in the toxicity of the intestinal flora as the child grows older. The increase in virulence is stimulated by the increasing complexity of the diet enhanced by incidental attacks of gastroenteric catarrh. The bacterial agent involved is a disputed point.

In his work on rabbits, Wells (17) described experiments in which he found that obstruction of the lumen alone produced a non-inflammatory mucocele while deprivation of the blood supply alone produced non-inflammatory atrophy. Injection of bacteria from appendicial pus, either into the lumen or intravenously, produced no inflammation of the appendix. However, obstruction of the lumen combined with deliberate trauma to the mucosa allowed the normal bacterial flora to enter the tissue and produce typical obstructive appendicitis in almost every case.

Bowers (19) described the following sequence of events in the production of acute appendicitis by obstruction and infection. The lumen of the appendix slowly becomes occluded by an enlarging fecalith or because of some other mechanism and forms a closed loop. Peristalsis is stimulated as the appendix attemps to overcome the obstruction. Mucosal secretion is stimu-

lated. The lumen gradually distends with fluid from this source and also from the action of bacteria and putrifaction. Vascular congestion, edema, and diapedesis of leukocytes follow. With increased intraluminal pressure, the anti-mesenteric blood supply is embarrassed. During this time, the mucosa becomes ulcerated from pressure, and bacteria invade the tissues. Primary obstruction of the appendix may be caused by kinking, luminal scars, congenital bands or membranes, foreign bodies, and, most often, by appendicoliths. Nelson (91) has observed one-third of inflamed appendicies obtained at surgery and autopsy to contain fecal concretions, while there was less than three per cent of calculi in normal appendicies.

It deserves mentioning that even though obstruction is present, it may be relieved by the expulsion of the fecalith into the cecum, by dissolution of the fecalith, or possibly, at times, by relaxation of the muscular spasm which may have been present at the base of the appendix thus allowing the appendicial contents to escape (18).

Appendicitis has been known to follow trauma in the region of the appendix with such frequency that its etiological significance cannot be ignored (20). The mechanism of traumatic appendicitis has been assumed to be the distention of the lumen of the appendix by trauma with subsequent impairment of the appendicial circulation and necrosis of the

wall of the appendix (21). According to Bissell (22), the application of force to the external abdominal wall results in a rush of cecal contents into the lumen of the appendix causing mucosal tears and rapid invasion of the appendix wall by bacteria. There is some support for the contention that trauma, however, is much more often a predisposing than an exciting cause. In other words, the appendix was previously diseased, but would not perhaps have given rise to acute symptoms unless it had been injured. Mention suffices to point out the role of trauma in the etiology of appendicitis particularly when dealing with a highly active age group.

Clinical Picture

The variability of position of the childhood appendix makes it a mistake to think of a single clinical picture in acute appendicitis. Bruce (23) has described five distinctive types:

> Type I. With rigidity and tenderness over McBurney's point in the right iliac fossa, we have the typical textbook-picture of acute appendicitis. If the appendix lies immediately beneath the abdominal wall, uncovered by bowel or omentum, the physical signs may be limited to an acutely tender area. Naturally, the size of this area will depend on the extent of the peritoneal reaction, and although the appendix may be only moderately inflammed, rigidity and tenderness may be elicited far beyond the middle line.

Type II. If the appendix lies along the lateral wall of the right iliac fossa, the physical signs may be limited to a zone about two fingers-breadth or less parallel to Poupart's ligament. This is a common site of appendicular abscess in cases neglected for three or four days.

Type III. Pelvic appendicitis has been said to be the most difficult type to diagnose and thus the most liable to cause acute general peritonitis. A child complains of pain low down in the abdomen and may have discomfort in passing urine. In pelvic appendicitis, the appendix lies so far distant from the anterior abdominal wall that the intensity of all physical signs is diminished and the right iliac fossa is often clear; but in every case, there may be found over the lower right rectus muscle a small triangular rigid area which tapers gradually outwards towards the iliac fossa and to a lesser extent across the mid line.

Type IV. All appendices found behind the cecum may be called <u>retrocecal</u>, but the term is generally applied to a sessile appendix closely adherent to the posterolateral wall of the cecum or ascending colon. A retrocecal appendix lying high in the loin is far nearer the muscles of the back than the anterior abdominal wall and thus pain in the back is common and the usual physical signs in the front are often dull and ill-defined. Very little tenderness may be elicited but on bimanual palpation, an appreciable fullness may be found in the loin compared with the contralateral side.

Type V. With a high appendix in an early attack, it may be difficult to differentiate high appendicitis from pneumonia, but in the latter disease there is more respiratory distress and the general picture is out of proportion and not in keeping with the signs of commencing appendicitis. The physical signs of high appendicitis resemble those present in adults suffering from acute cholecystitis or subacute perforation of a duodenal ulcer.

The pain of acute appendicitis involves two pathways. The early pain is characterized as being an aching, cramping or hunger type of pain which, though usually poorly localized, may be associated with the epigastrium. It is mediated by the splanchnic or visceral pathways, being transmitted to the spinal cord over the splanchnic nerves. After a variable period, the patient usually describes a localization of pain by showing that the pain has moved from the midline to a point he may indicate somewhere in the right lower abdominal quadrant. If a definite small area of tenderness can be demonstrated, it is very likely to represent the location of the appendix. That tenderness together with the classical rebound type of pain will be the result of transmission from the parietal or somatic pain fibers. These fibers run in the segmental nerves and provide an accurate means of locating an inflammatory process (124).

History

If the child has reached an intelligent age, an accurate account of the subjective symptoms he has experienced may be derived, but there will have to be varying dependency upon that history as well as one given by the parents or friends (18). In this age group, it is difficult to be accurate about the time of onset of the disease and in many instances the onset was vague and the initial symptoms were of a general nature. The

younger the child, the less probable, naturally, is the history of previous attacks. Further, in view of the frequent intestinal upsets of childhood, a history might well be confusing. However, a good history should be attempted, not only to aid in making a diagnosis of appendicitis, but also to help eliminate the prodromes of certain infectious diseases (24). To establish the exact cause of abdominal pain in the younger age group, a careful searching history of the present illness and feeding habits is essential. The precise time of the appearance, the reappearance or accentuation of these symptoms in respect to associated disturbances such as anorexia, fever, and change in the infant's sleep pattern should be determined (27). A common history is that the child has been peevish and irritable and off his food for a day. Although he may have vomited more than once, his parents are not unduly alarmed and do not consider calling a doctor. The next day the child appears much improved but hasn't had a bowel movement and a cathartic is given. The sequel is only too well known (123).

