ABDOMINAL CALCIFICATIONS AND DIAGNOSTIC IMAGING DECISION MAKING: A TOPIC REVIEW

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ABSTRACT

Objective: To review commonly encountered calcifications found within the abdomen as seen on the lumbar spine radiograph and to determine which advanced imaging modality is best to thoroughly assess the patient.

Methods: Searches of electronic databases and textbooks were conducted to construct this narrative overview.

Discussion: By categorizing the type of calcification and localizing it anatomically, most often a definitive diagnosis can be reached. Two commonly encountered conditions, abdominal aortic aneurysms and urinary calculi, are used to compare the main advanced imaging modalities (diagnostic ultrasound and computed tomography) used to further assess abdominal calcifications.

Conclusion: In most circumstances, either diagnostic ultrasound or computed tomography will establish a definitive diagnosis and offer thorough imaging assessment for abdominal calcifications. (J Chiropr Med 2006;5: 43–52)

Key Indexing Terms: Radiography, Abdominal; Tomography, X-Ray Computed; Ultrasonography

INTRODUCTION

In the chiropractic setting, plain film radiography is the most widely utilized imaging modality. The abdominal plain film, otherwise known as the abdominal scout view or kidney, ureter, and bladder (KUB) examination, is rarely obtained. However, the frontal lumbar spine radiograph is commonly acquired and includes the same anatomy as the KUB, granted that there is different factoring and slightly more collimation than a typical KUB. Consequently the frontal lumbar radiograph usually produces adequate evaluation of the abdomen. In medicine there is ongoing debate over the necessity of the plain film abdomen. As a result, its role has been curtailed and will likely become even more so with the shift toward utilization of computed tomography (CT) and diagnostic ultrasound (DUS) as

primary abdominal imaging modalities.¹ The lumbar spine radiograph, however, will likely continue to be a commonly acquired study in both medical and chiropractic settings. Often abdominal calcifications are visible on plain film radiographs. These calcifications can mislead, give concern to and possibly confuse the treating doctor. The main objective of this paper is to review the commonly encountered abdominal calcifications and discuss appropriate imaging and clinical decision making with regard to them.

METHODS

PubMed and Google Scholar literature searches were performed comparing DUS and CT with regard to detection and characterization of abdominal calcifications. Other sources of information include ra-

diology textbooks commonly available for use in chiropractic practice and chiropractic radiology residencies.

DISCUSSION

Four Types of Calcifications

There are 4 morphologic categories of calcifications that have been established, each with unique radiographic characteristics that allow for reasonable differential diagnoses and sometimes location relative to abdominal contents. The 4 categories are 1) concretions, 2) conduit wall calcification, 3) cyst wall calcification, and 4) solid mass calcification.^{2,3}

1) Concretions

Concretions are calcifications that form within a duct or hollow organ. They are typically formed by

precipitation of calcium salts that form concentric layers over time, similar to the formation of a pearl within an oyster. The radiographic appearance varies from a radiolucent center with a faint degree of calcification and smooth bordered to dense calcification demonstrating detailed layers and faceted or irregular borders (Fig 1). Typical locations for concretions are the gallbladder (gallstones), urinary tract (renal, ureteral or bladder stones), diverticulum/appendix (fecalith, appendicolith), and pelvic veins (phleboliths). Once laminations or layers are detected in an abdominal calcification it is fairly certain to be a concretion. Sometimes, if the concretion is large enough it may be interpreted as a possible calcified cyst (cyst wall calcification). If the outer wall is incompletely calcified then it is more likely a cyst wall calcification and not a concretion.^{2,3}

Figure 1. Concretions (a) classic laminated (layered) appearance of a gallstone; (b & c) multiple gallstones in the right upper quadrant and the same patient with the image enlarged; (d) multiple faceted gallstones.

2) Conduit Wall Calcification

A conduit is defined as a channel or pipe for conveying water or other fluids.⁴ Conduits found in the abdomen include ducts in the urinary tract, pancreatic ducts, vas deferens, fallopian tubes, biliary ducts and blood vessels. Conduit wall calcification by definition is calcification limited to the wall of the conduit. Radiographic appearance can vary, from partial calcification that presents as specks along the anatomical route of a vessel, to parallel tracks, to

branching tracks, to ring-like opacity when seen en face (Fig 2). The most common type of conduit wall calcification is arterial, and can occur in any vessel but is most common in the aorta, internal and common iliac arteries, renal and splenic arteries. These are relatively easy to identify and categorize based on anatomic location.^{2,3}

3) Cyst Wall Calcification

Cyst wall calcification is found within the wall of a fluid filled cyst or hollow organ. Included in this

