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• Biceps Tendon: Differentiation of the Anechoic Lesions

• Developmental Dysplasia of the Fetal Hip

• Primary Hepatic B-Cell Lymphoma Mimicking Cholangiocarcinoma
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Cover images (left to right): Niagara Falls, Ontario; Canadian Arctic fox; Whistler Mountain, Alberta.

Above images (left to right): Canadian geese, Ontario; frozen Lake Louise, Alberta; Mount-Tremblant Ski Resort, Quebec.
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This will be a very interesting issue for many of you. We have an award-winning article by Rua El-kasheef titled “Use of Sonography in the Diagnosis of Developmental Dysplasia of the Fetal Hip.” Rua presented her paper at the 2013 Winnipeg Conference, and it was very well received. This article, which won first place in the student category in the Canadian Society of Diagnostic Medical Sonographers (CSDMS) Excellence in Ultrasound, is published without some copyrighted diagrams and images that were incorporated in the original award submission. We don’t believe that the excluded material greatly affects the continuity and impact of the article.

This represents a common situation with student submissions. Because of students’ limited clinical experience and exposure, their access to non-copyrighted clinical images is quite restricted. Many students must resort to borrowing images from other sources. This is fine for program and CSDMS award submissions, but it is often difficult and often impossible to obtain copyright permissions to publish these images in The Canadian Journal of Medical Sonography (CJMS).

Jennifer Denbok, a previous CSDMS Board of Directors student representative and a recent graduate of the British Columbia Institute of Technology (BCIT), also contributes a fine case report, titled “Primary Hepatic B-Cell Lymphoma Mimicking Cholangiocarcinoma.” We want to commend all our Canadian students for their willingness to submit their program’s clinical papers to CJMS; most are really wonderful papers that demonstrate the enthusiasm of our students. We need to continue to encourage and congratulate them on their hard work and share in their passion for their new profession.

Tony Li again contributes some very useful information on musculoskeletal (MSK) sonography. Tony is a very busy Toronto sonographer who has a keen interest in MSK and hopes to share his knowledge with others who practise it.

This willingness to share his experiences and knowledge is commendable.

I encourage all members to review the new Sonography Canada website being revealed in January 2014, particularly the CJMS tab. The editorial board has been working diligently to enhance the Instructions to Authors tab to make submitting an article easier and less daunting. CJMS will also be adding a new submission category: pictorial case reports. For those of you who are seeing interesting pathology but are a little leery of the hurdles of becoming a published author, I encourage you to consider submitting a pictorial case review. This requires great images but much more limited text. The guidelines are listed under the Instructions to Authors tab, along with the revised instructions on original research, case reports, book reviews, comments, etc. Remember if it’s interesting and challenging to you, it will be of interest to your colleagues. This will be a great learning tool for us all.

In the initial 2014 issue, there will be a book review of the new World Health Organization guidelines on clinical ultrasound by CJMS editor Marion Cairnduff. This should be of interest to all as there are many jurisdictions in the world that do not have access to the levels of education and technical resources that we do here in Canada; so, have a look at this revised international reference tool.

Please make special note of the CSDMS information on the 2014 Banff Conference and Annual General Meeting. It has a very interesting educational agenda with something for all sonographers, regardless of discipline, in a truly awe-inspiring setting. The Calgary organizing committee has been working extremely hard to make it a great success.

Kim Boles, CRGS, CRVS, FCSDMS
Editor-in-Chief
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Sonography of the Long Head of the Biceps Tendon: Differentiation of Anechoic Lesions

Tony Y. Li, CRGS, CRVS, RDMS, RVT

Abstract
Anechoic lesions are the commonest findings in the ultrasound examination of the long head of the biceps tendon. Many abnormalities in the bicipital region and other regions of the shoulder can cause a similar anechoic appearance. Therefore, the differentiation of these lesions during ultrasound scanning is critical to providing correct diagnostic evidence. Based on clinical experiences and literature review, the sonographic characteristics of the commonly seen anechoic lesions in the bicipital region (such as sheath effusion, tenosynovitis, peritendinous cyst, biceps tendon rupture, and adjacent subacromial-subdeltoid bursa effusion) are discussed.

Sonographic Anatomy of the Long Head of the Biceps Tendon
The LHB tendon originates from the superior glenoid labrum, glenoid rim, and supraglenoid tubercle of the scapula. It can be divided into the proximal intra-articular portion and the distal bicipital groove portion. The intra-articular portion courses over the humeral head from cranial to caudal in the glenohumeral joint, where its cross-section shape shifts from an oval to a more rounded shape. Sonographically, the aspect of the tendon over the upper humeral head may be visualized on a short-axis scan when the patient’s arm is externally rotated and flexed posteriorly (Figure 1A). Before the LHB tendon descends into the bicipital groove between the greater and lesser tuberosities, it first goes through the rotator cuff interval between the supraspinatus and subscapularis tendons (Figure 1B, 1C). Because of this close relationship, rotator cuff abnormalities may affect the LHB tendon directly. The LHB tendon goes down in the groove (Figure 2), where it is invested by a
Synovial sheath extended from the synovial lining of the glenohumeral joint; therefore, the LH B tendon sheath has a communication with the joint. Fluid in the joint can drain into the sheath. The sheath ends in a blind pouch beyond the distal end of the bicipital groove while the LH B tendon attaches to the belly of the biceps muscle below the groove where this myotendinous junction is located deep to the tendon of the pectoralis major muscle, which inserts into the greater tuberosity lip (Figure 3). In the proximal bicipital groove, there is a thin layer of fibrous tissue called the transverse humeral ligament. This ligament over the groove bridges the greater tuberosity and the lesser tuberosity to form an osteofibrous tunnel. On transverse imaging, the ligament appears as a hypoechoic structure overlying the tendon (see Figure 2A). The vascular supply to the tendon is from the anterior lateral branch of the anterior circumflex humeral artery at the medial distal portion of the tendon; it then goes up along the lateral side of the tendon in the bicipital groove to nourish the proximal portion of the LH B tendon (Figure 4).

