Volume 11, Issue 3 ▪ 2020

CJMS

Canadian Journal of Medical Sonography

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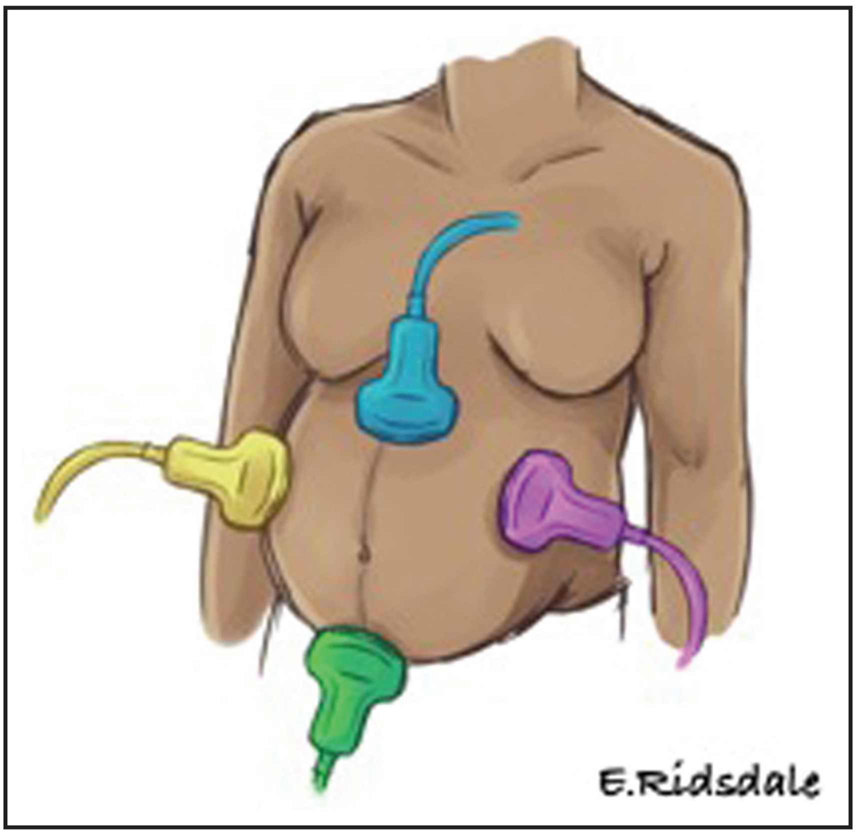

Case Study of a Pancreatic Head Lesion in an Adolescent Female following Abdominal Trauma | *Sandra Taves, BSc, CRGS, RDMS*

Optimizing Imaging Techniques for the Fetal Heart: A Pictorial Essay | *Cathy Ridsdale, BSc, CRGS, CRVS, RDMS, RVT*

Strain Imaging in Echocardiography Part 3 of 3: Cardiac Pathology and Patterns of Strain | *Babitha Thampinathan, HBSc, RDCS, CRCS (AE), Marcello Seung Ju Na, H.BSc, RDCS (AE), MHI (Candidate) Jennifer Lam, BSc, RDCS, CRCS (AE)*

Publications Agreement Number 40025049
ISSN: 1923-0931

Sonography Canada Échographie® Canada

Volume 11, Issue 3 • 2020

Publications Agreement Number 40025049

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About the Cover

This image is Figure 9 from Optimizing Imaging Techniques for the Fetal Heart: A Pictorial Essay by Cathy Ridsdale. The diagram demonstrates the many different locations the transducer can be placed on the maternal abdomen. Image created by Em Ridsdale and used with permission.

Message from the Editor-in-Chief

In March, Canada began to shut down as numbers of COVID-19 cases and deaths increased rapidly. As I write this editorial, many provinces in Canada are reopening businesses to varying degrees, as reported cases and deaths from COVID-19 are decreasing. Physical distancing and mask-wearing are standard protocols in most provinces.

Ultrasound departments at hospitals and clinics are gradually resuming normal services. Departments are reorganising their environmental designs per COVID-19 recommendations with changes in physical areas as well as bookings. Educational institutions are conducting sonography programs online utilizing simulation software; some are conducting live intensive simulated scanning so that the students can start their clinical practicums. All of Canada is creating a safe and hopefully sustainable environment while awaiting news on a vaccination for COVID-19.

This issue of CJMS includes a case report by Sandra Taves on a 12-year-old with a pancreatic head mass that was followed for about two years using ultrasound as the main imaging modality. I would like to commend this author for following up with this case for an extended time so that the evidence could be shared with all sonographers.

Knowledge for the sonographer and optimization of the fetal cardiac sonographic protocol is presented by Cathy Ridsdale who has conducted webinars and presentations on this very valuable topic. This issue's cover image comes from Cathy's article and was created by Em Ridsdale.

Babitha Thampinathan, Marcello Seung Ju Na, and Jennifer Lam are presenting the final section (Part 3) on "Strain Imaging in Echocardiography," in this article they describe the cardiac pathology and patterns of strain imaging. I hope that you have enjoyed this three-part series and have been able to apply their information on strain imaging.

The *CJMS* encourages you, a member of Sonography Canada to share your evidence-based practice with your fellow Canadian sonographers. Your reports and the processes used in your daily professional practice can enhance someone else's knowledge and skills. We would love to hear how you have changed your processes due to COVID-19 or write about another topic that interests you such as ultrasound, education, simulation, health care, or mental health.

We are here to support you, the member of Sonography Canada.

Pushing the boundaries

Sheena Bhimji-Hewitt MAppSc, DMS, CRGS, CRVS, RDMS, RVT

Editor-in-Chief

*This opinion in this editorial is that of the Editor-in-Chief and not that of Sonography Canada or the Sonography Canada Board of Directors.

Message de la rédactrice en chef

En mars, le Canada a commencé à fermer ses portes alors que le nombre de cas et de décès liés à la COVID-19 augmentait rapidement. Au moment où j'écris cet éditorial, de nombreuses provinces du Canada ouvrent des entreprises à des degrés divers, car les cas et les décès signalés par COVID-19 sont en baisse. L'éloignement physique et le port du masque sont des protocoles standard dans la plupart des provinces.

Les services d'échographie des hôpitaux et des cliniques reprennent progressivement leurs activités normales. Les départements réorganisent leur conception de l'environnement selon les recommandations de COVID-19, avec des changements dans les zones physiques ainsi que dans les réservations. Les établissements d'enseignement mettent en place des programmes d'échographie en ligne à l'aide de logiciels de simulation ; certains procèdent à des simulations d'échographie intensive en direct afin que les étudiants puissent commencer leurs stages cliniques. Ainsi, tout le Canada crée un environnement sûr et, espérons-le, durable, en attendant des nouvelles sur la vaccination contre la COVID-19.