Figure 2. Conduit Wall Calcification (a) typical appearance of a calcified abdominal aorta; (b & c) frontal and lateral views of the abdominal aorta with calcification extending into the common iliac arteries.

category is vascular aneurysm. A pattern of a curvilinear calcification is essential for this category (Fig 3 and 4). To differentiate between cyst and conduit wall calcification, it is important to establish that the diameter of the calcification is greater than that of the normal conduit. In addition, cyst walls may only be partially calcified, which allows for differentiation from concretions, where typically the entire circumference is calcified. At times there may be what appears to be internal calcification of a cyst but this typically represents dense calcification of a wall that is not tangential to the x-ray beam. Entities that present with cyst wall calcification are: 1) aortic, splenic and renal artery aneurysms; 2) the gallbladder and; 3) cysts found within the kidneys, adrenal glands, spleen, liver, mesentery and ovaries.^{2,3}

4) Solid Mass Calcification

Solid mass calcification can present with a wide range of radiographic patterns. Typically there is a dense center with irregular margins. There may be amorphous (irregularly shaped), curvilinear, flocculent (flake-like), streaked or speckled calcific opacities within the mass as well as regions of lucency. Calcified solid masses can appear anywhere in the abdomen. The most commonly seen mass calcifications are calcified mesenteric lymph nodes (Fig 5). These are most likely calcified as a result of previous infection, such as tuberculosis. In women, a common uterine lesion that presents with a solid mass calcification is the benign uterine fibroma or leiomyoma (Fig 6). These have a "mulberry" pattern of calcification or sometimes a cyst wall-like appearance. Unfortunately, solid mass calcifications can also be seen in malignancies of the liver and kidneys as well as accompanying a multitude of benign tumor processes. This type of calcification is sometimes seen within the spleen or pancreas.^{2,3}

Location as a key to diagnosis

When evaluating the frontal lumbar spine/abdominal radiograph, it is practical to break the film down into quadrants for descriptive and anatomical purposes. These are right upper, left upper, right lower, and left lower quadrants (Fig 7 and Table 1).⁵ When questions arise on the frontal projection, the lateral projection will assist in localizing any visualized calcifications. The terms used to describe the anatomical location of a calcification relative to a respective organ or bowel structure are anterior (typically intraperitoneal) and posterior (typically retroperitoneal) (Table 2).⁵ Location and

the type or pattern of calcification are key to establishing a potential diagnosis as well as assisting in the decision about which, if any, imaging modality should be acquired next to confirm a suspected diagnosis and/or further assess the patient. Many entities exist within the abdomen that present with calcifications. Only the most common ones are discussed in this paper.

Right Upper Quadrant

The presentation of a right upper quadrant concretion seen in the anterior aspect of the abdomen is classic for cholelithiasis (gallstones) (Fig 8).³ Gallstones may or may not be symptomatic and typically a thorough abdominal examination of the patient with follow-up DUS or CT and referral to a gastroenterologist is appropriate management by the chiropractor.³

Right Lower Quadrant

Right lower quadrant calcifications are less common than those found in the right upper quadrant. Some calcifications that can be seen in this quadrant are calcified lymph nodes (solid mass) (Fig 5) or an appendicolith (concretion) (Fig 9).³ Both require some degree of follow up. It is not always important, but may be useful to determine active or previous infection to arrive at a diagnosis of calcified lymph nodes. It is necessary to rule out appendicitis with an appendicolith, and to know that they can be associated with perforation of the appendix, particularly in children.³ If the patient has abdominal pain with the presence of an appendicolith then DUS or CT evaluation with medical referral is appropriate.³

Left Upper Quadrant

The left upper quadrant may present with calcified cysts within the spleen or mesentery (Fig 4) and possibly splenic artery atherosclerosis (conduit wall) or aneurysm and renal artery aneurysm (cyst wall). Either DUS or CT evaluation of the region to help localize a calcification within a structure or organ is appropriate.^{2,3}

Left Lower Quadrant

Within the left lower quadrant, lymph node calcification (solid mass) can be seen as can urinary tract calculi (concretion) within the ureter. Little else is typically found in this region.

Figure 3. Cyst Wall Calcification (a & b) demonstrating calcified abdominal aortic aneurysm. Note the thin calcified wall visualized on the frontal projection (white arrows). (c) Axial CT of the abdomen demonstrating a large abdominal aortic aneurysm. Note the extensive calcification on the anterior wall.

Figure 4. Left upper quadrant cyst wall calcification seen within the spleen. This represents a hydatid cyst (parasitic infection).