**Effusion**

Effusion in the sheath is the most commonly seen anechoic change. The fluid may come from the glenohumeral joint because of the synovial sheath communication with it, the tendon sheath itself, or other shoulder lesions. Since the shoulder examination is usually carried out with the patient in a sitting position, most fluid in the sheath is usually collected in the dependent portion or blunt end of the sheath. On normal transverse imaging, a very thin peritendinous anechoic rim can occasionally be seen surrounding the tendon; this can be either a small amount of fluid or the synovium of the sheath (Figure 5). If the amount of fluid in the distal portion of the sheath only partially encircles the tendon on transverse view, it is still considered to be a small amount of fluid and a normal finding. However, if fluid is focally located at one aspect of the tendon, it may resemble a peritendinous cyst or even a

![Figure 1. Intra-articular portion of the LHB tendon. Short-axis views of the LHB tendon (thick arrow) in proximal (A), intermediate (B), and distal (C) aspects. The supraspinatus tendon is indicated by the arrowhead. The subscapularis tendon is indicated by the thin arrow.](image1)

![Figure 2. A, Short-axis view of the bicipital groove portion of the LHB tendon (arrow) and the transverse humeral ligament (arrowhead). B, Long-axis view of the LHB tendon (arrow).](image2)

![Figure 3. Myotendinous junction of the LHB tendon. The junction (thick arrow) is deep to the tendon (thin arrow) of the pectoralis major muscle in the short-axis view.](image3)
small distended subacromial-subdeltoid bursa anterior to the sheath. (The differentiation of these two lesions is discussed later in this article.) On transverse imaging, an abnormal amount of fluid in the sheath is usually shown as an obvious peritendinous anechoic rim (Figure 6A), the length of which may range from the lower third to the top of the groove on long-axis imaging (Figure 6B). However, when an abnormal amount of fluid in the sheath is suspected, care should be taken to prevent excessive pressure from the transducer on the

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**Figure 4.** Vascular supply of the LHB tendon. Power Doppler imaging of the anterior lateral branch (arrowhead) of the anterior circumflex humeral artery in the short-axis view (A) and long-axis view (B) shows the artery is lateral to the LHB tendon (arrow).

**Figure 5.** A, Short-axis view of normal anechoic rim (arrows) around the LHB tendon. B, Long-axis view.

**Figure 6.** A, Short-axis view of effusion (arrow) of the sheath of the LHB tendon. B, Long-axis view of the effusion (arrow).
Figure 7. Tenosynovitis of the LHB tendon. A and B, Short- and long-axis views, respectively, of the anechoic lesion (arrow). C and D, hyperemia in the anechoic rim as shown by power Doppler imaging.

Figure 8. Short-axis view (left panel) and long-axis view (right panel) of a typical peritendinous cyst (arrow) of the LHB tendon.
bicipital region. Pressure may push the fluid away from the imaging area and lead to misinterpretation. Whenever a positive peritendinous anechoic rim is identified in the sheath, effusion is always a possibility, suggesting an intra-articular pathology, rotator cuff tear, or capsular lesion, which requires further examination of the other shoulder regions. Another possibility is tenosynovitis, which is discussed next.

Tenosynovitis
Inflammation of the synovial sheath investing the tendon is called tenosynovitis. It can have many etiologies or be idiopathic. This condition is most commonly due to repetitive strain from overuse of the tendon. Another relatively common cause is arthritis (e.g., rheumatoid arthritis), which can cause inflammation of both the joint and the tendon sheath. Acute tenosynovitis usually results in an abnormal amount of fluid encircling the tendon, resembling the tendon sheath effusion caused by joint or other shoulder lesions. If the fluid in the sheath is more than proportional to that observed in the posterior joint recess, it is highly likely that the effusion is caused by tenosynovitis. In the subacute and chronic stages, tenosynovitis demonstrates not only increased fluid but also thickened synovium, which on grey-scale imaging appears as an increased width of peritendinous anechoic rim (Figure 7A, 7B). Therefore, it is imperative to differentiate the anechoic hyperplastic synovium from the anechoic effusion caused by other lesions. Since tenosynovitis is an inflammatory condition, power Doppler imaging shows hyperemia in the anechoic rim and also increased vascularity in the groove medial to the tendon (Figure 7C, 7D). These are the key characteristics of tenosynovitis. However, a potential pitfall can occur if one mistakes the normal vascularity representing the anterolateral branch of the anterior circumflex humeral artery lateral to the tendon for an increase in vascularity. This can result in a misdiagnosis of tenosynovitis if there is a pre-existing peritendinous anechoic rim caused by effusion.

Peritendinous Cysts
Peritendinous cysts in the bicipital region are mainly ganglion cysts whereas tendon sheath cysts are very rare. Although peritendinous cysts are not very common in the bicipital region as compared to other regions such as the wrist and hand, their sonographic appearances are similar: they appear as a well-defined anechoic area adjacent to a tendon (Figure 8). In the bicipital region, an eccentrically located cyst presents as a small focal sheath effusion located on an aspect of the tendon (Figure 9). The differentiation of these two entities is important because a cyst may exert a mass effect on the biceps tendon, causing tendinopathy and symptoms. However, this differentiation is relatively difficult and requires comprehensive evaluation. A rule of thumb is that most ganglion cysts tend to be round or oval and are noncompressible. By comparing the length of the anechoic area in the sheath in short-axis and long-axis views, the shape can be easily determined (Figure 10). The next step is to determine whether the anechoic lesion is compressible by applying pressure over the area through the transducer. A cyst will present a negative result. However, focal effusions can present with both negative and positive findings, depending on the location of the effusion in the sheath and on the patient’s habitus. If the effusion is located anterior or posterior to the tendon and the patient is thin, the compression result may be positive. If the effusion is located medial or lateral to the tendon or the patient is obese and has thick arms, the compression result may be negative. When a tentative conclusion cannot be reached by combining the shape and compression evaluation results, follow-up scanning may be
Figure 10. Determination of the shape of anechoic lesions. A, Long-axis view of the cyst (arrow) also shown in Figure 9A shows the length to be similar to or a little more than the width. B, Long-axis view of the focal effusion (arrowhead) also shown in Figure 9B shows the length to be much greater than the width.