Ce numéro comprend un rapport de cas de Sandra Taves sur un enfant de 12 ans présentant une masse de tête pancréatique qui a été suivie pendant environ deux ans en utilisant les ultrasons comme principale modalité d'imagerie. Je félicite l'auteur d'avoir suivi ce cas pendant une longue période afin que les preuves puissent être partagées avec tous les échographistes.

Les connaissances pour l'échographiste et l'optimisation du protocole d'échographie cardiaque fœtale sont présentées par Cathy Ridsdale qui a organisé des webinaires et des présentations sur ce sujet très intéressant. L'image de couverture de ce numéro provient de l'article de Cathy et a été créée par Em Ridsdale.

Babitha Thampinathan, Marcello Seung Ju Na et Jennifer Lam présentent la dernière section (partie 3) sur "L'imagerie des contraintes en échocardiographie". Dans cet article, ils décrivent la pathologie cardiaque et les modèles d'imagerie des contraintes. J'espère que vous avez apprécié cette série en trois parties et que vous avez pu appliquer leurs informations à l'imagerie des contraintes.

La CJMS vous encourage, en tant que membre de Sonography Canada, à partager votre pratique fondée sur des données probantes avec vos collègues échographistes canadiens. Vos rapports et les processus utilisés dans votre pratique professionnelle quotidienne peuvent améliorer les connaissances et les compétences de quelqu'un d'autre. Nous aimerions savoir comment vous avez modifié vos processus en raison de COVID-19 ou écrire sur un autre sujet qui vous intéresse, comme l'échographie, l'éducation, la simulation, les soins de santé ou la santé mentale.

Nous sommes là pour vous soutenir, vous qui êtes membre de Sonography Canada.

Repousser les limites

Sheena Bhimji Hewitt

Rédactrice en chef

*Cette opinion dans cet éditorial est celle du rédacteur en chef et non celle de Sonography Canada ou du conseil d'administration de Sonography Canada.

Case Study

Sandra Taves, BSc, CRGS, RDMS

Case Study of a Pancreatic Head Lesion in an Adolescent Female following Abdominal Trauma

About the Author

Sandra Taves graduated from McMaster University/Mohawk College with a Bachelor of Medical Radiation Sciences in 2018. She is currently a Diagnostic Medical Sonographer at The Hospital for Sick Children and St Michael's Hospital in Toronto, Ontario. She is passionate about sonography, specifically continuing education and patient care. When not working in ultrasound, she can be found enjoying her other passions, film, and farming. Correspondence can be directed to taves.sandra@gmail.com

ABSTRACT

Pancreatic trauma is rare in adults but has an increased incidence in pediatric patients. A 12-year-old, Southeast Asian patient presented with abdominal trauma to her umbilical region. On sonographic examination, a complex pancreatic head lesion was identified; multiple differentials given were that of a hematoma, walled-off pancreatic necrosis (WOPN), or a solid pseudopapillary epithelial neoplasm. A magnetic resonance imaging, blood analysis, and biopsy of this lesion were non-conclusive. Serial ultrasounds over 94 weeks from date of injury showed a change in the pancreatic echogenicity and correlated with blood work to be pancreatitis; followed by the resolution of the pancreatic head lesion. The lesion was diagnosed as a complication of pancreatic trauma and called a WOPN.

Keywords: pancreas, pancreatitis, ultrasound, walled-off pancreatic necrosis, solid pseudopapillary epithelial neoplasm, acute necrotic collection

Introduction

Pediatric pancreatic trauma due to blunt abdominal trauma has an incidence of 2–5%, making it a relatively uncommon injury.[1] Common causes of pediatric pancreatic trauma are motor vehicle accidents, bicycle handlebar impact, and child abuse.[4] Pancreatic lesions identified following pancreatic trauma may be as sequela of the trauma such as hematomas, pseudocysts, or walled-off pancreatic necrosis (WOPN) or the lesion may be incidental of the trauma but may be a neoplasm.[2,4] The following case study describes the ultrasound imaging findings over 94 weeks for a 12-year-old female with a pancreatic head lesion following abdominal trauma from a soccer ball. On ultrasound examination, the pancreatic head lesion was identified as a heterogeneous mixed cystic/solid lesion with an echogenic capsule. At initial presentation, the patient was given the differential diagnosis of a hematoma, WOPN, or a solid pseudopapillary epithelial neoplasm (SPEN). Magnetic resonance imaging (MRI), blood analysis, and biopsy of this mass were inconclusive.

Case Description

A 12-year-old Southeast Asian female presented to the emergency department following abdominal trauma to the peri-umbilical region. The injury was caused by a soccer ball earlier that day. She presented with severe abdominal pain in the periumbilical region and vomiting. The patient was referred for an abdominal ultrasound. On ultrasound examination, a large, mixed (cystic/solid) lesion was identified within the pancreatic head. Based on the clinical presentation of abdominal trauma the primary diagnosis was that of a pancreatic hematoma, with a secondary differential of a neoplasm. The reporting radiologist referred the patient to a specialist pediatric hospital for further investigation.

Five weeks following the initial incident the patient was seen at a pediatric hospital and referred for MRI and ultrasound of the abdomen. Since the incident, the patient stated that they had no recurrence of pain or vomiting. The MRI identified a lesion in the pancreatic head measuring 4.3 × 4.6 × 5.3 cm. An abdominal ultrasound was performed following the MRI. A Phillips IU-22 machine was used with the C5-1 and Linear 17 – 5 MHz transducers. During the examination, a mass was palpable with transducer pressure in the umbilical region, superior, and to the right of the umbilicus. On ultrasound, a well-defined, avascular, 4.8 × 4.4 × 4.0 cm, mixed (cystic & solid), heterogeneous lesion with a well-defined echogenic capsule was identified in the pancreatic head, the rest of the pancreas was homogeneous. Multiple, solid, punctate, non-shadowing echogenic foci were seen within the lesion causing twinkling artifact on colour Doppler (Figure 1). The pancreatic duct and common bile duct were normal. There was no mass effect on the surrounding tissues or vessels.

Compared to the images at onset five weeks prior, the lesion was considered unchanged in size. The differential diagnoses of the lesion at this point were still WOPN or SPEN. The patient case was reviewed and her clinicians decided to monitor the patient with ultrasound while conducting further analysis through blood samples, MRI, and a biopsy to obtain a diagnosis. Blood samples were taken to monitor blood serum amylase and lipase levels (Table 1).

MRIs were conducted at four different times to provide further characterization of the lesion. Radiology reports stated that the signal characteristics and the contrast enhancement were suggestive of SPEN. At week 63, an endoscopic transduodenal ultrasound biopsy was performed to obtain a core biopsy for pathology. Lab results confirmed the sample contained necrotic tissue and degenerated blood. These results are indeterminate; the sample proved the presence of necrotic tissue, however, necrotic tissue may be found in either WOPN or SPEN, therefore the test was non-diagnostic for WOPN or SPEN.