Physical Examination

Nothing is more important in examining an infant than an evaluation of the child as a whole. Not only should note be made of the obvious--is the infant acutely ill as reflected in a feeble cry, the loose skin, the pallor--but an evaluation of the mental development can also be made. If there is evidence of subnormal

mental development, one can safely assume that the child's reactions to pain are likewise abnormal and evaluation of illness can not be made according to the prescribed pattern (1).

Palpation of a sore abdomen is going to be resisted by almost every child regardless of age. Potts (1) suggests that time spent in proving to the suspicious child that the doctor is not a monster with a knife or needle up his sleeve but a sympathetic friend will be quite worthwhile. It must be remembered that, at the last, the sick child may respond to no amount of reasoning however persuasive.

Much is to be said for the examination of the abdomen done before disrobing the child while the mother still holds it. Felsen suggests examination with the patient in a warm bath may facilatate palpation (91). Some abdominal relaxation may be derived by holding the dhild's head or legs elevated. Frequently, evaluation of the abdomen will be limited to those brief moments of relaxation when the screaming child gasps for breath. In the infant and younger child, it is often helpful to give the baby a bottle or to distract him while keeping the hand gently resting on the abdomen. There is a place, even, for the use of sedatives in this examination (26).

In infants and children, the technique of palpation differs some from that employed in examining the adult. The basic prin-

ciple is that palpation should be a gentle as possible because more information can be derived in this way. In addition, a gentle touch will spare the child unnecessary pain and thus resistance may be lessened. The warm hand, laid flat on the abdomen, is allowed to rise and fall as the child breathes. Always approach any tender area from a distance with gradual movements in order to assure the child that he will not be hurt suddenly or unnecessarily. It is almost valueless and may even be misleading to ask repeatedly whether "this spot" or "that spot" is tender or hurts; and frequently the child will vigorously deny feeling any pain. Instead, the patient's face is carefully observed as light palpation is made with the ends of the fingers for more reliable information may so be gained. Even slight tenderness is reflected by an involuntary facial expression of pain. More severe pain will be met by attempts to remove the examiner's hands or by outcries and tears, and these areas should be noted. The seat of maximum tenderness will understandbly vary according to the position of the appendix (1)(123).

The physical findings will vary with the case, but, in general, it may be stated that the patient will favor a position of flexion. If on his back, the child will tend to have his knees drawn up; while, if on his side, the spine and thighs

will be flexed. Abdominal pain may have ushered in the symptoms of appendicitis, but the parent is frequently unable to recognize it as pain until the infant became irritable with the thighs flexed on the abdomen as a protective measure (50). It has been suggested that if the child can sit up without increasing the abdominal distress, or if the child will voluntarily sit it is presumptive evidence that the condition is other than acute appendicitis (39).

Abdominal auscultation may reveal diminished to normal peristaltic sounds if the appendix is not ruptured, but almost invariably, peristalsis is hyperactive in acute enteritis or if there is a spreading peritonitis. There is diminished peristaltic activity if paralytic ileus has set in (32)(107).

Many of the signs described to assist in making the diagnosis of appendicitis are predicated on the location known as McBurney's point. McBurney's point is located by trisecting a line drawn between the right anterior superior iliac spine and the umbilicus. McBurney's point will be found where the lateral and middle thirds meet (118).

The literature is replete with descriptions of signs, the value of which is a much disputed subject. Aaron's sign is the one in which pressure over McBurney's point produces pain in the epigastric, umbilical, or left hypochondriac regions.

Owen described a sign of rebound tenderness elicited by the sudden removal of pressure after gas has been driven out of the cecum by steady hand pressure. Potts (1) suggests that too much reliance on the sign of rebound tenderness can be misleading because it will make any case of colitis or even constipation look like appendicitis because when pressure in the easily distensible cecum is suddenly changed there is a twinge of pain.

Evaluation of Rovsing's sign has led to criticism that instead of "moving gas into the cecum by continued pressure" as was explained by Rovsing, no evidence has been found to support that mechanism of action. Instead, it is suggested that since a positive sign is due to an increase of tension in the peritoneum and muscles of the right iliac fossa, the sign is only an indirect method of estimating tenderness in the right iliac fossa and hence, having no diagnostic value, should be given up (115). Others feel that when Rovsing's sign is present and the diagnosis is thought to be acute appendicitis, the organ is probably lying in such a position that part of it, at least, is in direct contact with the anterior abdominal wall (116).

An intern has contributed another sign which bears his name, Brittain, in which palpation of the right lower quadrant of the abdomen in the presence of gangrenous appendicitis invariably produces sudden retraction of the right testicle. Release of

the pressure drops the testicle to its normal position.

Increased tonus of the abdominal muscles--rectus rigidity--is not a sign of acute appendicitis, but rather, one of peritonitis for it is impossible to contract one rectus muscle without contracting the other. In correctly testing for this sign, both hands must be placed on the patient's abdomen, one one each rectus muscle. With gentle pressure, a comparison between the two is made. If there is a difference, it suggests that there is a mass underlying the rigid rectus. In acute appendicitis, such a mas would either be a localizing inflammatory appendicial mass made up of appendix, terminal ileum and omentum, or an appendicial abscess. When both recti are rigid, it denotes a muscular defense in response to an underlying peritonitis. Should such a rectus suddenly be released, the patient will wince because of so-called "rebound tenderness"--Blumberg's sign (118).

For completeness, mention should be made of Ligat's reflex in abdominal diagnosis. To elicit the reflex, the patient should be flat on his back and as completely relaxed as possible. The skin and subcutaneous tissue of the abdomen is firmly picked up between the finger and thumb avoiding any downward pressure on the abdominal wall while using the same amount of pinching pressure as the procedure is repeated over the entire abdomen. A positive test is based on finding an area of hyperalgesia which

corresponds to a given area in which inflammation of a particular viscus manifests itself. For the appendix, this roughly corresponds to McBurney's point (71). It must be remembered, however, that demonstration of tenderness on a superficial level may be a cutaneous hyperesthesia corresponding to the distribution of the tenth, eleventh, and twelfth thoracic nerves. The differential is that the tenderness associated with an inflamed viscus is deep and increases with increased pressure while in cutaneous hyperesthesia, increased pressure does not produce a more severe pain. Leak (121), who took a particular interest in the subject of appendicitis following infections of childhood, observed a number of children during an epidemic of measles. He first noted a child with vomiting and all the signs of acute appendicitis including a positive Ligat's test. Subsequently, he found the test positive in every patient who later developed measles except in one. In several, it was present as long as ten days before the rash developed. In fact, the test was positive some time before Koplik's spots were visible thus suggesting that the virus produces some catarrh of the appendix during the prodromal stage of the disease.