Figure 11. A typical subacromial-subdeltoid bursa effusion. The bursa (arrow) is superficial and lateral to the LHB in this short-axis view.

Figure 12. Short-axis views showing the similarities of subacromial-subdeltoid bursa effusions to focal sheath effusions and peritendinous cysts. A, The bursa effusion (arrow) looks like a sheath effusion superficial to the LHB tendon (arrowhead). B, The bursa effusion (arrow) looks like a cyst.

Figure 13. Long-axis view showing the relationship of the subacromial-subdeltoid bursa and the bicipital groove. The bursa (arrow) is outside of the bicipital groove (arrowhead).
Figure 14. Compression of the subacromial-subdeltoid bursa. Left and right panels respectively are views made before and after compression of the bursa (indicated in left panel by the arrow). In both panels, the LHB tendon is indicated by an arrowhead.

Figure 15. Complete tear of the LHB tendon. A, Short-axis views of empty bicipital groove (arrow, left panel) and contralateral normal LHB tendon (arrowhead, right panel). B, Long-axis views of empty bicipital groove (arrow, left panel) and contralateral normal LHB tendon (arrowhead, right panel).
helpful, based on the fact that effusion usually elongates with time.

Small Subacromial-Subdeltoid Bursa Effusion

The subacromial-subdeltoid bursa is a large bursa located inferior to the acromion and the coracoacromial ligament, deep to the subdeltoid muscle. The upper aspect of the bicipital groove is covered by the anterior portion of the bursa.1 Normally, the bursa cannot be identified with ultrasonography unless a bursa effusion (bursitis) occurs. Moderate and large bursa effusions are easier to identify and have less chance of being mistaken for other lesions (Figure 11). However if the bursa effusion is small, it may appear as a well-defined anechoic change superficial to the biceps tendon on transverse view; this can look like a small superficial effusion of the tendon sheath (Figure 12A) or a peritendinous cyst (Figure 12B). Theoretically, a small subacromial-subdeltoid bursa effusion over the biceps tendon would be obviously different from a similar effusion in the sheath since the bursa is separated from the biceps tendon by one layer of fibrous tissue transverse humeral ligament and two layers of synovium (one from the bursa and the other from the sheath). In practice, however, that is not the case. A way to differentiate the two is to rotate the transducer to the long-axis view; in this view, the anechoic bursa can be identified outside of the bicipital groove (Figure 13). To differentiate a small bursa effusion from a cyst, pressure can be applied through the transducer over the anechoic area. If a cyst is present, the shape of the anechoic area will not change whereas a bursa will be easily compressible (Figure 14).
Rupture of the Long Head of the Biceps Tendon

Rupture of the LHB tendon is not uncommon. It usually happens in the intra-articular portion 1.2 to 3.0 centimetres from the tendon origin (called the hypovascular zone). The empty bicipital groove between the retracted proximal and distal ends may be filled with fluid that can appear as an anechoic change. Regardless of whether the rupture is acute or chronic, the anechoic change without tendon echotexture in the bicipital groove (empty groove) should be identified in both short-axis and long-axis imaging (Figure 15). The typical “Popeye” sign on the anterior aspect of the middle arm signifies the possibility of a LHB tendon rupture, and the above-mentioned sonographic characteristics can usually be identified. Even though there sometimes may be no “Popeye” sign because of a partial tear or not-retracted distal end of the rupture (self-attachment into the groove), an anechoic change is usually shown in the bicipital groove. This should be differentiated from the similar appearance caused by simple effusion. In such a situation, comparative study with the contralateral bicipital groove may be the most effective approach. In simple effusion, the echotexture and thickness of the biceps tendon are similar to those of the contralateral one, whereas in the above-mentioned tendon tear, the affected biceps tendon usually appears to be either thinner than the contralateral tendon (Figure 16) or shows a disrupted and not-aligned tendon echotexture.

References
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In past years, when economies, companies, and memberships have declined, the Canadian Society of Diagnostic Medical Sonographers (CSDMS) has grown and prospered. CSDMS has taken on a number of initiatives to help promote growth within its organization in two key areas:

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Primary Hepatic B-Cell Lymphoma Mimicking Cholangiocarcinoma: A Case Report

Jennifer Denbok

Abstract

Cholangiocarcinoma and primary hepatic lymphoma are both rare primary liver neoplasms that are diagnostically challenging and that, in the case described here, prove the importance of differential diagnoses.

A 49-year-old woman with classic symptoms of cholecystitis presented for an abdominal ultrasound examination. She underwent multiple imaging tests that all seemed to point to a diagnosis of cholangiocarcinoma. Through biopsy, she was proven to have diffuse large B-cell lymphoma of the liver. A lack of any lymphadenopathy indicated that this might be a rare case of primary hepatic lymphoma. Although her management and outcome were not known at the time of this writing, the prognosis for lymphoma is much better than for cholangiocarcinoma. This case is important for sonographers because ultrasonography is typically the modality of choice for investigating right upper quadrant pain and other common symptoms of both cholangiocarcinoma and lymphoma in the liver. This case also underlines the importance of considering a differential diagnosis for unusual liver lesions as it has a huge impact on patient management and outcome. Additionally, this case represents a rare diagnosis of primary hepatic lymphoma. The ultrasonographic appearance of primary and secondary lymphomas in the liver is discussed.