Ultrasound monitoring showed progressive changes in the pancreas over weeks 64 to 68. Figure 2 shows images taken at week 64 with the Samsung RS85 machine, C7-1MHz transducer. On ultrasound, the lesion was stable but the pancreas showed an increase in echogenicity and heterogeneity.

At week 68, the pancreatic head lesion measured 7.4 × 3.9 × 5.9 cm, appearing more echogenic and ill-defined. Figure 3 A–C shows the ultrasound images taken at week 68 using the Philips IU22 machine with the C5-1MHz transducer. The pancreas appeared heterogeneous with a prominent pancreatic duct, when correlated with blood work this was diagnosed as acute pancreatitis. The pancreatic head lesion was more ill-defined with a central echogenic area.

At week 94, ultrasound was performed using the Samsung RS85 machine, C7-1MHz transducer. Figure 4 shows the pancreatic parenchyma and area of the previous pancreatic head lesion. The pancreas appears mildly echogenic, attributed to previous inflammatory

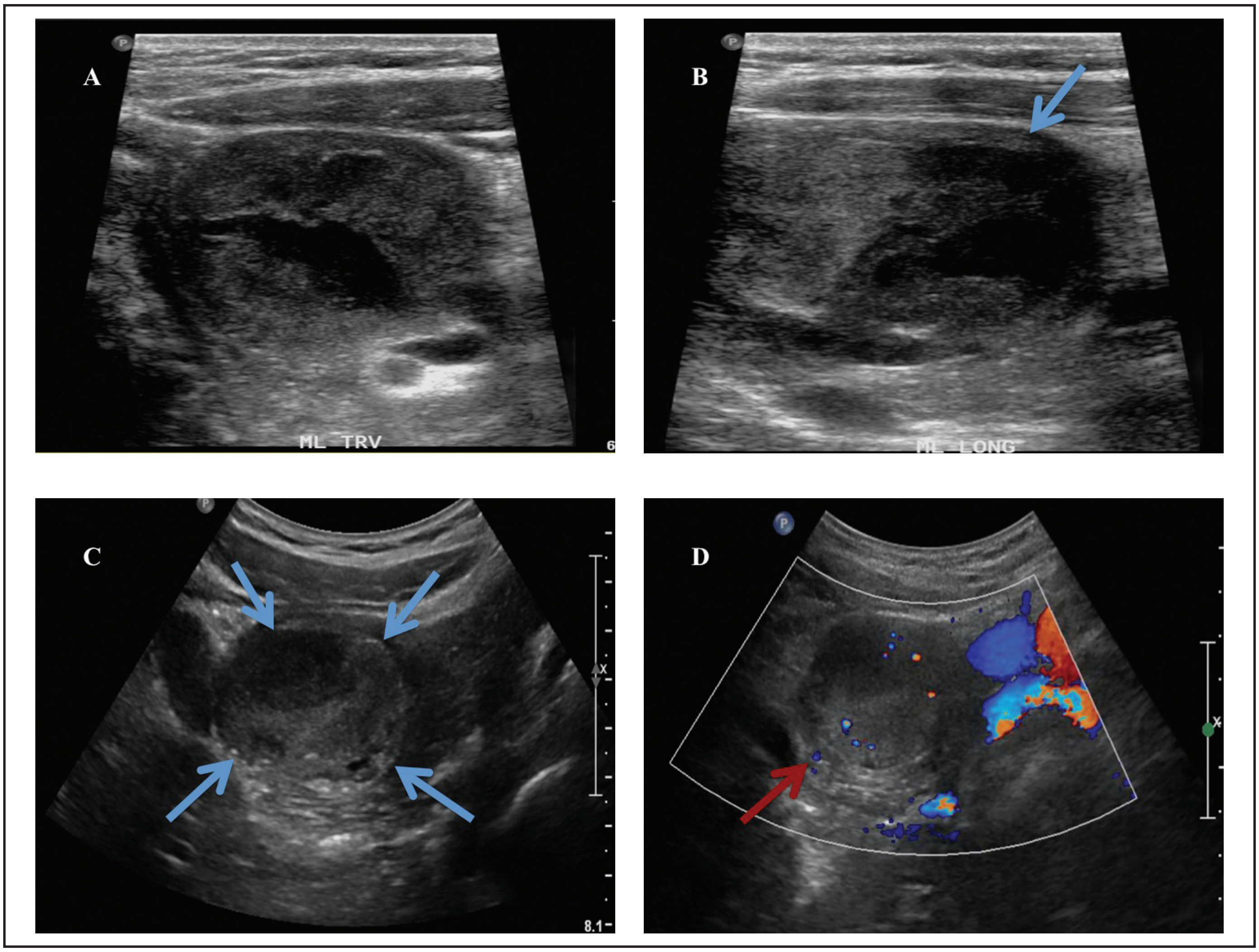

Figure 1. Week 5. (A) Transverse: Pancreatic head lesion. (B) Sagittal: Pancreatic head lesion with a homogeneous rim of pancreatic tissue (blue arrow). (C) Transverse: Pancreatic head lesion showing echogenic capsule (blue arrows) and hypoechoic rim of pancreatic tissue. (D) Colour Doppler: Pancreatic head lesion with twinkling artifact. Trace flow in the posterior lateral aspect of the lesion in the pancreatic tissue (red arrow).

Table 1. Weeks Since Abdominal Trauma versus. Blood Serum Amylase and Lipase

Weeks Since Abdominal Trauma	Amylase (Normal <102 u/L)	Lipase (Normal 4 – 39 u/L)
0	?	?
5	66	26
16	70	18
64	71	30
66	337	736
66	267	647
68	178	413

changes. The pancreatic head is heterogeneous with no evidence of a discrete pancreatic head lesion. The patient is scheduled for follow up in one year to ensure complete resolution of the lesion.

Discussion

This young female patient presented with a history of abdominal trauma, sonographically, the pancreatic head lesion was a large, heterogeneous, mixed (cystic-solid) lesion with an echogenic capsule.