Other signs dealing with pressure on blood vessels or with muscular movements have been described. The femoral sign is elicited by pressure on the right femoral artery as it passes

below Poupart's ligament. The increased pressure in the iliac artery in the presence of a diseased viscus produces abdominal pain (39).

The obturator internus sign locates an acutely inflamed appendix, but does not diagnose it. The test is performed by bending the knee and internally rotating the flexed thigh. This moves the obturator internus muscle through its full range of motion and will cause hypogastric pain if an acutely inflamed appendix overlies its fascia. Pelvic inflammatory disease, however, can also produce a positive obturator sign. The iliopsoas sign is not a diagnostic sign for acute appendicitis, but will help locate an inflamed appendix lying retrocecally when it involves the fascia of the psoas muscle. For this test, the patient is placed on the left side with the right thigh fully extended. If pain over the appendicial area is produced, the test is considered positive (40)(110).

Meltzer's sign is the production of definite tenderness when pressure is made over McBurney's point while the right leg is extended, the patient lying on the back, arms elevated and the left knee partly flexed. It is presumed that this position will impinge the appendix between the abdominal wall and the body of the psoas muscle (39)(40).

Richet and Netter (41) point out that of all the physical signs, the most evident is the contraction of the adductors of the right thigh. Muscular relaxation must be complete with the patient lying on the back with mouth open, thighs half flexed, heels flat on the bed, and the knees touching. Placing a hand or finger on the internal edge of each knee, pressure is directed from within outward tending to separate the knees from each other. It is necessary to use a mild constant pressure equally on both sides. The maneuver is not painful. Nearly always, there is a slight contraction, a simple hypertonia, the abduction being less marked on the right than on the left; at the same time there is a sensation of opposing resistance. The sign has symptomatologic value for it is never present in other disorders of the right side of the abdomen. It is found with equal frequency in adults and children.

In an attempt to rule out chest pathology, Lliescu's sign has been used. In this, pressure is made on each side of the neck in the centers of the triangles formed by the origins of the sternocleidomastoid muscles which will thus cause compression of the phrenic nerves. If there is an abrupt lessening of the abdominal symptoms, it is assumed that the lesion is above the diaphragm. Salzer modified the test by applying the

pressure on the phrenic nerves where they pass over the scalenus anticus muscles, and if there is marked differences in the sensitivity on the two sides with the patient making a defensive movement, the lesion is said to be above the diaphragm (39).

Since the most common condition which offers difficulties in diagnosis is the upper respiratory infection, a careful examination of the throat and chest must never be omitted. Inspection of the throat might well be a final procedure since it is usually met with resistance and coercion may be needed (123).

There is some difference of opinion as to whether the trauma of a rectal examination should be imposed on infants and children inasmuch as so little is frequently learned. By virtue of the fact that the finger reaches much farther anatomically in the rectum of the child than in the adult, significant findings--a tumor mass, an abscess, or tenderness--may be identified which could not be accomplished by palpation through the abdominal walls. If done, this examination, also, should be deferred until the last (66)(106)(117).

Symptoms

Abdominal pain, vomiting, and localized tenderness are the cardinal manifestations of acute appendicitis in infancy as in adulthood. However, signs and symptoms are difficult to inter-

pret in pediatric patients and are often obscured by coexisting infection and antibiotic therapy (27).

The first indication of trouble is nearly always abdominal pain. This is present in practically every case, and, in its absence, a diagnosis of appendicitis can hardly be justified. According to Binks (117), if the pain is not sufficient to have kept the child awake or at least to have seriously interfered with sleep, it is not likely to be an acute appendicitis. In spite of limited powers of expression, the child usually conveys to the parents that he has pain or discomfort in the abdomen. Understandably, it is rare that accurate information about the type of pain or its situation is given (123). The classical method of onset is with a pain or "stomach ache" in the upper abdomen. The pain may vary from vague, intermittant, and colicky to sharp and severe. The pain usually later becomes more pronounced in the lower abdomen and commonly localizes on the right side although, as has already been pointed out, may vary considerably depending upon the site of the appendix. Many children, when asked where the pain is most severe, will lay the hand over the umbilical region (28). Typically, if rupture of the appendix occurs, the child may become almost symptom-free for a few hours, but then the pain returns with increased intensity. Irritability and restlessness in the infant may be

the sole objective evidence of abdominal pain (26)(27).

The next symptoms to present themselves are nausea and vomiting, and these frequently follow the initial pain within an hour. Since vomiting is the common accompanyment of many childhood diseases, vomiting which persists after the stomach has been emptied along with continuing pain is of great significance. Rarely, nausea and vomiting may not occur, but the patient will give a history of a profound distaste for food. Anorexia, then, is considered by some to be a more reliable symptom than nausea and vomiting (24)(30). Anorexia, nausea, and vomiting are actually degrees of one symptom, being dependent upon the degree of distention in the appendix with vomiting associated with a greatly distended appendix (118).

The degree of fever or pulse rate are of little value in the diagnosis of appendicitis in infants because of the variability of these factors. Early in the disease, there is usually no temperature elevation, but later there may be a slight one. An initial high fever is seldom found in acute appendicitis, hence, such an elevation suggests some other condition (118). While the general feeling is that the temperature may range from normal to 102°, in a series of 1,000 children, Norris (33) found the ranges from 97° to 109°. In this connection, Rose (120) sug-

gests that children with a rapidly evolving acute obstructive appendicitis have a characteristic hectic flushing of the cheeks that is of diagnostic value when seen. Stucky (31) suggest that when the temperature is high it is often found that the patient has an inflamed throat as well as abdominal symptoms and signs. According to Pounders (28), the presence of a high temperature is of value only in ruling out appendicitis. This points up the previously mentioned relationship between the lymphoid tissues of the ileum and the appendix with the tonsil and adenoid infection. The subnormal temperatures occasionally encountered may be explained on the basis of alterations in the narrow limits of the physio-chemical conditions of the infant.

