Overview of the ultrasonography techniques in the diagnosis of appendicitis – elaboration of a novel anatomy scanning method

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Abstract

This article aims to introduce a novel anatomical scanning method which requires scanning according to varied anatomic positions of the appendix based on the widely used graded compression method. We suggest placing the probe longitudinally in the region of the terminal cecum and moving it laterally to explore the sub-cecal appendix. The probe should be placed transversely on the medial side of the cecum to explore the pre-ileal appendix or post-ileal appendix. Placing the probe perpendicularly along external iliac vessels can help explore the pelvic appendix. The probe should be placed transversely on the paracolic sulci, and moved along the paracolic sulci to observe the extra-peritoneal appendix. Using the cephalic end of the probe as a pivot, push and squeeze the cecum to make it move bilaterally as much as possible, in order to expose the retro-cecal appendix behind the air-filled cecum. It is our belief that this anatomical scanning method will greatly improve appendix detection rate and diagnostic accuracy, and provide guidance for surgical localization.

Keywords: ultrasonography; appendix; appendicitis

Introduction

Acute appendicitis, the most common acute surgical abdomen [1-2], is likely to be misdiagnosed as other relevant diseases clinically [3]. Ultrasonography is an inexpensive, portable and non-irradiating examination, which can be rapidly performed with little patient preparation, making it an ideal noninvasive means to image the abdomen, particularly in observing the appendix. Therefore, it is safe to use especially in children and older and pregnant women. Although ultrasonography is widely used in the examination of acute appendicitis [4-8], multiple fac-

tors can affect the visualization of the appendix including the relatively small diameter and length of the appendix, its deep and variable location, covering of intestines, disturbance of intestinal gas, and so on [9]. Therefore, diagnostic accuracy of ultrasonography is strongly technique-dependent [10-11], resulting in difficulties in scanning the appendix for many sonographers and sonologists, especially inexperienced junior sonographers and sonologists, as well as the loss of their diagnostic confidence.

In 1980s, Puylaert et al described the unique ultrasonic characteristic of acute appendicitis as the ‘target sign’ and established the graded compression method for ultrasonic examination of acute appendicitis [6,12,13]. Currently, this technique is still a common skill and its wide application greatly enhances diagnostic accuracy of appendicitis [7,14-22]. However, for some children and those patients who are unconscious, in a coma, suffering from mental problems, dementia, and deafness, or having language issues, the vague description of pain sites and medical histories or lack of typical symptoms make it difficult to find tenderness points ac-

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curately, leading to a higher rate of misdiagnosis or false negative results [4,23-25].

This article aims to introduce a novel anatomical scanning method. Based on the graded compression technique, this method would scan all possible positions of the appendix in order to provide a comprehensive, detailed and accurate examination, and we believe that this will greatly improve the appendix detection rate and diagnostic accuracy and provide guidance for surgical localization. In addition, combining with previous ultrasonic scanning techniques, this article provides a comprehensive overview of methods, techniques and other considerations of scanning of the appendix, in order to make the ultrasonic scanning technique more scientific and comprehensive and provide guidance and confidence for junior sonographers and sonologists in diagnosing acute appendicitis.

Instruments and probes

High-quality images require resolution as well as a penetrating ability of image. A high-resolution color Doppler ultrasonic diagnostic instrument equipped with a broadband variable frequency convex array probe (frequency varied from 2.0 MHz to 5.0 MHz) and a linear array probe (frequency varied from 3.0 MHz to 12.0 MHz) is recommend, which can be used on patients of different sizes and achieve a good balance of resolution and penetrating ability according to the patients' size and lesion depth. Meanwhile, the ultrasonic system should possess multiple functions including harmonics and compound imaging, in order to obtain high-quality images. 2D pulse-inversion harmonic imaging function of the machine can adjust the appropriate frequency and harmonic waves according to the patients' size and lesion depth.