Pathophysiology and Demographics

Abdominal Trauma and Pancreatitis

Pediatric patients are more susceptible to pancreatic trauma due to the lack of retroperitoneal fat.[4] Trauma to the pancreas occurs from an anteroposterior force – bike handlebars, motor vehicle accident, sports ball - which compresses the pancreas against the spine.[1] The resulting compression most commonly causes

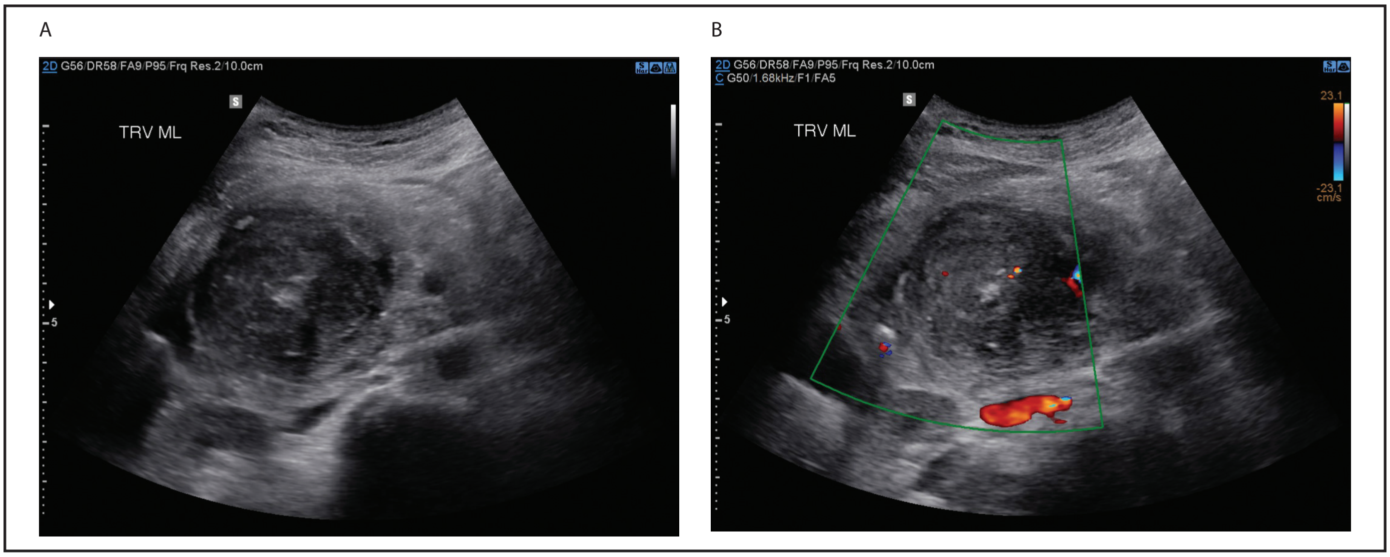

Figure 2. Week 64. (A) Transverse: Pancreatic head lesion- no change from previous. Pancreatic tissue is echogenic. (B) Transverse: Colour Doppler: Pancreatic head lesion with twinkling artifact with peripheral vascularity (same as previous).

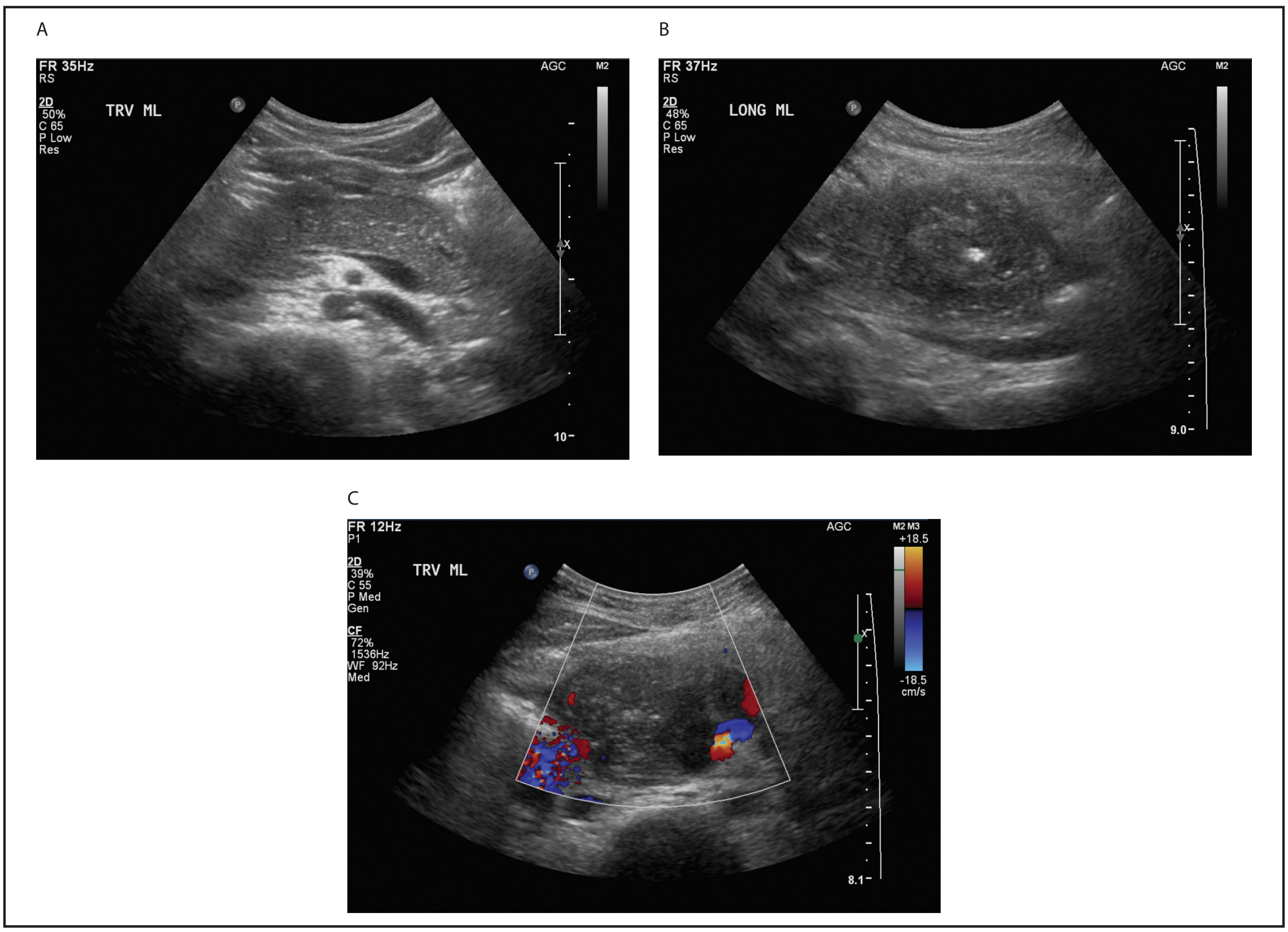

Figure 3. Week 68. (A) Transverse: Heterogeneous pancreatic parenchyma with the prominent pancreatic duct. (B) Sagittal: Pancreatic head lesion; ill-defined with a central echogenic area. (C) Sagittal: Colour Doppler shows peripheral vascularity with no echogenic foci seen within the lesion.