As for the pulse, Binks (117) feels that while the pulse rate is usually elevated, of greater significance is a continued rise. He feels that a rise of ten points, especially if the child is asleep, demands further examination. His general feeling is that if, following admission to the hospital, the pulse rate does not increase, it is highly probable that the case is not appendicitis. The so-called diagnostic ratio should be kept in mind--that for every degree of temperature rise there is a ten beat pulse rate increase.

Most authors feel that the leukocytes are usually definitely increased with the ordinary range between 12,500 and 15,000.

While a high blood count is indicative of some condition other than appendicitis, there are so many variations that a high count can by no means rule out appendicitis. Fairly high counts are common where there is gangrene, rupture, or abscess. It should be pointed out, then, that the over-all range has been described as from 3,100 to 60,000 (24)(28)(32)(33). In a study made at this university, McIntire and Jahr (34) found a range of from 6,500 to 27,700 in the white blood cell count. They concluded that it is not the total count, but rather the differential count which logically must be considered in the diagnosis of acute appendicitis. A shift to the immature forms is a more valid basis for diagnosis than the net white count. Mills (35) has pointed out that in addition to the greater value of the differential count, the ratio of nonfilamented to filamented cells is particularly useful. When the ratio is less than one, that is, when there are more segmented forms than staff forms, the prognosis is good, while if the ratio is nine to one in favor of the staff forms, the prognosis is grave. The presence of leukopenia in acute appendicitis suggests a grave prognosis (36).

Chills may occur at the onset of an attack, but are usually considered as indicative of rapidly developing gangrene of the

appendix. With the development of chills on the second or third day and associated high fever, metastatic or embolic abscesses should be considered.

Changes in bowel function depend on the relationship of the appendix to the bowel. If the inflamed appendix does not irritate the bowel, the motions will be normal or the patient may be constipated. Constipation is a cause of abdominal pain and vomiting and this condition is often diagnosed as appendicitis. If, on the other hand, the appendix is so situated that through its inflammation there is an irritation of the terminal portion of the ileum, then the motions will be more frequent and softer than usual, but not diarrheal. When the cecum or colon is irritated, there will be diarrhea and sometimes the passage of unusual amounts of flatus. When the rectum is irritated, a spurious diarrhea in the passage of mucus with tenesmus will occur. These changes in bowel habits may occur before the onset of any pain. In young children, information on bowel habit is often the least accurate part of the history. Diarrhea may paradoxically be the first sign of constipation. It may also be caused by the unnecessary and dangerous practice of giving purgatives. To explain why, in spite of the many injunctions against using cathartics the patient is impelled to take a purgative in the belief that it will relieve the pro-

blem, Dailey (119) suggests that in the early hours following the onset of acute appendicitis, the patient frequently experiences what may be described as a subjective sense of constipation. Accompanying the feeling that the bowels should move, there is a desire to void, but an inability to do so. The sensation is the subjective counterpart of the mild paralytic ileus that accompanies the early phase of the disease (123).

Diagnosis

Such frequent mention is made to Abt and his early work (37) that it seems apropos to quote him: "The symptoms of appendicitis in infants show such marked variation from those which occur in older children and adults that the presence of the disease in very young children is worthy of special attention. Finny is quoted (38) as saying that "in adults, the tendency is perhaps rather to mistake something else for appendicitis, while in the child, it is to mistake appendicitis for something else." Two peculiarities have been noted of appendicitis in childhood; the first is the insidiousness of the onset and the second is the rapidity of the progress to gangrene and perforation. It has been well stated by McLanahan (49) that "any discussion of the diagnosis of appendicitis should start with

axiomatic principle that abdominal pain, vomiting and slight fever should always be considered due to appendicitis until proved otherwise."

The ease with which the diagnosis can be made is related to the accuracy of the history and the ability of the patient to convey his symptoms together with the physical findings elicited and the laboratory findings. Dailey (119) says that with a good history and physical examination, acute appendicitis should be diagnosed clearly in the majority of cases. He feels that laboratory examinations are of secondary value only.

Thorek's "Two Question Test" is one of the simplest, most effective, and rapid methods of diagnosing appendicitis. Although he claims it will suggest the diagnosis in over seventy percent of cases, it understandably will be less accurate when dealing with infants and children. "Where was your pain when it started?" is the first question, and, in answer, the patient usually points to his entire abdomen. To the second question: "Where does it hurt you now?" the patient usually replies by indicating the region of McBurney's point.

The pertinent laboratory tests may be considered both as an aid to diagnosis and also as an estimate of the patient's general condition. Mention has already been made of the blood

count. It might be added here that the hemoglobin estimation is also a guage of hydration. The white count usually shows a more labile response to infection or dehydration in children than in adults. In interpreting the differential count, one should bear in mind the normal relative leukocytosis of children under four. The urinalysis serves in helping to rule out renal conditions, although it must be remembered that red and white blood cells may be present if the appendix lies in contact with the ureter or bladder (32). In addition, the urinalysis gives an estimate of the general state of hydration (43). The sedimentation rate is uniformly normal in acute appendicitis except where there is an associated peritonitis (42). The plain roetgenogram of the abdomen is often of great aid in proving or disproving the presence of intestinal obstruction and frequently helps to localize the pathologic changes. In general, the use of barium is rarely necessary. X-ray studies of the chest have great value in cases of suspected appendicitis when there is any question of detecting and ruling out pneumonia (45).

Differential Diagnosis

There is probably nothing more perplexing or difficult to evaluate than the child with abdominal pain. Even if the

child is able to talk, it is difficult to determine just how much pain he really has. Further, it is hard to localize the areas of tenderness. The problem is further complicated because abdominal pain is frequently a symptom in childhood, not only of surgical diseases, but of medical diseases as well. In many instances, the pain is associated with a relatively inocuous disease, such as food indiscretion. On the other hand, it may indicate the need for surgical exploration (54).