Ultrasound examination techniques

1. The "mowing-the-lawn" technique

In ultrasonic examination of the acute abdomen, including acute appendicitis, diseases of liver, gallbladder, pancreas, spleen, and kidney should be excluded one by one before applying "mowing-the-lawn" technique [26,27]. This technique can comprehensively scan digestive tract, ureters, mesentery, abdominopelvic cavity, retroperitoneal cavity, uterus and uterine adnexa and so on. Suspicious lesion sites or tender points are supposed to be examined more carefully.

In "mowing the lawn" scanning technique, the patient lies in a supine position, and the abdomen is divided into 5-6 longitudinal regions with partially overlapped areas to allow for a thorough scanning [26]. This tech-

Fig 1. The "mowing-the-lawn" technique. The probe moves longitudinally from one side to the other side of the abdomen, and the adjacent scanning area is partially overlapped to achieve an entire scan of the abdomen.

nique was named because the operation is similar to that of "mowing-the-lawn" (fig 1). Puylaert et al scanned with "mowing-the-lawn" technique using a broad-based, high-frequency probe, which was considered useful in the scanning of small intestine disease, due to the contrast between the thickened and hypoechoic wall with surrounding hyperechoic fatty tissue [26].

Generally, the depth of the abdominal cavity ranges from about 5 to 20 cm after compression, which is obviously beyond the exploratory capability of a high frequency linear array probe. Therefore, in order to obtain a general overview of abdomen by using the "mowing-the-lawn" technique, the 3.5 MHz convex probe is a better choice. Applying a high-frequency linear array probe to a suspicious lesion or tenderness point confirmed by a convex array probe would ensure a clearer view of the local condition, especially in obese patients.

When applying "mowing-the-lawn" method, special attention should be paid on whether there exist situations such as bowel-wall thickening, luminal dilatation, adhesion between the bowel and abdominal wall and adhesion between adjacent bowels and ascites (fig 2).

2. Graded compression technique

In many prospective studies, the graded compression scanning technique has been recognized as the standard scanning technique of the appendix, with a sensitivity of 77-89%, and a specificity of 94-96% [6,13,28-31]. This technique can be used in combination with the "mowing-the-lawn" technique using a 3.5 MHz convex probe to scan the whole abdomen, or it can be used alone, usually

Fig 2. Observing the relationship between the bowels and abdominal wall with the “mowing-the-lawn” method: a) the adjacent intestine (IN) and abdomen wall in the upper abdomen during deep inhalation; b) the gas-filled bowel moves toward the head in relation to the abdominal wall when patients exhale; c) and d): the cross and longitudinal section of the right abdomen. The bowels and the abdominal wall are fixed and wrapped by hyperechoic omentum (OM). No relative movement is observed during deep breaths.

with a high frequency probe, to scan the suspicious lesion or tenderness point located by “mowing-the-lawn” method. During examination, pressure should be increased gradually and within tolerable range of the patient, and the whole process should be gentle, similar to the traditional palpation of abdomen. The pressure is appropriate when iliac vessels and psoas major muscle can be clearly visualized.

Applying consistent proper pressure while repeatedly and slightly moving the probe sideways helps eliminate intestinal gas at the local site by squeezing intestinal lumen, and remove mesentery and omentum from over the intestines, thus increasing the rate of lesion detection. When moving the probe sideways or rotating the probe, it is important to maintain pressure at the local site, and not to relax.

Through morphological changes of the lesion after grade compression, tension of the luminal content, mobility and stiffness of the lesion and its relationship with surrounding tissue could also be revealed. Applying moderate pressure to the site of suspicious lesions or point of maximum tenderness will help find the cause of acute abdominal pain.