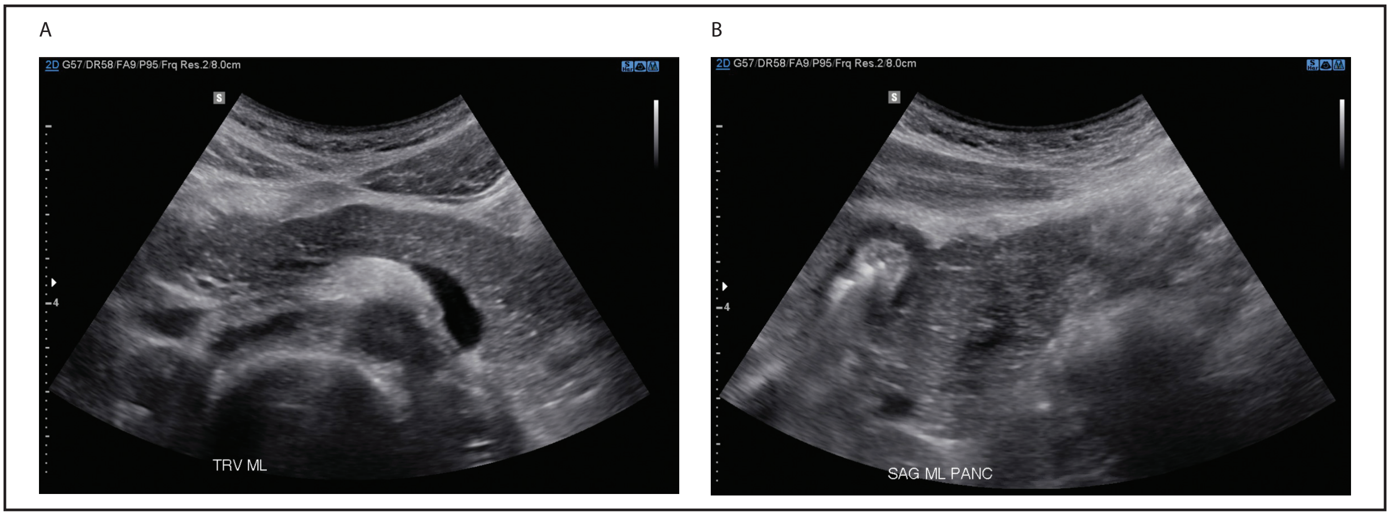

Figure 4. Week 94. (A) Transverse – Pancreatic parenchyma appears mildly echogenic, decreased echogenicity compared to the previous. The pancreatic duct is not seen. (B) Sagittal – The pancreatic head appears heterogeneous, with no pancreatic head lesion seen.

damage at the junction of the pancreatic head and body.[1] Presenting symptoms of pancreatic trauma may be nonspecific relating to diffuse abdominal pain, guarding, and tenderness.[1] Pediatric patients assessed following abdominal trauma may have acute pancreatitis induced from pancreatic trauma.[1] The Atlanta classification system defines acute pancreatitis as serum amylase or lipase levels three times higher than normal along with abdominal back pain.[4] If classification criteria are met, pancreatitis may be diagnosed without further imaging.[4] However, normal amylase and lipase levels are not diagnostic to rule out pancreatitis.[1] A retrospective study of 1821 pediatric trauma patients showed that 23% had elevated amylase and lipase, and less than 1% had a pancreatic injury.[1] As a result, serum amylase and lipase are unreliable markers for traumatic pancreatitis.[14,15] Pancreatitis has two morphologic forms, interstitial edematous or necrotizing.[4] Typical sonographic features of pancreatitis are focal or diffuse gland enlargement with an increase or decrease in echogenicity, little to no flow in the pancreatic parenchyma, and pancreatic duct dilation (>1.9 mm at 12 years old).[4] Necrotizing pancreatitis appears sonographically as poorly marginalized hypoechoic areas without vascularity.[4] Sonography is not the most sensitive imaging modality for detection of diffuse pancreatitis, however, it is reliable for follow up of pancreatitis related collections.[5]

Pancreatic Hematomas, Pseudocysts, WOPN, and SPEN

Bleeding from pancreatic trauma causes a hematoma that exhibits as an intra-parenchymal, ill-defined fluid collection on ultrasound.[4] Hematomas on ultrasound are initially anechoic from acute bleeding, becoming more hyperechoic and heterogeneous as the blood clots, and finally more hypoechoic/anechoic with resolution through liquification.[4] Additionally, hematomas may have septations, internal calcifications, and layering debris.[4,16] Diagnosis of a hematoma is made through the combination of patient clinical presentation and serial sonograms of the lesion; which shows a decrease in size and echogenicity over time until resolved.[4,16] Surgical management is rarely required for pancreatic hematomas; acute fluid collections will decrease in size and resolve spontaneously.[4,17] In this case study, the sonographic features of an echogenic capsule combined with the lack of change in echogenicity was counter to the typical sonographic appearance of a hematoma. Differentials to a hematoma are fluid collections related to pancreatitis, either pseudocysts or walled off necrosis.[1]

Pancreatitis related fluid collections are simple pseudocysts or WOPN.[4] Pseudocysts are simple fluid collections formed from leakage of pancreatic enzymes in interstitial pancreatitis.[1] Sonographically, pseudocysts appear as anechoic, homogeneous fluid