The condition most frequently mistaken for appendicitis is acute non-specific mesenteric lymphadenitis. Many times, the differentiation is impossible except by operation. This acute inflammatory process involving the mesenteric lymph nodes is usually associated with tonsillitis and pharyngitis. The presenting symptom is abdominal pain, which may be generalized or localized anywhere in the abdomen. The pain is usually constant, but there may be exacerbations or occasional twinges of sticking pain. At times, there may be a cessation of pain for several hours, much the same as that following rupture of an appendix. The pain does not radiate. There may be a history of previous attacks of a similar kind which may help suggest a diagnosis. Nausea is present in practically all patients, though occasionally it may be absent. Vomiting

will occur in a severe attack, but is less common than with appendicitis. Constipation is not an important symptom with diarrhea almost as frequent, but neither pronounced. With gentle but prolonged palpation, the initial voluntary guarding will go and it will be possible to feel the posterior abdominal wall and possibly the glands themselves in a way impossible with appendicitis. Temperatures range from normal to a slight elevation with no apparent connection between the duration of symptoms and the fever. The white blood count is rarely above 10,000. X-ray examination is of little value. However, a careful study of the stool may help in the differentiation, especially when a pale, fatty stool is found. The fatty stool undoubtedly is due to blockage of the lymphatic vessels. If it is minimal, a short period of careful observation sufficient to indicate that the process is stationary or subsiding and hence is not typical of acute appendicitis may be justified. Vomiting, changes in tenderness, temperature alteration and white cell count changes are the factors to be considered. If acute appendicitis cannot definitely and completely be ruled out, exploratory laparotomy should be done since the danger from appendicial perforation is greater than from surgical exploration in mesenteric adenitis (25)(26)(32)(44)(45)(46)(47)(48).

The inclusion of a discussion of Meckel's diverticulum is important, when, according to Gross (70), approximately half of all patients experiencing complications from a Meckel's diverticulum come to the hospital within the first two years of life. The important consideration is the manner in which the clinical picture of diverticulitis resembles that of acute appendicitis, and the absolute diagnosis can be made only at operation. It is interesting to note that in sixty per cent of the cases of Meckel's diverticulum in one series, the admitting diagnosis was appendicitis (73). Further, the presenting symptom was abdominal pain, usually periumbilical at first, with later localization in the right lower quadrant. Nausea without vomiting was commoner than was a combination of the two. According to Everhart (74), the differentiation from appendicitis may be made because of the distention which appears early and localizes to the lower half of the abdomen in a case of diverticulosis. Intestinal bleeding is occasionally associated with inflammation of the diverticulum, but does not occur as frequently as with ulceration. Pinto and Moraes (75) contend that a preoperative diagnosis of diverticulosis is rarely made because the clinical signs of its complications are not specific and may be the signs of other and

more common acute abdominal conditions. The role of a Meckel's diverticulum in intussusception will be discussed later.

Under the broad heading of intestinal obstruction come several entities which may produce symptoms to confuse a diagnosis of appendicitis. The symptoms of acute intestinal obstruction vary in severity according to the cause of the obstruction, but may be listed as pain, localized or general; vomiting, which soon becomes fecal in character; shock, varying somewhat with the cause of obstruction; distention, usually marked; and ofte, by the palpation of a tumor (77).

According to a series by Wilson et al (77), strangulated inguinal hernia was the most common cause of intestinal obstruction in infants and children. This usually presents with symptoms of vomiting and distention while being characterized by a sudden onset and localized tenderness over the herniation (78). Occult hernias, without obstruction, may occur and be confused with appendicitis. Diagnosis of ahernia is not difficult if thr protrusion is evident and the mass can be replaced or reduced. When protrusion is not evident, but the history of such is definite, one is often able to verify the suspicion by the increased thickness of the spermatic cord on that side (79). Dunavant and Willson (81) suggest that it has not been sufficiently emphasized that in some cases it may be difficult or impossible to demon-

strate a hernia even when the patient is crying or straining.

Intussusception is a relatively common lesion among young children with the ileocecal area involved most commonly in infants, but the colico-colic area may be most frequent in older children. Three clinical pictures are described. There are those of the type with sudden onset of attacks of severe colicky abdominal pain causing the infant to scream and usually accompanied by vomiting and later by the passage of blood and mucus in the stool. Peristaltic sounds are active, and on palpation a mass can be felt in the region of the transverse and descending colon. In the second type, there is a similar extent of intussusception, but the symptoms are milder with the child reported as having blood in the stools associated with mild abdominal pain. A mass may be felt. In the third type, these patients have sudden bouts of severe abdominal pain, often localized in the lower right quadrant of the abdomen, but have no other complaints or findings except a questionable mass in the painful area. In the three types, there are four cardinal symptoms in the diagnosis of intussusception: (a) periodicity of pain, (b) vomiting, (c) passage of mucus and blood per rectum, and (d) the presence of a palpable mass in the abdomen (80)(82). Unfortunately, there are many

departures from the classic picture. For one, the circulatory disturbance may be so massive that shock occurs before the colic pattern becomes established; or, the intussusceptum may be loosely held so that pains are irregular nor is the typical bowel mass produced. Plain x-rays are usually not helpful since evidence of obstruction does not appear until relatively late in the course of the disease (43). The role of a Meckel's diverticulum in giving rise to an intussusception by acting as a foreign body which the bowel attempts to expel is an important one (83). Most intussusceptions are seen in infants under two years of age, and in these cases, an etiologic factor frequently cannot be demonstrated (84).

Intestinal obstruction due to neurogenic obstruction of the colon may also be mistaken for appendicitis early because of the obvious distress of the child, but with the increasing distention associated with retention of feces as could be demonstrated by x-ray, a differentiation could be made (85).

Pyloric stenosis might be confused with acute appendicitis in the very young, but the findings of characteristic vomiting following feedings in the infant two to three weeks old suggests stenosis. In the majority of cases, a mass can be palpated in

the epigastrium or right upper quadrant and this, with the forceful vomiting, supplies the diagnosis. There frequently are associated visible peristaltic waves (77)(86).

Until recently, childhood peptic ulcer was regarded almost as a medical curiosity, but recent evidence has indicated that this ailment is not nearly so rare as was previously believed. Using autopsy statistics as a basis for computation, Goldsberry (96) suggests that there are approximately 50,000 undiagnosed gastric ulcers between the age of one and six. By the same means, autopsy statistics suggest an incidence varying from 1 to 1.5 per cent with the added significance that the ratio of duodenal to gastric ulcer from the literature would be in the ratio of more than ten to one (97). This serves to emphasize that peptic ulcer, like other medical entities, is uncommon but does exist and if a high index of suspicion is exercised clinically, more frequent diagnosis would result.

The symptomatology of peptic ulcer in children would seem to be somewhat dependent upon the age of the patient rather than the location of the lesion. In infants, the feeding problem complex group of symptoms together with the vomit-

ing of blood may be the first indication. In the older children, abdominal pain, vomiting and constipation, nausea, and anorexia are the usual presenting symptoms. At any age, persistent abdominal pain may be experienced, usually referred to the umbilicus, but there does not seem to be any noticeable difference in the area of pain distribution between gastric and duodenal lesions (98).