Although radiological imaging has vastly improved in recent years, there are occasionally cases and diseases that prove difficult or even impossible to accurately diagnose on the basis of imaging alone. Hepatic masses and lesions have an extensive range of potential etiologies and are considered commonplace in the world of diagnostic imaging, specifically ultrasonography. Occasionally, however, these lesions and their concurrent pathology elude definitive radiological diagnosis, especially if they are relatively rare, such as cholangiocarcinoma and primary hepatic lymphoma. This report presents a case that was thought to be cholangiocarcinoma on the basis of diagnostic imaging but was proven (through tissue sampling) to be a case of diffuse large B-cell lymphoma (DLBCL) of the liver with no concurrent lymphadenopathy. Although primary hepatic lymphoma (PHL) is rare, this case fits the criteria for it. A similar case of PHL emphasizes the need to consider differential diagnoses for anomalous liver masses seen by ultrasonography: a patient with PHL was deemed to have an inflammatory pseudotumour that subsequently went untreated until the entire right lobe of the liver had been invaded. This misdiagnosis resulted in delayed treatment and
a significantly decreased prognosis for the patient. The significance of considering a differential diagnosis and the role of ultrasonography in the incidental discovery of these lesions are emphasized here as ultrasound examination is a commonly used test for patients with right upper quadrant pain.

Case
A 49-year-old woman presented to our emergency department with an abrupt onset of severe right upper quadrant pain. She stated that it had started while she was eating some fried chicken. No symptoms of jaundice were present, and she was treated with some analgesics. Laboratory blood work results for complete blood count, chemistry, and liver enzymes were all within normal limits, including total bilirubin of 10 µmol/L. The patient was then scheduled for an ultrasound examination to rule out any biliary cause of her pain. At the abdominal ultrasound examination (4 days following the onset of the initial symptoms), she stated that her pain was gone and that the area was only mildly tender. Sonography was performed with a General Electric LOGIQ E9 imaging system with a 2- to 5-MHz transducer. A sonographic Murphy sign was not present. Several heterogeneous hypoechoic ill-defined lesions were seen within the liver; all were near or directly adjacent to the portal and/or hepatic veins (Figure 1). Because the borders were ill-defined, it was difficult to delineate any separation between the lesions.
Colour Doppler interrogation did not indicate blood flow within the lesions. Additionally, the gallbladder showed diffuse wall thickening (up to 14 mm), intraluminal debris, and traces of pericholecystic fluid surrounding it (Figure 2). The cystic duct was hypoechoic with internal echoes that extended into the dilated common bile duct (CBD), which was 13 mm at maximal diameter but tapered smoothly into a normal pancreatic head (Figure 3).

In an attempt to characterize the liver lesions, a computed tomography (CT) scan with non-contrast, arterial, and venous phases was performed. Similar to the ultrasound examination results, an ill-defined hypodense area with tubular extensions into the liver parenchyma was seen (Figure 4). There was no distal biliary dilatation, but the hepatic duct confluence was hypodense. Notably, no periaortic lymphadenopathy or other abnormalities were seen in the abdomen or pelvis.

A magnetic resonance imaging (MRI) scan with dedicated magnetic resonance cholangiopancreatography (MRCP) sequences was performed to further characterize the biliary findings. MRCP provides a detailed but non-invasive assessment of the biliary tree. Again, an infiltrating tumour was seen along the portal triads and was inseparable from the hepatic vasculature. Normal flow in these vessels suggested that there was no vascular tumour invasion. The lesion was hypointense on T1 and slightly hyperintense on T2, with early irregular enhancement. MRCP images confirmed a dilated CBD with a normal distal duct and minimal intrahepatic biliary dilatation. Up to this point, all of the imaging studies seemed to suggest a diagnosis of cholangiocarcinoma and a differential diagnosis of atypical hepatocellular carcinoma or metastases from an undiagnosed primary lesion.

An ultrasound-guided biopsy was performed to characterize the exact histopathology because the imaging diagnosis was inconclusive. Surprisingly, the pathology examination revealed that the liver lesion was “intermediate-grade B-cell lymphoma, suspicious for diffuse large B-cell lymphoma.” Because ultrasonography, CT, and MRI did not reveal any lymphadenopathy, chest radiography was performed; the result was normal. The results of bone marrow aspiration and further blood testing were also normal and “negative for lymphoma involvement.”

A staging CT scan performed 7 weeks after the initial CT scan showed stable liver and biliary findings and no lymphadenopathy in the chest, abdomen, or pelvis.

### Management and Outcome

At the time of writing, the patient had undergone her full chemotherapy treatments which had much reduced the size of the liver lesions. Typical treatment for most types of non-Hodgkin lymphoma, including DLBCL, involves the chemotherapy regimen known as “R-CHOP”: six to eight cycles of rituximab with cyclophosphamide, doxorubicin, vincristine, and prednisolone. The exact response to these
drugs varies, but the cure rate is typically 60–80%, especially for intermediate-to-aggressive lymphoma subtypes. New treatments that use targeted chemotherapy based on the tumour’s biomarkers are being tested and show promise for improved patient outcomes.