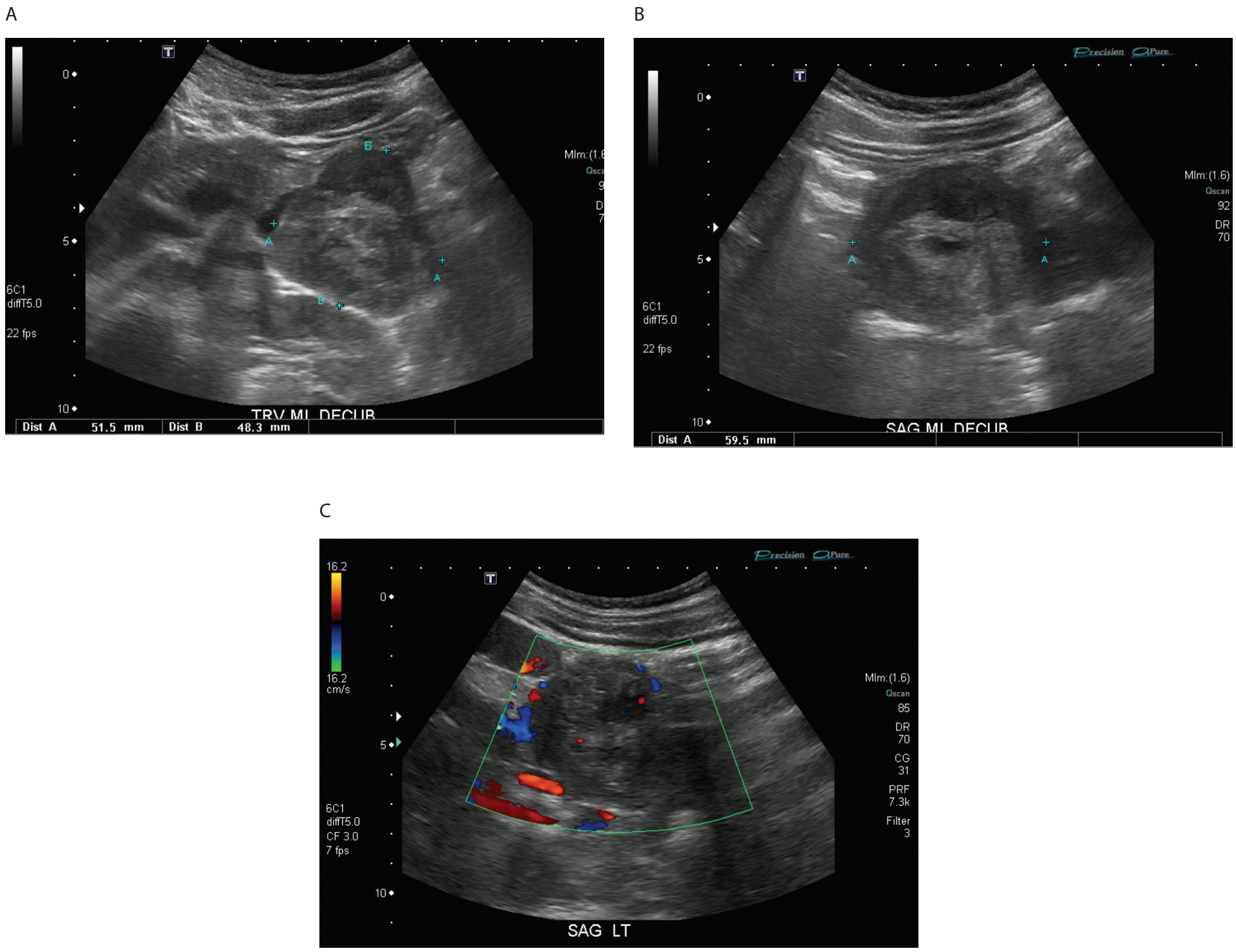

Figure 5. (A) Transverse: Pancreatic head/body are homogenous, pancreatic tail shows a complex lesion, suggested differential is SPEN. (B) Sagittal: Lesion in the pancreatic tail has areas of hyperechoic and hypoechoic tissue and central cystic space. (C) Sagittal: Colour Doppler shows vascularity within the solid components of the lesion.

collections with transmission and a thin echogenic wall.[1,17] The presence of a wall differentiates pseudocysts from other acute fluid collections.[1,17] Pseudocysts are more likely to occur with pancreatic lacerations and are less likely to resolve spontaneously,[4,5] Endoscopic retrograde cholangiopancreatography (ERCP) is an accurate method to investigate for pancreatic injury, and may be used to treat pseudocysts with drainage when necessary.[5] The pancreatic head lesion identified in this case was complex ruling out the possibility of pancreatic pseudocyst.

Acute necrotizing pancreatitis is a severe form of acute pancreatitis that involves necrosis of the pancreatic tissues, peripancreatic tissues, or both.[4,18] In the setting of necrotizing pancreatitis, cell death creates inflammation leading to devitalized tissue.[3] The resultant collection of fluid and necrotic tissue is called an acute necrotic collection (ANC).[18] An ANC that persists beyond 4 weeks and is encapsulated is called WOPN.[4,18] WOPN will occupy or replace the pancreatic parenchyma, appearing heterogeneous with a thick wall.[4] Additional sonographic features of WOPN are internal debris causing fluid-debris levels, septations or calcifications.[4] WOPN may be sterile or infected through bacterial contamination.[3,18] WOPN that becomes infected occurs in up to 70% of cases and has a mortality rate approaching 100% if surgical intervention and drainage is not performed.[3] WOPN presents as a collection following abdominal trauma that persists for more than four weeks and contains necrotic tissue and blood products from an episode of pancreatitis.[3]Management of WOPN is conservative based on clinical presentation, some WOPN resolve spontaneously while others require drainage or surgical intervention.[19] Sonography is a cost-effective and reliable modality to follow WOPN to ensure stability and resolution of the lesion.[1] The lesion identified in the pancreatic head in this case study matched the sonographic features of WOPN supported by biopsy results containing necrotic tissue.

SPEN or Frantz tumour, is a rare tumour of the pancreas comprising less than 3% of all pancreatic tumours.[7] SPEN is an exocrine tumour originating from the pancreas composed of solid, cystic and pseudopapillary components.[1] Epithelial cells are the solid component of the tumour forming pseudopapillary patterns around blood vessels.[2] SPEN has a numerous amount of small, delicate blood vessels that make the tumour prone to degeneration causing hemorrhage and necrosis forming the cystic components of the lesion.[2] SPEN has a clinical presentation of vague abdominal pain or discomfort, nausea, vomiting and very rarely jaundice.[6] In a systematic review of cases of SPEN by Law et al., 38.1% of patients were asymptomatic leading to an incidental diagnosis of the lesion through palpation on physical examination or identification by diagnostic imaging for other reasons such as abdominal trauma.[6] SPEN is primarily diagnosed in females accounting for 83% of reported cases; the mean age range at diagnosis is 21.97 years of age, with 22–52.6% of patients being pediatric.[6,7] Several studies have proposed a positive racial connection between SPEN and black and East Asian ethnicities.[2] SPEN is not known to have any genetic or hormonal relationship.[2] Histologically, SPEN is a slow-growing lesion; however, the tumour is characteristically large at diagnosis with a mean tumour size of 8.6 cm.[6,8] The relatively large mean size at diagnosis may be attributed to the lack of clinical symptoms that would traditionally initiate earlier investigations and diagnosis.[2] Blood work and laboratory tests for SPEN yield normal, or non-diagnostic results.[9] The most common location of SPEN is in the pancreatic tail, 35.9%, followed by the pancreatic head, 34%.[6] Sonographically, SPEN presents as a large, well-circumscribed mass with a fibrous capsule and variable internal echogenicity.[2] The fibrous capsule surrounding the tumour appears echogenic to the surrounding pancreatic tissue.[2,6] As the tumour grows it becomes heterogeneous, filled with cystic spaces because the delicate blood vessels within the tumour begin to degenerate leading to hemorrhage and necrosis.[2,6] Sonographically, hemorrhage and necrosis create a mixed solid-cystic appearance that may have associated internal debris causing fluid-debris levels.[6] Other sonographic features include septations and calcifications normally concentrated within the capsule.[2] Doppler analysis of SPEN shows an avascular or hypovascular lesion with the peripheral flow in the solid epithelial tissue.[9] Figure 5 shows sonographic images of a lesion that had the differential diagnosis of SPEN taken with the Toshiba Aplio500, C6-1MHz transducer on a pediatric female patient.