Almost any of the symptoms listed might well occur in appendicitis. In differential diagnosis, x-ray and fluoroscopic examination may provide the diagnosis, but unless there has been visualization of the ulcer niche, the diagnosis is never fully justified. The periodicity of pain, night pain, and the relief by antacids or milk may suggest a diagnosis of ulcer.

Although rare, there are pelvic conditions in the female which may offer some confusion with acute appendicitis. Among these is torsion and infarction of the normal ovary. In most of the recorded cases, the right ovary has been involved and a classical picture simulating acute appendicitis has resulted. The physical findings are usually limited to deep abdominal tenderness or rigidity and the small tender pelvic mass may be palpated per rectum (87). Ovarian cysts are not uncommon prior to the age of puberty and they attract attention by

lower abdominal discomfort, by progressive enlargement of the abdomen, and by acute episodes of severe abdominal pain related to the torsion of the pedicle (88). After reporting what they consider the first case in world literature of a dermoid cyst with torsion in a three year old, Guzzo et al (111) state that one must always consider this possibility in a female child with periumbilical pain and progressive anorexia. In their case, there was a normal blood picture which would tend to rule out appendicitis. The diagnosis may be aided by x-ray or palpation under anesthesia when muscle guarding elimination may permit a definitive diagnosis.

Another confusing entity is that of infantile colic. It is characterized by a screaming infant with suffused face; arms and legs drawn tightly against the trunk, the abdomen distended and rigid, but relaxing between paroxysms of pain. The symptoms usually start after feeding and are worse late in the day. Besides the typical pattern, the infant often makes sucking movements and appears to be searching for food. Usually these infants have a great deal of gas as manifested by belching, flatus, and rumbling. In all instances, an adequate history with details about the feeding, the kind of food, how it is prepared, how it is fed to the infant, the baby's reactions during feeding,

the rate of gain, the bowel condition, whether laxatives are used, or, if on mother's milk, whether the mother is taking medicine must be obtained. The environmental factors of family tensions together with the emotional make-up of the child must also be considered. Then, with a thorough physical examination, other conditions resembling this syndrome can be ruled out (51-53)

Of the abdominal disturbances which also present problems, acute gastro-enteritis as a cause of intermittent cramping abdominal pain is well known and may be confused with appendicitis. From this and the vomiting, the abdominal pain usually diffuses with little or no localization such as is the case in appendicitis. It is important, however, to recognize that the presence of diarrhea does not rule out the possibility of acute appendicitis. If there is localized abdominal tenderness, the history of diarrhea must be accepted as being compatable with the diagnosis of acute appendicitis. There may be a moderate to high fever with increased pulse rate, but the white blood count is usually not elevated (32)(54)(55). Constipation, on the other hand, may also be confused with appendicitis in that it also produces abdominal discomfort with general malaise. A history of dietary and bowel habits may be of value in establishing a diagnosis (56).

The inflammatory condition described variously as "regional ileitis," "nontuberculous granuloma of the intestine," "Chron's disease," may be confused with both the acute and chronic forms of appendicitis. The classic description of regional ileitis by Chron et al (89), while predominatly a disease of adult life, is being recognized with increasing frequency in children. Their paper listed four clinical types and of the first of these, "acute intra-abdominal inflammation," they suggested that it was "impossible to distinguish these cases preoperatively from those of acute appendicitis." There are pain and tenderness in the right lower quadrant, the elevation of temperature and white blood count similar to appendicitis, but only the development of symptoms seems to be somewhat slower. Oleson (90) rather peesimistically suggests that a certain amount of undiagnosed abdominal pain in children represents regional enteritis not sufficiently acute or severe to demand the x-ray examination which might demonstrate it. Closely related to this is the appendicular form of bacillary dysentery as described by Felsen (91). While a history of colitis or acute diarrhea with or without mucus and blood is suggestive of dysentery, the differentiation with this and appendicitis is extremely difficult.

The "throat infections" such as tonsillitis, pharyngitis, nasopharyngitis, sore throat, colds, bronchitis, upper respiratory tract infection, influenza, and, of course, pneumonia, frequently present symptoms of abdominal pain not unlike appendicitis. Brenneman (62) has described two distinct types of pain in this connection. The most frequent and characteristic occurs early in the disease and is commonly intermittent, paroxysmal or colicky of varying severity, but accompanied by little or no tenderness and is practically always referred to the region of the umbilicus. The second type of pain is less clearly defined, but also less severe and sharp and, although it may be constant, more often it is intermittent with paroxysms of severity. Localization may occur anywhere in the abdomen although most frequently it occurs in the umbilical region or on the right side. A clue to the source of the pain may be derived by systematically examining the nose, throat, and ear of every child complaining of diarrhea or a stomach condition together with a careful exploring of the history for evidence of familial respiratory conditions (59).

It is well known that pneumonia and diaphragmatic pleurisy, particularly in infants and children, can simulate acute abdominal conditions (63). The involvement of the right lung may irri-

tate the adjacent intercostal nerves causing referred pain and tenderness and even muscle spasm in the lower right quadrant (64). The difficulty is increased some because an early right-sided pneumonia often produces abdominal pain and rigidity before any chest signs can be made out. Generally speaking, the superficial signs of rapid, shallow breathing, grunting expiration, movement of the alae nasi with respiration and, when present, cyanosis, will help establish the diagnosis of pneumonia. Further, in pneumonia, vomiting is not so common while the temperature is usually quite high. There is also a marked increase in the white blood count. The pain on pressure over the abdomen is usually above the cecal region with a diffuse tenderness which disappears with deep pressure. The x-ray, of course, is of much assistance in detecting the chest involvement of pneumonia. Physical examination of the chest in suspected cases must be thorough (117). It should be remembered that, conversely, consolidation of the right lower lobe may be secondary to a high appendix with inflammation.

The immediate previous history may or may not be of value because there may have been a preceding minor upper respiratory infection. There is some value in noting the general appearance for in pneumonia the patient is restless, face flushed, skin dry,

and he appears ill. The patient with appendicitis assumes a position of flexion ard may not appear to be very ill. The face is pale, and the skin is moist. Fallis (60) makes the observation that "children with pneumonia and other infections will sleep for long periods of time, but a child with acute appendicitis will not sleep and neither will it let anyone else sleep."