Discussion
Based on multimodality imaging findings, the patient’s condition was thought to be a type of cholangiocarcinoma (CCA). Differential diagnoses included atypical hepatocellular carcinoma, gallbladder neoplasm with liver metastases, and metastases from an undiagnosed primary tumour. Ultrasonography was essential for diagnosis because it (1) was able to rule out cholecystitis or cholelithiasis as a cause of the patient’s symptoms, (2) demonstrated that the liver lesion was tracking along the portal veins but was not causing any significant intrahepatic biliary dilation, and (3) showed non-obstructing debris within the inflamed gallbladder and dilated CBD. These findings, although essentially not diagnostic, triggered further testing that otherwise might not have been done. On the basis of imaging findings, intrahepatic CCA (malignancy of the biliary ducts) was suspected because the lesions appeared to be spreading along the portal triads with dilation of the CBD. This type of cancer is rare (only 1–2 cases per 100,000 in North America) and is difficult to diagnose, as is PHL. The major difference is that CCA is considered to be fatal, can be treated (although not cured) only with aggressive hepatectomy, and has a 5-year survival rate of only 5–10%. In contrast, DLBCL (both nodal and extranodal) is a “potentially fatal but also a potentially curable illness” with

Figure 5. Variable appearances of B-cell lymphoma in the liver: multiple hypoechoic liver lesions in four different cases. Source: Reprinted with permission from Ultrasoundcases.info.
a chemotherapeutic cure rate of more than 50% and an overall 5-year survival rate of 60%.\(^3\)\(^,\)\(^7\) This is a dramatic difference in both prognosis and treatment for the patient; a diagnosis of DLBCL provides a reasonable possibility of a cure and a much more favourable prognosis than the initial suspected diagnosis of CCA.

In general, ultrasound imaging is frequently the test of choice for investigating abdominal pain, jaundice, or suspected hepatic or biliary pathology, all of which may typically be associated with CCA and hepatic DLBCL. One of the difficulties is a lack of standardization for the assessment of malignant features of CCA even after the diagnosis has been made.\(^8\) Ultimately, a tissue sample must be obtained when CCA is suspected, because diagnostic imaging is not able to provide a definitive diagnosis.\(^1\) Similarly, a diagnosis of lymphoma can be confirmed only through immunohistochemistry analysis.\(^3\)\(^,\)\(^7\)

In this case, the pathologist who examined the specimen explained that the lymphoma was growing in the connective tissue of the portal tracts surrounding the branches of the biliary tree. The proliferating cells may have infiltrated the common hepatic duct and bile duct, migrated retrograde through the cystic duct, and thus caused an inflammatory reaction from the gallbladder. These findings explain why the condition was deemed suspicious for CCA on ultrasound examination and how the gallbladder was involved. However, this particular case was atypical for DLBCL because it appeared to have originated in the liver and because no primary lymphadenopathy was found.

DLBCL cases represent roughly one third of all cases of non-Hodgkin lymphoma, which is a relatively common malignancy in the Western population.\(^3\)\(^,\)\(^7\)\(^,\)\(^9\)\(^,\)\(^10\) Approximately 30–40% of DLBCLs have an “extranodal origin,” which means that they originate in an organ outside of the lymphatic system, most commonly in the gastrointestinal tract.\(^5\) Secondary liver involvement is quite common in advanced disease, but it is extremely rare for the liver to be a primary extranodal site.\(^3\)\(^,\)\(^9\)\(^,\)\(^10\)

PHL makes up less than 1% of all extranodal lymphomas and only 0.016% of all NHLs.\(^9\)\(^,\)\(^11\) In this case, lymphadenopathy was not found anywhere else in the abdomen, pelvis, or chest; the lymphoma appeared to be confined to the liver. For this to be classified as PHL, lymphoma anywhere else – bone marrow, lymph nodes, spleen, etc. – must be excluded, as was done with this case. PHL is so uncommon that it is “low on the differential even when compared with the rare diagnosis of CCA,”\(^12\) but even DLBCL is often forgotten as a possible diagnosis for pathology outside the lymphatic and gastrointestinal systems.\(^11\)

The ultrasonographic findings for lymphoma in the liver tend to be nonspecific, but ultrasonography is important for ruling out other diagnoses (such as cholecystitis or cholelithiasis in this case). Ultrasonographic diagnosis of lymphoma in the liver is problematic because the liver lesions vary in appearance. They may be single (42%) or multiple to diffuse (50%) and are usually hypoechoic with some mass effect (Figure 5).\(^3\)\(^,\)\(^8\)\(^,\)\(^9\)\(^,\)\(^10\)\(^,\)\(^11\)\(^,\)\(^13\) Hepatomegaly may be noted if the lesions are large or diffuse.\(^3\)\(^,\)\(^9\)\(^,\)\(^11\) Lymphadenopathy, splenomegaly, or both may be found if the lymphoma has a nodal origin, but these findings will not be seen in cases of PHL.\(^9\) Because PHL is rare and ultrasonographic findings are nonspecific, these lesions are often misdiagnosed as hepatitis, hepatocellular carcinoma, or metastatic spread from the colon.\(^10\)

Ultrasonography is certainly useful for discovering liver lesions and other co-existing pathology, but it is limited (as it is for detecting CCA) by the variable appearance and presentation of lymphoma in the liver; lymphoma should be considered as a differential diagnosis for hypoechoic atypical liver lesions.

This again highlights the importance of considering other diagnoses, even rare ones such as CCA and extranodal lymphoma, during the assessment and diagnosis of unusual liver masses. Diagnostic imaging and pathological analysis are both essential in the diagnosis pathway. Ultrasonography is often used as an early test to assess these masses although it is limited by a lack of standard imaging features for lymphoma of the liver.

**Acknowledgements**

I would like to thank the radiologists at Chilliwack General Hospital (CGH) who took the time to discuss this case and its diagnosis with me, the CGH sonography team that assisted and encouraged me with this project, and the team of instructors of diagnostic medical sonography at the British Columbia Institute of Technology who guided me class along the path to success.

**References**

characterization and outcome of primary nodal and extranodal diffuse large B-cell lymphoma in the rituximab era. Leuk Lymphoma 2010;51(7):1225–32.