Pelvis

Within the pelvis, phleboliths (phleb = vein, lith = stone) are the most commonly encountered calcification in the pelvis and they present as characteristic concretions in the lower portion of the pelvic inlet and despite sounding scary are considered incidental findings.³ Uterine fibromas (Fig 6) will be seen here.³ This is a benign tumor of the uterus and once detected a gynecological referral and follow up DUS or CT of the pelvis may be indicated.³ Although almost always benign, they can negatively impact pregnancy and may grow large enough to require surgical excision.

Diagnostic Ultrasound vs Computed Tomography

Classification of the calcification into one of the 4 major categories combined with anatomical local-

Figure 5. Solid Mass Calcification (a & b) characteristic "popcorn" presentation of calcified lymph nodes, both found in the left lower quadrant; (c) post-infectious changes to the spleen which is completely calcified, seen in the left upper quadrant.

Figure 6. Frontal and lateral view of a leiomyoma or uterine fibroma (solid mass calcification) within the pelvis. Note the "mulberry" appearance.

ization is essential to establishing a definitive diagnosis. However, there are times where there is no clear distinction between categories, or the anatomical location appears to contradict the type of calcification visualized. In these situations, or as part of the natural course of appropriate follow up of recognizable calcifications, advanced imaging may be ordered. The most appropriate modalities to further assess calcifications within the abdomen are DUS and CT.

Both DUS and CT will aid in determining the location of the calcification and may provide additional insight into the nature of the calcification. Two clinical entities that present with calcifications on plain film are abdominal aortic aneurysms and urinary tract calculi. Patients with both of these conditions are seen in the chiropractic office and they may present with musculoskeletal pain patterns. It

Figure 7. Demonstrating the four main quadrants visualized on a frontal radiograph.

TABLE 1
ANATOMICAL LOCATION OF VISCERA

ANATOMICAL LOCATION OF ORGANS AND BOWEL	
RIGHT UPPER QUADRANT	LEFT UPPER QUADRANT
LIVER	SPLEEN
GALLBLADDER	MESENTERY
PANCREAS (PORTION)	PANCREAS (MOST)
ADRENAL GLAND	ADRENAL GLAND
KIDNEY/URETER	KIDNEY/URETER
RIGHT LOWER QUADRANT	LEFT LOWER QUADRANT
APPENDIX	URETER/BLADDER
URETER/BLADDER	OVARY
OVARY	UTERUS
UTERUS	MESENTERY
MESENTERY	SMALL PELVIC VESSELS
SMALL PELVIC VESSELS	

is important that the chiropractor be aware of these conditions, their clinical presentation and imaging appearance. Using abdominal aortic aneurysm and urinary tract calculi as examples, a comparison between the utility of DUS and CT follows.

One author has suggested that atherosclerotic plaques can increase a patient's risk for development of disc degeneration and is associated with the

TABLE 2
ANTERIOR AND POSTERIOR STRUCTURES OF THE ABDOMEN

ANATOMICAL LOCATION OF ORGANS AND BOWEL	
ANTERIOR STRUCTURE	POSTERIOR STRUCTURE
LIVER	KIDNEYS AND URETERS
GALLBLADDER	PANCREAS
SPLEEN	OVARIES (BETWEEN RECTUM AND BLADDER)
STOMACH	UTERUS (BETWEEN RECTUM AND BLADDER)
OMENTUM	RECTUM
BLADDER	BLADDER (PORTION)
UTERUS (PORTION)	PROSTATE (PORTION)
PROSTATE (BELOW THE BLADDER)	PORTIONS OF SMALL AND LARGE BOWEL
PORTIONS OF SMALL AND LARGE BOWEL	

occurrence of back pain.⁶ The hypothesis is that atherosclerosis of the aorta leads to ischemia in the lumbar region, which may lead to disc degeneration.⁶ Thrombus formation is typically abundant in atherosclerotic aneurysms and serious concerns include rupture of the aneurysm and an embolus that may occlude distal vessels. Abdominal aortic aneurysms measuring 6 cm pose a 42% risk of rupture within 5 years, 1 measuring 8 cm or more will have a 75% risk. Mortality from a ruptured abdominal aortic aneurysm ranges from 50% to over 90% depending on the patient's general health and time to surgery.⁷ In the emergency department setting dealing with a symptomatic population for abdominal aortic aneurysms, DUS has been shown to be both sensitive and specific for ruling in or out aneurysm and appropriately directing those needing urgent consultation and surgery.⁸