3. Anatomical scanning technique

For cases from which a satisfactory image could not be obtained with graded compression, anatomy scanning of common appendix areas may be useful. Anatomical scanning technique is based on different anatomical locations of the appendix. Connected to the posterior-inferior-medial wall of the terminal cecum, the appendix is usually located in the lower right quadrant of abdomen, presenting as a narrow, hollow, blind-ended tube. The location of the root of appendix is usually 1.7–2.5 cm below the ileocecal valve, which is relatively consistent [32–33], while the free end of the appendix may point toward different directions. According to the position of its free end, the appendix can be classified as pre-ileal (1–18.8%), retro-ileal (0.4–12.5%), sub-cecal (2.26–19%), retro-cecal (7–65.3%), pelvic (31–55.8%), peritoneal and other types (0.05–4.2%) [34–36] (fig 3). Regardless of

Fig 3. Anatomic variation of the appendix. The blind end of the appendix may point toward different directions according to which the positions of appendix can be classified as pre-ileal, retro-ileal, sub-cecal, retro-cecal, pelvic, peritoneal and other types.

whether the patient has appendicitis, complete ultrasound scanning should be performed at these anatomical positions of the appendix to avoid misdiagnosis.

The steps are as follows:

a) Looking for hepatic flexure of colon:

Beginners can start with a 3.5 MHz convex probe and position it transversely on the right hypochondrium. At this position, the ultrasound image would display the transverse section of the lower part of right anterior lobe of liver, under which lies the hepatic flexure of colon. The anterior wall of the colon presents as transverse and linear iso-echo and the gas within the colon presents as multiple-reflection or attenuation (fig 4).

b) Looking for the cecum:

Because of the variety of locations of the cecum, including the infrahepatic areas, pelvic cavity and even the left side of abdomen, accurately finding the cecum adjacent to the appendix is very important.

The probe should be rotated by 90° clockwise in situ and positioned longitudinally on the hepatic flexure of colon, then the sonographer can scan along the ascending colon downwards until reaching the area where the bow-

Fig 4. Looking for the hepatic flexure of colon: a) The probe is positioned transversely on the right hypochondrium; b) The lower anterior lobe of the right liver (L), cross section of the right kidney (RK) and hepatic flexure of the colon (HFC) filled with gas are seen on the ultrasound.

el air disappears. The cecum is the beginning of the large intestine and is usually located in the right iliac fossa. When standing, the cecum could fall into pelvic cavity. It is posterior to the abdominal wall, anterior to the iliopsoas muscle, and connected to the terminal ileum on its left, with the right paracolic sulci on its right. The ileocecal valve is used as the dividing line of the ascending colon in the upper region and the blind-ending of cecum in the lower region. A child's cecum is usually higher in position. On ultrasound, the cecum usually presents as a mildly dilated aerated bowel-like structure connected to the ascending colon. In general, the anterior wall of cecum can be displayed clearly, while the posterior wall is blurred due to the disturbance of gas within the cecum. High frequency ultrasound could further display the ileum connected to the medial wall of the cecum. Most of the cecum and adjacent ileum canal can be squeezed and closed with pressure (fig 5).

c) Showing the sub-cecal triangular region to explore the sub-cecal appendix:

When placing the probe longitudinally below the region of the cecum, the left side of the sonographic image shows the hyperechoic gas-filled cecum, and the right side shows the sub-cecal triangular region, which is comprised of the inferior wall of the cecum or the lower margin of the multiple reflections of the gas within the cecum, the surface of the iliopsoas muscle and the anterior wall of the abdomen. Normally, the sub-cecal triangular region is filled with intestines, omentum, fat, and other tissues. After applying pressure and moving laterally and repeatedly to enlarge the scanning area, the sub-cecal triangular region usually can be completely pressed shut, because of the high mobility of intestine and omentum (fig 6).

When appendicitis occurs, the intestines and fat within the sub-cecal triangular region get involved. A large

Fig 5. Looking for the cecum: a) The probe is positioned longitudinally to the hepatic flexure of colon; b) The sonographic image. The lower anterior lobe of the right liver (L), longitudinal section of the right kidney (RK) and ascending colon (AC) filled with gas are seen; c) The probe longitudinally moved from the hepatic flexure of the colon to the cecum; d) The longitudinal section of the gas-filled ascending colon and cecum (CE), corresponding to the lower probe of c); e) The probe is positioned on the cecum and rotated to a cross section angle, corresponding to the lower probe of e); f) The cross section of the gas-filled cecum (CE).