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REGISTRATION

<table>
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<tr>
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Full Registration Includes:
- Admission to all educational program lectures and exhibit area
- Breakfast, Lunches* & Refreshment Breaks daily
- Welcome Reception, Wednesday May 7th
- Awards Luncheon, Thursday May 8th
- Exhibitor’s Reception, Thursday May 8th
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*NEW for 2014: Lunch is provided for both Thursday and Friday, Brunch will be provided on Saturday

Please select the area you intend to attend

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FRIDAY LUNCH & LEARN SESSIONS

- Cardiac
- CJMS
- Exam
- Live Demo
- Article Writing
- Item Writing

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Use of Sonography in the Diagnosis of Developmental Dysplasia of the Fetal Hip

Rua El-kasheef

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Abstract
Historically, plain radiographic film examinations were the norm for diagnosing developmental dysplasia of the hip (DDH); but today, sonography has also proven to be a safe and effective alternative (before the bones have ossified) to using plain film. This article outlines important features of DDH, such as risk factors and clinical signs, along with a look at the Ortolani and Barlow stress manoeuvres done by physicians for DDH screening. The unique ability of sonography to mimic these manoeuvres during examinations is outlined, along with the steps to completing an ultrasound examination for DDH. The differences between the European and Canadian protocols are also noted. Furthermore, the important anatomy of the fetal hip is explained, along with its normal and abnormal appearances. During diagnosis, the severity of the condition is now determined using the Graf classification system, which is outlined. Because sonography has become the primary diagnostic tool for DDH, it is important to be familiar with the proper methods needed for screening. Due to the vast abundance of research done on DDH, this article focuses on key information most relevant to sonographers.

Developmental Dysplasia of the Hip
With such a wide array of processes and sequences of events required to result in a healthy, fully developed human being, it is a wonder that these processes often happen so flawlessly. The human body is truly an amazing machine, though mistakes can sometimes occur. From the moment of conception to delivery, to all the events leading up to death, any combination of errors can happen. A condition called developmental dysplasia of the hip (DDH) is one of these instances where things have gone wrong. It is also known as developmental dislocation because it is an ongoing developmental process, and is more formally called congenital dislocation of the hip. This condition is clinically described as an instability of the hip, and it occurs when the hips have not developed correctly.

In a study conducted by the National Health Service Litigation Authority over a 10-year period, DDH was found to be the third most common cause of pediatric orthopedic referrals. DDH encompasses a wide variety of pathologies affecting the hip including frank or partial dislocation and subluxation of the hip, joint laxity, and/or dysplastic hips. It also includes instable or malformed/misaligned hip joints. DDH can result in premature degenerative joint disease, impaired walking (or waddling), and chronic pain.

Early diagnosis of this condition is the key to good achievable outcomes. If not caught early, the condition may not be recognized until the child begins to walk; in such cases, muscles often tighten and limit the child’s movement. However, dysplasia is a dynamic process and cells can return back to their normal function. Thus, many cases of DDH...
resolve spontaneously without treatment.\(^2\)

Screening for DDH has become routine along with clinical evaluations of infants at birth and occurs in 1.5–20 per 1,000 live births.\(^1\) Factors affecting DDH are multifactorial and include genetic and racial factors, age, gender and physical factors.\(^3\) Females tend to be six times more likely to develop DDH than males, and this is believed to be due to estrogen and hormonal influences.\(^2\) Also, DDH tends to be three times more likely to occur in the left leg.\(^2\) Risk factors include family history, breech intrauterine positioning, and in utero postural deformities. Additionally, maternal primiparity, high birth weight, oligohydramnios, and congenital anomalies also play a role.\(^1,5\)

**Testing for DDH**

Part of the initial testing for DDH screening includes assessing for asymmetry of the hip and gluteal folds, shortening of the hips, and the infant’s ability for abduction (Figure 1).\(^2\) Other signs of DDH may include flattening of the buttoc; in children who are standing or walking, external rotation of the affected leg may be noted.\(^6\) Bilateral DDH is the hardest to assess with only visual examination of the child because neither of the legs can be used as a reference of normal.\(^6\) Examination also includes performing the Barlow manoeuvre, typically only done by the physician.\(^4\) This manoeuvre involves simultaneous flexion and adduction of the hips while applying anterior force (Figure 2).\(^1\)

The Barlow manoeuvre, also known as a push manoeuvre, is a stress test to identify a dislocation through the presence of instability.\(^4,7\) Another important manoeuvre done by the physician is an Ortolani manoeuvre.\(^4\) This manoeuvre helps with reduction of the dislocation if possible.\(^4\) This involves holding the infant’s thigh firmly on either side, while flexing and abducting the hips.\(^4\) The examiner then applies a posterior force in an attempt to relocate the hip, as seen in Figure 2.\(^4\) If the manoeuvre is done correctly, a “clunk” is heard as the femur is pushed back into the acetabulum.\(^4\) These types of examinations are subjective and dependent on experience level of the examiner.\(^1\) Both the Barlow and Ortolani manoeuvres become less sensitive as a child gets older and develops thigh muscle strength.\(^1\)

**Sonography**

Sonography is an excellent complement to the Barlow and Ortolani manoeuvres because it allows for similar movements to be done during a dynamic assessment that helps verify the examiner’s findings.\(^4\) The combination of the two makes for a more sensitive and specific test than clinical examination alone,\(^1\) thereby helping to minimize unnecessary treatment.\(^1\) Traditionally, plain radiographic film examinations were the first choice for imaging the fetal hip, though common practice has now shifted toward sonography in an attempt to minimize unnecessary radiation exposure.\(^4\) Radiography, however, is preferred when the child is somewhere between 6 months and 1 year due to the greater amount of ossifying bones;\(^5\) sonography is not very useful when assessing ossified bone.\(^5\) In the first 6 months, ultrasound is better suited in the evaluation of immature/non-ossified skeletal bones and the soft tissues associated with it.\(^4\) Sonography has also shown not to cause any increased laxity of the hip joint during assessment.\(^1\) As always, the ability to perform real-time dynamic assessments is an upside.\(^4\) Ultrasound is reliable, is non-invasive,\(^3\) can be

---

**Figure 1.** Left hip dysplasia. A shortened femur, an inability of full abduction, and symmetrical gluteal and thigh folds are noted. Source: Reproduced with permission from Porth CM, ed. Essentials of Pathophysiology – Concepts of Altered Health States, 2nd edition. Philadelphia (PA): Lippincott Williams & Wilkins; 2007.\(^2\)

**Figure 2.** Barlow (top) and Ortolani (right) stress manoeuvres.
done without sedation, and allows for assessment in multiple planes. However, because sonography is operator dependent, the possibility of identifying nonexistent pathology is always present.