While comparing CT and DUS in the evaluation of abdominal aortic aneurysms the cost of the examination must be considered. DUS tends to be less expensive than CT. Both modalities are effective in calculating the external diameter of a calcified aneurysm. One study showed DUS to be better in assessing true lumen size and detecting small mural thrombi while an additional study found that CT was better at demonstrating calcifications within the wall.^{9,10} Based on the imaging assessment alone DUS should be the modality of choice in the diagnosis, serial evaluation and management of a patient with an abdominal aortic aneurysm.⁹ DUS is also the most cost-effective, non-invasive method of evaluation of an abdominal aortic aneurysm. However, CT of the abdomen and pelvis, particularly if

Figure 8. Solitary gallstone (concretion). Note the location in the right upper quadrant and anterior in the abdomen (white arrow).

performed with contrast, is more accurate at determining size, volume of thrombus formation and anatomy for surgical planning. Both modalities will confirm the presence and give an accurate size assessment of the aneurysm. Surgical candidates will most likely be imaged with contrast enhanced CT.¹¹

Patients with acute flank pain must be evaluated for urinary tract calculi. In the detection of these calculi in a patient with flank pain the most likely initial imaging modality will be plain film radiographs.¹ The typical radiographic presentation is a small, sometimes undetectable calcification in the paraspinous region from the kidneys or ureters, that may be detected along the course of the urinary tract, all the way down to the bladder on a frontal lumbar or abdominal radiograph. On the lateral projection, they can be found overlying the spine, posteriorly

Figure 9. Axial CT of the abdomen demonstrating an appendicolith (concretion) (white arrow) within the appendix. This would be found within the left lower quadrant of the abdomen on plain film.

within the abdomen (Fig 10). It is when these calculi are not detected on plain film and there is a strong clinical suspicion that calculi are present that DUS and CT examinations should be considered.

Non-enhanced spiral CT is now the standard imaging modality used for the acute flank pain patient.¹² The sensitivity and specificity of spiral CT is greater than that of plain film abdominal radiographs and intravenous urography or pyelography for the detection of urinary calculi.¹² However, when urinary tract calculi are detected, the patient is followed up with intravenous urography. The goal with this modality, which is still used in the follow-up and management for detected urinary calculi, is to assess the degree of urinary backup and renal function, not for the detection of calculi. Most patients who have known urinary calculi will eventually have an intravenous urography contrast study performed.

A study by Thoeny¹³ compares DUS and CT for upper urinary tract calculi. In the detection of calculi the study found that CT examination due to its speed, safety, accuracy and sensitivity, is the modality of choice. CT also exposes the patient to less radiation than the traditionally combined plain film abdomen/IVU examination. Consequently, in medicine, there is an attempt to discontinue the use of the plain film radiography for calculi detection and follow up imaging and replace it with the scout CT examination. A scout CT examination is not a complete CT evaluation that provides axial images of an

Figure 10. Solitary renal calculi (concretion) within the kidney, note the location in the left upper quadrant and posterior abdomen overlying the spine (white arrow).

area of interest, but is a scout image, resembling a plain film radiograph, and is used as a guide to localize the axial image slices relative to surrounding anatomy. However, the results of a study by Jackman et al¹² clearly show that the plain film radiograph is more sensitive than the scout CT in the detection of urinary calculi. The study showed that of the calculi visible on the plain film radiographs 51% were not seen on the scout CT. The

authors' conclusion is that the plain film should remain as the imaging modality of choice in this situation and should not be replaced by the scout CT evaluation.

When comparing DUS and CT for the detection of urinary tract calculi, there are several factors that must be considered. For example DUS is widely available, does not expose the patient to ionizing radiation and is cheaper than CT. CT is more expensive, less available and does give a radiation dose to the patient. Both studies can assess the patient independent of renal function and neither requires contrast enhancement.¹² A study by Patlas et al¹⁴ comparing the two modalities, specifically DUS and non-enhanced spiral CT, demonstrated equal sensitivity in detecting calculi. Considering other factors such as cost and radiation dose the conclusion was to utilize DUS and for CT to be used only in cases where DUS is not available or fails to provide adequate information. Another study by Ripolles found CT to be the most accurate imaging technique for the detection of ureteral calculi but remarked that there is value in plain films combined with DUS. Combined they have a lower sensitivity than CT examination but also have a lower radiation dose and still provide practical value to the diagnostician.¹⁵

CONCLUSIONS

In the chiropractic setting, where plain film radiography is frequently used, it is common to identify calcifications within the abdomen. By determining which of the 4 main categories a calcification belongs in (concretions, conduit wall, cyst wall, and solid mass type) and by localizing the calcification in a specific anatomic structure or area, one can arrive at a short list of differential diagnoses and often a definitive diagnosis.

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