Differential diagnoses for SPEN include neoplastic lesions such as exocrine and endocrine tumours and non-neoplastic lesions such as pseudocysts, necrosis and abscesses.[10–12] The sonographic presentation of the pancreatic head lesion in this case study combined with the clinical presentation of a young Southeast Asian female with no previous signs and symptoms before abdominal trauma is distinctive of SPEN allowing for exclusion of other neoplastic conditions.[2] Differentiation of SPEN from non-neoplastic lesions is done through clinical presentation, blood work, sonographic features and microscopic analysis.[10–12] If a pancreatic lesion is a suspected SPEN, the patient will undergo further imaging to confirm the diagnosis. Multidetector computed tomography (CT) and MRI are imaging modalities to further characterize SPEN lesions.[9] MRI provides helpful characterization of the capsule of the tumour and the intratumoural solid and hemorrhagic components.[9] Endoscopic ultrasound with fine-needle biopsy and core biopsy is recommended if radiographic features are not specific enough to diagnose SPEN.[6] Biopsies may be inconclusive due to the amount of necrotic tissue within SPEN.[13] A diagnostic biopsy will reveal vascular structures with neoplastic cells in a papillary-like array.[13] Rarely, SPEN behaves aggressively invading local tissues, and in extreme cases metastasizing to the liver, peritoneum, regional lymph nodes, and the greater omentum.[2,10] The primary treatment of SPEN is complete resection, with a 95% cure rate.[2,12] Following resection of the tumour, patients are monitored for recurrence; further adjuvant therapy is not normally necessary.[8] The biopsy results in this case study were of necrotic tissue, which is not diagnostic of SPEN. As a result, the management plan remained to monitor with ultrasound and conduct another biopsy.

In this specific case the clinical presentation of abdominal trauma along with ultrasound findings of a large, well-defined, heterogeneous pancreatic head mass, with a mixed cystic-solid component and a surrounding echogenic capsule were highly suspicious of both WOPN or SPEN.[1,2] Both differentials had to be investigated to obtain an accurate diagnosis.[6] Investigation with MRI, blood work, and biopsy were conducted but these were non-diagnostic, so serial monitoring with ultrasound was used to differentiate between a SPEN or a hematoma.

The serial ultrasounds over 94 weeks showed a large pancreatic complex head mass that was associated with pancreatitis, this head mass and pancreatitis eventually resolved confirming that this mass was a WOPN.

Conclusion

Pancreatic trauma is rare and occurs more frequently in children. A pancreatic lesion found following abdominal trauma must be analyzed indifferent to the trauma to ensure all possible differential diagnoses are considered.

Diagnosis of a pancreatic lesion is done through multifactorial analysis of clinical presentation, diagnostic imaging (MRI, CT, ultrasound), blood work, and pathology results.[2]

For the pediatric population, sonography is the initial imaging modality for diagnosis when clinical findings are equivocal.[1] Sonography is used to assess for hematomas, or traumatic pancreatitis and its complications. In this case study, sonography provided a safe and effective way to monitor the lesion without exposing the patient to any unnecessary radiation or interventional procedures. Ultimately, ultrasound imaging and the sonographer's examination identified resolution of the lesion, and blood work correlated to show an episode of acute pancreatitis before resolution of the lesion. Sonographic findings excluded SPEN and the pancreatic head lesion was a sequela of the trauma as a WOPN. Sonography provided a safe and accurate method to aid in the diagnosis of this pancreatic head lesion.

Conflict of Interest

The author has no conflict of interest to disclose.

References

1. Kumar A, Panda A, and Gamanagatti S. Blunt pancreatic trauma: A persistent diagnostic conundrum? World J Radiol 2016;8(2):159.
2. Chung EM, Travis MD, Conran RM. Pancreatic tumours in children: radiologic-pathologic correlation. Radiographics 2006;26(4):1211–38.
3. Stamatakos M, Stefanaki C, Kontzoglou K, Stergiopoulos S, Giannopoulos G, and Safioleas M. Walled-off pancreatic necrosis. World J Gastroenterol 2010;16(14):1707.
4. Siegel MJ, Chung EM. Adrenal Glands, Pancreas and Other Retroperitoneal Structures. Pediatric Sonography, 5th edition. Philadelphia: Lippincott Williams &Wilkins; 2011.
5. Debi U, Kaur R, Prasad KK, Sinha SK, Sinha A, and Singh K. Pancreatic trauma: a concise review. World J Gastroenterol 201;19(47): 9003.
6. Law JK, Ahmed A, Singh VK et al. A systematic review of solid-pseudopapillary neoplasms: are these rare lesions? Pancreas 2014;43(3): 331.
7. Słowik-Moczydłowska Ż, Gogolewski M, Yaqoub S, et al. Solid pseudopapillary tumour of the pancreas (Frantz's tumour): two case reports and a review of the literature. J Med Case Rep 2015;9(1):268.
8. Carlotto JR, Torrez FR, Gonzalez AM, et al. Solid pseudopapillary neoplasm of the pancreas. 2016;29(2):93–96.
9. Palmucci S, Uccello A, Leone G, et al. Rare pancreatic neoplasm: MDCT and MRI features of a typical solid pseudopapillary tumour. J Radiol Case Rep 2012;6(1):17.

10. Rebhandl W, Fellberbauer FX, Puig S, et al. Solid-pseudopapillary tumour of the pancreas (Frantz tumour) in children: Report of four cases and review of the literature. J Surg Oncol 2001;76(4):289–96.
11. Frost M, Krige JE, Bornman PC, et al. Solid pseudopapillary epithelial neoplasm-a rare but curable pancreatic tumour in young women. South African J Surg 2011;49(2):75–81.
12. Jha BM, Shah P, Agarwal, A. Solid pseudopapillary neoplasm of the pancreas mimicking a pseudocyst of the pancreas. Med J Armed Forces India 2015;71:S5–7.
13. Bhanot P, Nealon WH, Walser EM, Bhutani MS, Tang WW, and Logroño R. Clinical imaging and cytopathological features of solid pseudopapillary tumor of the pancreas: a clinicopathologic study of three cases and review of the literature. Diagnostic Cytopathol 2005;33(6):421–28.
14. Linsenmaier U, Wirth S, Reiser M, and Körner M. Diagnosis and classification of pancreatic and duodenal injuries in emergency radiology. Radiographics 2008;28(6):1591–602.
15. Matsuno WC, Huang CJ, Garcia NM, Roy LC, and Davis J. Amylase and lipase measurements in paediatric patients with traumatic pancreatic injuries. Injury 2009;40(1):66–71.
16. Hashimoto BE, Laing FC, Jeffery Jr RB, et al. Hemorrhagic pancreatic fluid collections examined by ultrasound. Radiology 1984;150(3):803–808.
17. Wootton-Gorges SL, Thomas KB, Harned RK, Wu SR, Stein-Wexler R, and Strain JD. Giant cystic abdominal masses in children. Pediatric Radiol 2005;35(12):1277–88.
18. Jha AK, Goenka MK, Kumar R, and Suchismita A. Endotherapy for pancreatic necrosis: An update. JGH Open 2019;3(1):80–88.
19. Tyberg A, Karia K, Gabr M, Desai A, Doshi R, Gaidhane M, et al. Management of pancreatic fluid collections: A comprehensive review of the literature. World J Gastroenterol 2016;22(7):2256.
20. Papachristou GI, Takahashi N, Chahal P, Sarr M, and Baron TH. Peroral endoscopic drainage/debridement of walled-off pancreatic necrosis. Ann Surg 2007;245(6):943.