**Parts of an Ultrasound Scan**

Sonography is used in two ways to assess the hip. First, a static assessment is done to identify anatomical abnormalities. Second, a dynamic assessment is performed to check for stability of the hip. The technique recommended by the American College of Radiology (ACR) and the American Institute of Ultrasound in Medicine (AIUM) is a mixture of morphological and dynamic assessments that are centred on the landmarks of the femur and the acetabulum. The ACR requires that the hip be imaged in two planes: coronal views at rest, and transverse views of a flexed hip with and without stress manoeuvres. These stress manoeuvres complement the Barlow and Ortolani manoeuvres; it is important infants stay relaxed to ensure that their movement does not stimulate muscle contractions that can affect the outcome of the test. Sonographers may allow infants to be fed or entertained with toys to keep calm. Infants may be laid on their side, though it is recommended that the examination be performed with infants supine with their feet facing the sonographer. The upper extremities should be clothed and the infants diapered, with the tabs only removed to expose the hip and thigh. It is recommended that when scanning the right leg, the sonographer should hold the leg with the right hand and scan with the left hand, and vice versa for the left leg. Scanning this way is necessary as stress manoeuvres can better be performed and a better plane of imaging can be maintained. Though scanning with the left hand may be challenging at first, especially for right-handed individuals, practice makes this process easier.

The examination should be performed using a linear array transducer to keep the study consistent with measurements in the Graf classification and other literature. Using a higher-frequency transducer (15–8 MHz) is ideal for infants less than 6 months old as it provides the best resolution with sufficient penetration. A lower-frequency transducer may be needed for infants after 6 months of age, when greater muscle development has taken place and increased penetration is needed.

**Anatomy**

Within a normal hip, the femoral head is positioned neatly within the acetabulum regardless of motion or stress. In lax hips, the head is normally positioned within the acetabulum at rest, but demonstrates mild subluxation with stress. With subluxated hips, there is displacement without dislocation; the femoral head remains partially covered by the acetabulum. With dislocation, the femoral head has no contact or coverage by the acetabulum. In subluxated hips, flexion and abduction do not improve the relationship of the femur and the acetabulum. In a dislocated hip, flexion and extension can decrease the amount of dislocation and make the hip appear subluxated. Complete dislocation is defined by the total inability of the femoral head to return back into the acetabulum. The acetabulum has become greatly dysplastic, ligaments have been stretched, and fibro-fatty tissue is now present in the acetabulum where the femoral head should be, leaving no room for relocation of the head back into the joint.

**Appearance of Anatomy on Sonograms**

As previously mentioned, the reason that sonography is so effective in examining this condition is because the bones of an infant have not ossified and are mostly cartilaginous. Cartilage appears hypoechoic compared with soft tissue. The acetabulum is composed of the ilium, ischium, and pubis bones, which all appear echogenic compared to the Y shape, hypoechoic triradiate cartilage holding the three bones together. The labrum forms the cartilaginous acetabular rim around the normal femoral head. Its lateral margins gradually become more fibro-cartilaginous, making it appear echogenic.

**Views Required for an Ultrasound Examination: European Protocol**

The coronal/neutral view is the basis for morphological assessment. The image is taken from the lateral aspect of the patient, with the femur in neutral position (Figure 3). Note that the sonographer may need to manually position the child’s legs in the desired position and hold them there for the duration of each individual assessment. The main landmark for this view is a straight horizontal iliac line projecting medially within the acetabulum, and the visualization of an echogenic labrum (Figure 4). The location of alpha and beta angles that should be taken in this plane can be seen in Figure 4. Most ultrasound machines have the ability to calculate these angles. The normal appearance of the fetal hip should reveal the femoral head resting in the acetabulum. When the hip is subluxed, the femoral head migrates laterally and superiorly. A partially dislocated femur appears to migrate away from the acetabulum, whereas with frank dislocation the femur is completely out of the acetabular socket. Images of all four positions of the femoral head in the coronal/neutral view can be found in sections 1a–1d of the appendix (posted online at sonographycanada.ca).
Coronal/flexion views are taken with the knee flexed while the transducer is moved antero-posteriorly to assess the entire hip (Figure 5). The key to this image is to get a straight horizontal iliac line. The normal appearance for imaging the mid-acetabulum (section 2a of the appendix) is said to appear as a ball on a spoon; the femoral head represents the ball, and the iliac line represents that handle.

If there is subluxation, the femoral head is displaced posteriorly and/or laterally (sections 2b and 2c of the appendix). Echoes may be observed between the femoral head and the acetabulum. A dynamic assessment called the push-and-pull manoeuvre can be used to assess for instability by angling and imaging more toward the posterior acetabulum (sections 3a and 3b of the appendix).
With instability, when the sonographer pulls the leg, the femur disappears from the plane of imaging (section 3a of the appendix). With dislocation, it may or may not move out of the plane. With instability, as the sonographer pushes the leg toward the patient, the femur remains in the plane over the triradiate cartilage (section 3b of the appendix). With dislocation, the head may be located over the triradiate cartilage lip as the leg is pushed. This gentle pushing motion resembles the Barlow manoeuvre done by the physician.