Fig 6. The sub-cecal triangular region: a) and c) when the probe is positioned longitudinally below the cecum (CE) and no pressure is applied, the triangle area consists of the lower margin of the multiple reflections caused by the gas within the cecum, the surface of the iliopsoas muscle (IM) and the anterior wall of the abdomen can be seen; b) and d) this triangle area can be completely compressed when pressure is applied.

Fig 7. Triangular region gets involved when appendicitis occurs. Triangular region is incompressible when appendicitis occurs. The intestines and adipose tissue within the sub-cecal triangular region will be involved. A large amount of omentum (OM) will accumulate in this area to wrap and adhere, leading to the fixation of the appendix (APP). (IM, iliopsoas muscle; CE, cecum)

amount of omentum accumulates in this area to wrap and adhere, leading to the fixation of the tissue within this region and making this region incompressible (fig 7). In this situation, if a long and incompressible tubular structure found in this area originates from the posterior-inferior-medial wall of the cecum and has a blind-end, an appendix in a sub-cecal position can be diagnosed (fig 8). Maybe because of early onset and obvious signs of sub-cecal appendicitis, it is easy to be correctly diagnosed in the early stage, and conservative treatment can be taken. Thus, the incidence rate of sub-cecal appendix diagnosed by ultrasonography using the anatomical method is higher (28%) than that of sub-cecal appendix (6%) confirmed by surgery according to research in our hospital (non-published data).

The sub-cecal triangular region cannot be pressed shut in most cases of appendicitis with various positions in the lower right abdomen, thus scanning the sub-cecal triangular region is very crucial. However, appendicitis

Fig 8. Scanning method of the sub-cecal appendix: a) sub-cecal appendix; b) the probe is placed longitudinally to the cecum; c) the ultrasonic wide-view imaging of the inflamed appendix (APP). The whole length of the appendix (between electronic calipers) can be seen. (IM, iliopsoas muscle)

cannot be excluded completely in spite of compressibility of the sub-cecal triangular region, and reasons are as follows: first, in some cases of mild simple appendicitis, the inflammation of the appendix has not yet spread to the triangular region; second, in cases of deep pelvic appendicitis, this triangular region can be pressed shut because the location of inflammation is far away from the inferior region of the cecum. So, in these cases, we need to expand the scanning range or scan with a high frequency ultrasound.

d) Scanning method of pre-ileal and post-ileal appendix:

When the probe is placed transversely on the central medial side of the cecum, and the graded compression

Fig 9. Scanning method of the pre-ileal appendix: a) pre-ileal appendix; b) the probe is placed transversely on the central medial side of the cecum (CE); c) the distal end of the ileum attaches to the inferior wall of the cecum when placing the probe transversely on the central medial side of the cecum; d) inflammation of the pre-ileal appendix (APP), which spans over the ileum and is adjacent to the abdomen wall. (IM, iliopsoas muscle) (IL, Ileum) (IV, Iliac Vessels)

Fig 10. Scanning method of the post-ileal appendix: a) post-ileal appendix; b) the probe is placed transversely on the central medial side of the cecum (CE); c) the post-ileal appendix (APP) spans over the deeper side of the ileum (IL). (IM, iliopsoas muscle)

method is used, moving the probe up and down in a repeated parallel pattern, or changing the direction of the probe upward and downward without changing the location of the probe will make it easier to detect pre-ileal or post-ileal appendix. If an incompressible blind-ended tubular structure which is medial to the cecum and always adjacent to the anterior abdominal wall without intestines in between is found, a pre-ileal position of the appendix can be diagnosed (fig 9). If during graded compression, only part of the appendix is adjacent to the anterior abdominal wall with the rest always separated by intestines, a post-ileal position of the appendix can be diagnosed (fig 10).

e) Scanning method of the pelvic appendix:

First, place the probe perpendicularly along the external iliac vessels, whose surface projection is the line from

the umbilicus to the middle of the inguinal ligament. And then, move the probe continuously from the beginning of the common iliac arteries (the umbilicus) to the inguinal ligament along the external iliac artery, maintaining the position of the external iliac artery in the center of the image. If an incompressible tubular structure is found superficially spanning over the iliac vessels, the appendix is highly likely in a pelvic position (fig 11). Pelvic appendix usually occurs because the cecum is located too low or the appendix is so long that it spans over the iliac vessel to enter the pelvic cavity. The blind end usually extends to the pelvic floor, making trans-abdominal ultrasound observation difficult. Transvaginal ultrasound has the advantages of a wide field-of-view, high frequency, smaller size, no influence from intestinal gas, and a shorter distance between the probe and appendix, thus it may increase the detection rate of pelvic appendix, especially the blind-end of it (fig 12).

Fig 11. Scanning method of the pelvic appendix: a) pelvic appendix originates from the cecum and spans above the iliac vessel with its end entering the pelvic; b) place the probe perpendicularly along the external iliac vessels and move the probe from the beginning of the common iliac arteries (the umbilicus level) to the inguinal ligament along the external iliac artery; c) the color Doppler shows the cross section of the iliac artery and iliac vein; d) a pelvic appendix (APP) spans above the iliac vessel and extends towards the pelvic (the two arrows show the root and blind-end of the appendix). (IM, iliopsoas muscle)

Fig 12. Pelvic appendix under transvaginal sonography. Transvaginal sonography shows a tube-like structure closed to the right wall of the pelvis and is next to the right ovary (ROV) with a thick rough wall and a good sound transparent property. Postoperative pathology indicates a low-grade mucinous tumor of the appendix. Transvaginal sonography can provide a good image in the pelvic appendix (APP).

f) Scanning method of the retro-cecal appendix:

Usually, it is the most difficult to detect the retro-cecal appendix by ultrasound because it is covered by gas in the cecum and is too deep. It is hard to obtain a satisfactory image in patients who are obese or have too much bowel gas even though the graded compression technique is applied. Because cecum is an intraperitoneal organ and has a certain degree of mobility, we can make use of these features in searching for the retro-cecal appendix. First, place the probe longitudinally and 3 cm from the right or left side of cecum. Then, by adding pressure while rotating the probe (angle of rotation should be about 90°) using the cephalic end of the probe as a pivot, push and squeeze the cecum to make it to move bilaterally as much as possible to expose the appendix behind it. A left-lateral position may increase the display rate of the retro-cecal appendix because the cecum will move slightly to the left due to gravity and the enlarged space between the cecum and iliopsoas. However, the movement of the cecum is limited due to the limitation of its length and the little mobility of the ascending colon as an inter-peritoneal organ. As a result, displaying the whole appendix is still difficult despite knowing its anatomical characteristics and using the method described above. Therefore, if an incompressible tubular structure is found behind the cecum, no matter whether the blind-end or the root can be clearly shown, a swollen appendix in a retro-cecal position should be considered, which has high specificity and sensitivity in diagnosing retro-cecal appendix (fig 13).

Fig 13. Scanning method of the retro-cecal appendix: a) a retro-cecal appendix (APP) is difficult to detect because the appendix is buried deeply by the cecum (CE); b) and c) place the probe longitudinally on the cecum, add pressure while rotating the probe (angle of rotation should be about 90°). Use the cephalic end of the probe as a pivot, push and squeeze the cecum to make it move bilaterally as much as possible in order to expose the appendix behind it; d) an uncompressible tube-like inflamed appendix (between the electronic calipers) is discovered behind the cecum after the previous scan method is applied; e) the blood supply around the appendix is abundant in color Doppler ultrasound imaging. (IM, iliopsoas muscle)

g) Scanning method of the extra-peritoneal appendix:

The extra-peritoneal appendix occurs when the appendix rotates towards the outside of the peritoneum posterior to the cecum during the descending of the cecum at embryonic stage. This phenomenon has a relatively low incidence rate of approximately 2% to 8%. Because this type of appendix is located behind the peritoneum and is not adjacent to the anterior abdominal wall, the symptoms are not typical because it usually shows up without rebound tenderness and muscle tension, leading to a frequent missed diagnosis. In addition, it is not covered by the greater omentum and intra-abdominal organs. Therefore, the inflammation of this type of appendix is hard to limit and spreads easily if not treated on time. Ultrasound examination of the extra-peritoneal appendix is harder because of its deep position and susceptibility to the interference of intestinal gas. When scanning, the retro-cecal, pre-ileal and post-ileal examination method can be applied to explore the appendix behind or postero-medial to the cecum. When the extra-peritoneal appendix extends from behind the cecum to the paracolic sulcus, scanning should be focused on the paracolic sulcus area (fig 14). In this situation, it is suggested to place the probe transversely on the right side of the hepatic flexure, then to slide the probe continuously to perform cross-sectional scanning at the paracolic sulci from top (hepatic flexure) to bottom (cecum) (fig 15). If an incompressible tubular or haustra-like structure is found, try exploring continually behind the cecum to differentiate the extra-peritoneal appendix from the colonic diverticulum (fig 16). If the interference of intestinal gas is prominent, ask the patient to lie on the left side, place the probe on the right lower quadrant, and apply graded compression to improve the detection rate of the appendix.

The anatomical scanning method offers a thorough examination of the common anatomical locations of the

Fig 14. Scanning method of the extra-peritoneal appendix: a) the extra-peritoneal appendix extends to the paracolic sulci; b) scanning should emphasize on the paracolic sulci area. The probe should be placed transversely on the paracolic sulci, and moved along the paracolic sulci to observe the extra-peritoneal appendix.

Fig 15. Sonogram of the extra-peritoneal appendix: a) place the probe transversely on the right side of the hepatic flexure of colon, then move the probe continuously to perform cross-sectional scanning at the paracolic sulci from the top (hepatic flexure) to bottom (cecum, CE); b) The extra-peritoneal appendix (APP) presents as a round anechoic area when the probe is transversely placed on the paracolic sulci; c) the probe is rotated 90° to present the longitudinal section of the appendix.

appendix, improving the detection rate of the appendix and reducing missed diagnosis. Meanwhile, knowing the location of the appendix could help determining the appropriate position of the incision, and avoid expanding the incision one more time. When the inflammation of simple appendicitis is mild, the surface of the appendix is smooth with no obvious adhesion to the surrounding tissue. Since applying pressure and moving the probe sideways can change the position of the appendix, more attention should be paid during exploration.

Fig 16. Sonogram of the colonic diverticulum. The probe is transversely placed on the paracolic sulci and the imaging shows that the cecum (CE) wall is slightly thickening especially the mucous layer but its multiple layer structure remains. The outer wall of muscle layers become discontinuous and the extrude diverticulosis (DI) can be seen. The diverticulosis is filled with fecalith inside and shows a hyperechoic pattern with obvious shadows. The lesions are wrapped by hyperechoic omentum. (IM, iliopsoas muscle)

4. High frequency scanning

It is difficult to obtain positive findings in about 20% of the patients with acute appendicitis using the 3.5 MHz convex array probe. Therefore, a high frequency probe should be tried even if no suspicious lesions or tender points are found. Furthermore, the high frequency probe has a better resolution, which is the prerequisite for detecting the root and blind end of the appendix. Each root and blind-end of the appendix should be examined carefully by a high frequency probe in order to ensure the accuracy of the examination (fig 17). A full bladder can affect appendix examination when using the graded compression technique, thus the patient should empty the bladder before the examination.