The differential diagnosis between these conditions and appendicitis is not always clear. According to Walter et al (54), the presence of persistent tenderness in the lower right quadrant of the child with a compatible history, including that of an upper respiratory infection, must be considered acute appendicitis. One must always bear in mind that pneumonia and acute appendicitis are not incompatable, with the clinical features of one overshadowing the other so that one condition may be entirely overlooked (60)(61).

In a differentiation of pneumonia from appendicitis, some of the features to be considered are: (a) the relaxation of the abdominal walls between respirations, (b) the possible presence of a cough, (c) the sudden rise of temperature to 103° or thereabouts and the tendency to remain with preceding chill or convulsions, (d) the more rapid respiration than the pulse

rate or fever would suggest, and (e) the decrease of abdominal tenderness with depression with the flat of the hand (58).

On occasion, measles and scarlet fever or meningitis may be confused with appendicitis in their early stages for they will begin with severe diffuse abdominal pain which is followed in a few hours by vomiting. In the case of scarlet fever, the characteristic rash does not appear until the second to third day. In measles or meningitis, the fever is usually high and there may be other signs which help to differentiate. With fortune, the Koplik's spots of measles may be detected while a corresponding leukopenia is noted. The examination of the abdomen of these patients is negative with active reflexes and no localized tenderness or increased muscle tonus. As has been previously mentioned, appendicitis may occur in conjunction with the exanthemas, and it may be particularly severe when it comes as a complication of measles (65).

Many children with acute rheumatic fever have pain in the abdomen as an early manifestation. Frequently, it will precede the appearance of other major and minor signs. The abdominal pain is usually a diffuse one or present in the epigastric area and tenderness or rigidity may not be present. There may be an accompanying fever, vomiting, and leukocytosis. Occasionally,

localizing findings occur in the right lower quadrant making the differentiation between the abdominal manifestations of rheumatic fever and appendicitis difficult or impossible. McLendon and LoPresti (26) suggest a trial of salicylates from which a dramatic response may be obtained if the symptom is a manifestation of acute rheumatic fever.

For completeness, mention should be made of thos paroxysmal episodes of abdominal pain associated with abnormal cerebral discharges. The symptom is a common aura of epileptic convulsions, and nausea or vomiting may occur during these episodes. The abdominal pain is acute, severe and colicky, localized to the periumbilical or epigastric area; and, because it may last from a few minutes to hours, the differentiation from acute appendicitis may be confusing. Consideration of temperature, leukocytosis, history and physical examination are helpful in arriving at a diagnosis (26)(27). An important feature of the pain is that it recurs at intervals from a day to several months long, and, between attacks, the child is perfectly well. Careful questioning may reveal that minor twitchings occur. Careful exploration of the history may reveal a clue in a familial tendency to epilepsy. In a few cases, the electroencephalogram can make the diagnosis (72).

Disorders of the genito-urinary tract serve further to complicate the diagnosis of appendicitis. A right kidney blocked by a stricture at the ureteric-pelvic junction, by an aberrant blood vessel crossing the ureter, or by a ureteral stone may give rise to fever, nausea, vomiting, and abdominal pain. The pain and tenderness are usually maximal in the flank. Examination of the urine may only be confusing according to the presence or absence of superimposed infection or from an overlying inflamed appendix. Pyelitis, more common in girls, usually begins with a chill and high fever that is irregular in nature. There may be some frequency of urination, but this, too, because of the position of the lower abdominal organs, may not be of value in differentiation. In pyelitis, the child is apparently ill, and it is a characteristic feature of the disease that there is a great mental irritability which makes examination difficult. The abdominal examination reveals local tenderness with a minor degree of muscular rigidity. Apart from the urine, the sex, the high temperature, the apparent general illness in the absence of severe local signs, the situation of the abdominal tenderness over the pelvis of the kidney, and the slight increase of muscular rigidity which accompanies the tenderness, the sequence of symptoms and signs differs from that

followed in appendicitis (5)(68).

Although ureteral calculus is rare, it does occur but usually presents distinctive features among which are the sharp, lancinating paroxysmal pains which radiate down the leg; the normal or subnormal temperature with a cold clammy skin; the usually normal count; but there may be confusing point tenderness (69).

Perinephritic abscesses are usually characterized by their insidious onset and septic temperature. In this, the major findings are marked tenderness in the costovertebral angle and a typical curvature of the spine. This latter fact is of considerable value in the differentiation from appendicitis with its attitude of flexion. If the sharp lancenating pain can be relieved by placing the patient ir the Trendelenburg position, the kinking of the ureter with the production of acute hydronephrosis should be considered. This Dietl's crisis can also be relieved by placing the child in the knee-chest position thus sharply differentiating from acute appendicitis (69).

Localized ureteritis secondary to an inflamed appendix is not uncommon and is diagnosed principally by finding abnormal numbers of red and white blood cells in the urine. Obstructive uropathy, however, with signs and symptoms resembling those of

ureterolithiasis produced by an inflamed appendix, is presumably rare, but consideration of the fact that an acute appendicitis can cause symptoms referable to the urinary tract is essential in a differential diagnosis (112). In one reported series of 1,402 consecutive cases of acute appendicitis, hematuria was found in 8.8 per cent (113), and in a series of 751 cases of retrocecal appendicitis, the incidence of hematuria was 13.9 per cent (114). It goes without saying, that if the abdomenal complaints have been recurrent, or if there is a reasonable question of urinary tract disease, it is highly desirable to obtain intravenous pyelograms (32).

The occurrence of cholelithiasis in childhood is rare, however, in patients with unexplained abdominal pain, it should be included in a differential diagnosis. The symptoms are largely those of upper abdominal pain, nausea, and vomiting. An accurate diagnosis by cholecystography is simple (92).

Infectious hepatitis is another disease, the clinical picture of which is entirely nonspecific at this age and indistinguishable from a variety of intestinal disturbances. The first symptoms are usually fever, irritability, and frequently, rhinitis. These are shortly followed by anorexia, nausea, vomiting, diarrhea, abdominal pain, and rigidity. The liver frequently is

enlarged and tender. Fever is common, but seldom high. The fact that infectious hepatitis in infants and young children is usually not characterized by jaundice further serves to complicate the picture. Should hepatitis be suspected, laboratory tests are useful in the differential diagnosis. The cephalin cholesterol flocculation test is positive in a high percentage of cases before the onset of jaundice. About the same time, urinary urobilin is increased followed by the appearance of urinary bilirubin. In the prodromal stage, the white blood count is normal or low despite symptoms of an acute infection. The sedimentation rate, however, is elevated in the prodromal stage, but drops to normal or subnormal at the onset of jaundice. Probably the earliest change is an increase in the direct serum bilirubin reaction. This is observed even in infants who do not become clinically jaundiced and occurs before the total bilirubin becomes elevated in jaundiced cases (100) (101).