Transverse/flexion views are performed with the knee flexed and the transducer placed posteriorly and laterally to visualize the medial acetabulum (Figure 6). Positioning of the transducer is important because improper positioning can cause an obstructed view of the femoral head by the metaphysis. In this view, the femoral head sits between the echogenic metaphysis (anterior) and the ischium of the bony acetabulum (posterior; see section 4a of the appendix). These two echogenic structures form a U shape around the femoral head during maximum abduction, and a V shape during maximum adduction (Barlow manoeuvre). In the normal hip, the femoral head is always in contact with the acetabulum, even with stress manoeuvres. A subluxated hip may show a slight malposition within the U shape during rest, and with stress will be displaced laterally while partially contacting the acetabulum. (The normal and subluxed appearance in this view can be found in sections 4a–4c of the appendix.) With dislocation, the head displaces laterally and posteriorly with no further contact with the acetabulum. Abduction (Ortolani manoeuvre) may reduce the degree of dislocation. This disrupts the normally seen U shape.

Transverse/neutral views require that the legs be brought down to a neutral position and imaging be taken from the lateral aspect of the thigh (Figure 7). If the hip is normal, the head appears directly over triradiate cartilage and resembles a flower (section 5a of the appendix). The head of the femur represents the bloom, the ischium (posteriorly) and the pubis (anteriorly) represent the leaves, and the echoes created by the triradiate cartilage represent the stem. The cartilage covering the pubis bone appears thicker than over the ischium. When the hips are malpositioned, tissue echoes may be noted between the femoral head and the acetabulum. Subluxation shows a shift in the head posteriorly, with partial contact with the acetabulum. In some cases of lateral dislocation, the femoral head does not come in contact with any of the bones. (Images of these views are found in sections 5a–5d of the appendix.)

Alternative views include anterior views performed with the hip flexed and abducted while the patient is supine. Images are taken from an anterior scanning plane, ensuring that the ultrasound beam is parallel to the femoral neck. A Barlow manoeuvre may be done during this scan to detect instability. With dislocation, the femoral head is displaced posteriorly.

Views Required for an Ultrasound Examination: Canadian Protocol

Much of the research on ultrasound examination of DDH has been done in Europe, where the Graf method has been greatly popularized. The Canadian protocol parallels the European protocol in that it also uses angle measurements and the Graf method. One of the greatest differences occurs when one compares the use of a dynamic assessment. Technologists in Canada typically do not use techniques such as push-and-pull manoeuvres. Every department and or radiologist may have a slightly different way of doing things; depending on the physician, manipulations may or may not be done by the doctor during scanning. A radiologist may choose to perform manipulations after the sonographer has taken the angle measurements, or an orthopedic surgeon may perform such manoeuvres afterward. As a result, the protocol for examination of DDH in Canada can vary from one facility to another.

Classification

DDH can be categorized using the Graf classification, which attempts to distinguish between normal, subluxable, and dislocatable/dislocated hips. Graf, the orthopedic surgeon who developed this evaluation technique, based it on...
coronal imaging of the hip using an articulated arm B-scan unit. This classification is broken down into four types and their subtypes. Alpha angles determine the type, and beta angles determine the subtype. Type 1 generally indicates that the hips are maturing normally, type 2 indicates an immaturity, type 3 suggests that the hips are subluxated, and type 4 indicates a dislocation. Figure 8 shows the important landmarks that need to be imaged in order to make accurate measurements. Specific alpha and beta angles and classifications can be found in Table 1. Sonography is quite useful in that it allows for easy follow-up using these classifications during the course of treatment.

Treatment
Treatment is always more effective when a condition is caught early; DDH is no exception. Treatment for DDH falls into two categories: non-surgical and surgical. Non-surgical treatments include abduction devices that promote the alignment and stability of the hip joint. One of the most common devices is a Pavlik harness. The length of the treatment depends on the severity of the condition, and sonography is used to monitor the patient throughout. Sonography is ideal because the transducer can be manipulated around the harness or cast as the anterior aspect of many abduction devices are open and allow access. Due to the fact the abduction devices are constantly worn during treatment, complications that can arise include avascular necrosis (AVN), pressure sores, and femoral nerve palsy (the leg “falls asleep”). Surgical intervention becomes necessary when non-surgical methods have been unsuccessful, the condition has been diagnosed late (defined as after 12 weeks), or the level of DDH is quite severe. AVN can also occur with surgery and can lead to the destruction of the hip due to growth arrest. Treatment options are summarized in Table 2 according to age group.

Conclusion
DDH is a dynamic process of the hip, and its treatment appears to show great rates of success. Though radiography was traditionally used in its assessment, sonography has proven useful in the assessment, diagnosis, and treatment of DDH. It allows for the categorization of varying degrees of stability of the hip using the Graf classifications. Though sonography is highly operator dependent, protocols created by the ACR and AIUM are thorough in the interrogation of

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**Table 1. Graf Classification**

<table>
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<th>Type</th>
<th>Indications</th>
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<th>Beta Angle (Cartilaginous Roof)</th>
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<td>Any</td>
<td>$\alpha \geq 60^\circ$</td>
<td>$\beta \leq 55^\circ$</td>
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<td>2</td>
<td>Suggests the hip is dysplastic or unstable</td>
<td>&lt;12 weeks</td>
<td>Adequate: $\alpha$ between 50 and 59° (dysplastic)</td>
<td>Covers the femoral head: $\beta \leq 77^\circ$</td>
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<td>3</td>
<td>Suggests the hip is subluxated</td>
<td>Any</td>
<td>Poor: $\alpha &lt; 43^\circ$</td>
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<td>4</td>
<td>Suggests the hip is dislocated</td>
<td>Any</td>
<td>Poor: $\alpha &lt; 43^\circ$</td>
<td>Shifted inferiorly</td>
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Source: Data from Kosar et al. and Paixao Jacobino et al.

**Table 2. Treatment for Developmental Dysplasia of the Hip**

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<td>Closed reduction and spica casting</td>
</tr>
<tr>
<td>&gt;18 months</td>
<td>Open reduction and spica casting</td>
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Source: Data from Paixao Jacobino et al.
the hip. Thus, physicians are better able to get a first-hand look at the fetal hip, allowing for a more accurate diagnosis and, thereby, better outcomes for the patient.

References


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