When the location where the terminal ileum joins the cecum or the ileocecal valve can be accurately identified, scanning can be performed 1-3 cm below this position. The root of appendix can be found more easily in this area [32-33]. When a tubular structure is found in the lower right quadrant of the abdomen without a clear presence of the root or blind-end, further attention should be paid to differentiate the appendix from the bowel. For example: if this tubular structure is an appendix, the inner layer (mucosal layer) should be smooth because the appendix does not have mucosal folds. If the inner layer appears as a tortuous linear echo, then it is likely to be the mucosal folds of small intestine. If it is still difficult to determine, we can take more time to observe the peristalsis or changes of the shape, for their occurrence identifies that the structure is the small intestine. Furthermore, a swollen appendix is incompressible, while intestine loops can be easily squeezed flat. The intestinal canal is continuous without a blind-end through the ultrasound (fig 18).

Ultrasonography can display many signs of appendicitis [13,37-38]. For example, an incompressible tubular

Fig 17. Appendicitis under high frequency ultrasound: a) 3.5 MHz convex array probe discovers a hypoechoic tube-like suspicious lesion in the right lower abdomen. The margin of the lesion is unclear; b) both the root and blind-end of the appendix (APP) are able to be displayed clearly by the high frequency probe. (IM, iliopsoas muscle) (CE, cecum)

Fig 18. The differences between the appendix and the bowel: a) and b) the mucosal layer of the appendix (APP) is smooth for it has no mucosal folds and the blind-end of the appendix can be discovered while the other bowels have multiple mucosal folds and no blind end (as shown in c). (IN, intestine)

structure in the lower right quadrant larger than 6 mm (external diameter) with one blind end and the other end connected to the posterior-inferior-medial wall of the cecum can be displayed, whose cross-section presents as a “target” sign [4,16,28]. The perforation of the appendix presents as the discontinuity of the wall of appendix at first. The cavity of suppurative appendicitis is usually full of punctate hypo-echo which represents thick and sticky pus, and sometimes a fluid level can be seen if the necrotic components vary in weight [12]. A soft tissue mass will form in the lower right quadrant when the appendix is perforated, and the surroundings of the appendix can also be seen quite clear with ultrasound. For example, when there is a lot of omentum or periappendiceal fat, and the echogenicity is increased, when its relationship with the intestine is fixed (immovable when applying pressure or breathing), when the adjacent intestinal loops show localized dilation, when the intestine is filled with liquid content, and the peristalsis is active and there is fluid accumulation in the right iliac fossa [39]. When multiple enlarged lymph nodes are detected in the lower right quadrant, the ones that move with respiration

are usually lymph nodes of the mesentery or omentum, and others which do not move with respiration are lymph nodes surrounding iliac vessels, over which the “cross peak sign” of intestine might occur [40]. The above features can all be observed by ultrasound. Both inflamed and normal appendix may contain gas, which may be confusing, but the latter one has a soft wall and its position is not fixed (fig 19).

Conclusion

In summary, when performing ultrasonic examination of the appendix, the triangular area under the cecum, which is the most common location of the appendix, should be examined first with graded compression after the “mowing-the-lawn” technique is performed across the whole abdomen for abdominal tenderness, and the root of a swollen appendix could be quickly located by moving the probe sideways towards the medial side of the cecum. Next, explore the medial area of the cecum transversely in search of pre-ileal and retro-ileal appendices. And then search along the iliac vessels for the

Fig 19. Sonographic feature of appendicitis: a) a longitudinally section of the swollen appendix (APP) with its wall intact; b) cross section of the swollen appendix wrapped by the hyperechoic omentum; c) hyperechoic fecalith with clear shadow can be seen within the swollen appendix; d) the wall structure of the appendix is swollen and the blood supply is abundant; e) simple appendicitis; f) suppurative appendicitis; g) gangrenous appendicitis. The wall becomes discontinues and fluid can be seen around the wall.

pelvic appendix. Subsequently, at the cecum area, push the cecum to one side with compression to search for the retro-cecal appendix. And lastly, search the paracolic sulci of the ascending colon for the extra-peritoneal appendix. After having searched the above sites, a comprehensive scanning should also be performed at the site of ectopic tenderness.

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