Pancreatitis is another uncommon disease, that occurring in childhood, may cause some difficulty in differentiation from appendicitis. Nausea and vomiting are common symptoms, but the outstanding diagnostic feature is the severe epigastric pain. The abdominal guarding or rigidity with a silent distending ab-

domen and evidence of increasing intraperitoneal effusion are seen in acute cases. A straight upright abdominal x-ray will help exclude a perforated peptic ulcer by the absence of air under the diaphragm. Markedly elevated serum amylase and urinary diastase, however, are the only certain confirmation in a diagnosis of acute pancreatitis (102)(103).

In rural districts, brucellosis might also be included in a differential diagnosis. This is a baffling disease with many symptoms, among which are abdominal pain and anorexia. By way of differentiation, the leukocyte count is usually low with a neutropenia. The brucellin skin test may provide the diagnosis (72).

Another not too uncommon problem in childhood is that of lead poisoning. Although the symptoms are varied, abdominal pain is frequent and mimics other gastrointestinal disturbances. The abdominal pain is generalized and colicky in nature and palpation does not usually disclose any definite point of tenderness. Vomiting occurs almost invariably and may not have any relation to the ingestion of food or may occur in the course of each meal (94). Diagnosis can be suggested by finding of anemia with basophilic stippling; the presence of coproporphyrinuria; glycosuria in the presence of a normal blood sugar; and x-ray

evidence of a lead line at the ends of the long bones. The concentration of lead in the blood is a very reliable guide to the presence of lead poisoning (95).

The two features of frequency of exposure and mimicing of other abdominal conditions makes insect bites such as the black widow spider an important inclusion in a discussion of appendicitis in children. Usually, the patient will not recall the bite, and so one is faced with symptoms of severe abdominal pain developing a board-like rigidity in a thrashing child who is doubled up. In all cases, a therapeutic test can differentiate a black widow spider bite from other acute abdominal emergencies. This test is performed by the intravenous injection of calcium gluconate or magnesium sulphate with immediate but perhaps only temporary relief in the case of the spider bite (104).

Henoch's purpura is the name applied to that group of symptoms in which patients have attacks of colicky abdominal pain with nausea, vomiting, and sometimes diarrhea with passage of blood in the stools. The attacks may present with urticaria and purpura or without these signs. If the abdominal symptoms are present without the skin lesions, the condition may simulate one requiring abiominal surgery and lead to a needless operation (66).

Certain infections and metabolic disturbances may produce abdominal pain and tenderness in children. For example, severe abdominal pain may be a pre-paralytic symptom of polio and provide considerable diagnostic difficulty (105). Diabetic acidosis is not infrequently associated with abdominal pain which may suggest appendicitis. Also, diabetic acidosis is frequently precipitated by a diffuse or suppurative infection. In patients with diabetic acidosis and abdominal pain, the problem is to determine if the appendicitis is a precipitating factor of acidosis. Usually, the onset of abdominal pain is early in appendicitis and late in the course of acidosis; but fever, localized abdominal tenderness, and leukocytosis are found in both (122). It is important to remember that these disturbances may also co-exist with a surgically correctable lesion which may be producing abdominal pain. Hence, localized abdominal tenderness may be the single most important factor to consider in evaluating the patient (54).

Summary

1. Some of the important physical differences between the infant and adult appendix are discussed.

2. The significant etiological agents in appendicitis are evaluated.

3. The classical physical findings in appendicitis are presented.

4. Problems relative to the presenting history in cases of acute appendicitis are generalized.

5. Important aspects of the physical examination of infants in suspected cases of acute appendicitis is presented.

6. The presenting symptoms of acute appendicitis in infants and children are elaborated.

7. The basis for establishing a diagnosis of acute appendicitis is discussed.

8. An evaluation is made of the criteria which must be considered in a differential diagnosis of acute appendicitis

Discussion

In the young child, the early diagnosis of acute appendicitis assumes great importance because of the serious character of the pathological changes exhibited in the rapidly advancing course of the untreated disease. Although several etiological factors seem important, there is no completely satisfactory answer to the question of what causes this disease entity. Nor is there any conclusive evidence why there should be such a rapid development of gangrene, rupture, abscess formation, and peritonitis in this disease in children. Since this be true,

the only hope of reducing the infant mortality from acute appendicitis lies in early diagnosis.

While it is true that the cardinal triad of appendicitis is abdominal pain, nausea, and tenderness, there are important impediments to an early diagnosis in infancy. Foremost among these is the fact that appendicitis in children is frequently attended with an atypical character and hence does not have the sharply classical outline. The differential diagnosis of the disease might be considered simpler in children because there are fewer conditions to eliminate, yet the ultimate diagnosis is really much more difficult because of the problem of getting an adequate history. If the hurdle of communication were not enough, the response of children to this disease adds further complications. Many children with appendicitis obscure their symptoms by their conduct simply because of the attraction of an intriguing, busy world of play and school. The child may feel a little sick or have a little pain, vomit, and then feel better while the disease process moves steadily on. Moreover, the free use of antibiotics for unrelated conditions may have obscured the symptoms of developing appendicitis and thus provide additional difficulty in diagnosis.

Perplexed by an inadequate history, one approaches the

physical examination of the child with diffidence for this, all too often, may not yield the much-sought diagnosis. There is much to be learned about the examination of children. Potts has very aptly suggested that examining the child's abdomen is like riding a bicycle--one learns a little about it by reading directions, but an occasional fall is expected even for those who have been riding long (1). The falls probably have their greatest value in promoting tolerance for those who are learning to ride.

When faced, then, with the child who complains or gives evidence of pain in the abdomen, it should always be borne in mind that, although more times than not this represents some minor disturbance, the possibility of appendicitis should not be lightly dismissed. As a spur to continued effort directed to an earlier diagnosis of appendicitis, it seems apropos to conclude with a comment from the surgeon Bastianelli: "When physicians are discussing whether the case is appendicitis or not, it is. When they are inclined to admit the possibility of appendicitis without being perfectly sure of it, it not only is, but is about to perforate. When the diagnosis is sure, there is already perforation with more or less circumscribed peritonitis (29)."

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