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Article Name: Case Study of a Pancreatic Head Lesion in an Adolescent Female following Abdominal Trauma

Author Name: Sandra Taves

1. Pancreatic trauma can lead to which of the following sequela (pick all that apply)

a) Pancreatitis
b) Hematomas
c) Solid Pseudopapillary Epithelial Neoplasms
d) Pseudocysts

2. SPEN is most commonly large at diagnosis because of

a) A lack of signs and symptoms
b) Rapid cell division and growth

3. A sonographic heterogeneous, mixed (cystic – solid) lesion with an echogenic capsule in the pancreas is suggestive of which lesions (pick all that apply)

a) Solid Pseudopapillary Epithelial Neoplasm
b) Pseudocysts
c) Hematoma
d) Walled Off Pancreatic Necrosis

4. Walled Off Pancreatic Necrosis always requires surgical intervention

a) True
b) False

5. Sonography provides safe and effective monitoring that combined with multifactorial analysis can lead to the diagnosis of pancreatic lesions

a) True
b) False

Pictorial Essay

Cathy Ridsdale, BSc, CRGS, CRVS, RDMS, RVT

Optimizing Imaging Techniques for the Fetal Heart: A Pictorial Essay

ABSTRACT

Cardiac defects are the most common congenital anomalies in the fetus. In the majority of cases, these anomalies can be detectable by sonography. The utility of diagnostic ultrasound in fetal heart assessment depends on the quality and completeness of the exam. This pictorial essay will focus on the Sonography Canada National Competency Guideline preferred image views for assessment of the fetal heart. To achieve the best outcomes, image optimization and exam efficiency will be discussed for this challenging organ.

Introduction

Fetal cardiac abnormalities occur in 8 of 1000 live births.[1] The ability of sonography to identify the presence of these abnormalities as early as possible prenatally allows for parental counselling and the potential to improve birth outcomes. Although the fetal heart is scanned throughout pregnancy, the optimal time to scan for these defects is 18–22 weeks' gestation.[2] Imaging of the fetal heart provides some unique challenges over other areas routinely scanned by sonographers. At this time, fetal movement is unpredictable, the fetal heart is very small (approximately 25mm in size[1]), and normally beats between 120 and 180 bpm (beats per minute).[3] Maternal body habitus will also play a role in the sonographer's ability to visualize fetal structures. All of these factors contribute to the challenge to produce high-quality images necessitating the use of image optimization techniques. Poor imaging of the fetal heart is one of the most common reasons for a patient to be recalled.[1] This pictorial essay will discuss the accepted fetal heart views and optimization strategies to produce high-quality sonographic images.

Review of Standard Fetal Heart Images

Sonography Canadas National Competency Guidelines recommends screening of the fetal heart to include the following fetal imaging: 4 chamber (4CH), stomach for situs, left ventricular outflow tract (LVOT), right ventricular outflow tract (RVOT), 3 vessel view (3VV), aortic arch (AA), ductal arch (DA), and m-mode for fetal heart rate (FHR).[4] A Phillips EPIQ systems was utilized to obtain all images

4 Chamber View (4CH)

To obtain the 4CH view (Figure 1) the transducer is oriented transverse on the fetal thorax with a slight angulation towards the fetal head and fetal right shoulder.[2]

An optimal 4CH view can rule out 10 to 96% of fetal heart abnormalities.[3] It will assess the normalcy of interventricular septum, interatrial septum, movement of foramen ovale, compare the size of ventricles and atria, as well as the movement and location of the mitral valve and tricuspid valve. This view is also good for demonstrating

Figure 1. 4 chamber view demonstrating heart size (1/3 size of thorax), situs (left side of thorax), and axis (45° angle towards the fetal left side). The following anatomy is also assessed; Ao = aorta; LA = left atrium; RA = right atrium; LV = left ventricle; RV = right ventricle; IVS = interventricular septum; IAS = interatrial septum; FO = foramen ovale; MV = mitral valve; TV = tricuspid valve.[5]

the pericardium, myocardium, and endocardium. It is the best view for demonstrating pericardial effusion, pleural effusion, presence of intracardiac tumors and arrhythmias.[3]

LVOT

The LVOT (Figure 2) is obtained by angling the transducer more superiorly towards the fetal head, from a 4CH view.[6] The orientation of the aorta and left ventricle is the main feature of this image. The size of the ascending aorta/aortic root and the movement of the aortic valve should also be assessed when imaging this view; rule of thumb, the diameter of the normal aorta is approximately 4mm at 20 weeks' gestation.[3] A normal LVOT image rules out abnormalities of the interventricular septum, aortic stenosis, and truncal abnormalities.

RVOT

To obtain the RVOT long-axis view (Figure 3A) the transducer is further angled superiorly towards the fetal head.[2] The RVOT can also be viewed as a short-axis view (Figure 3B) by rotating the transducer 90° counterclockwise from the long axis view. The combination of the 2 views will rule out pulmonary stenosis, aortic stenosis, bicuspid aortic valve, and size discrepancy of Ao and MPA (the Ao and MPA should be approximately the same size).[3]

3 Vessel View (3VV)

Another view to demonstrate the relationship of the Ao and MPA is the 3VV (Figure 4). From the long axis, RVOT view the transducer is angled even further upwards towards the fetal head.[6] This view is the most superior view of the fetal heart. It is best for evaluating the size and orientation of the Ao and MPA. Truncal abnormalities, stenosis of Ao or MPA are examples of the abnormalities this view can rule out.[3]

Aortic Arch (AA) & Ductal Arch (DA)

The final views of the fetal heart routinely scanned by the general sonographer are the AA and DA. These are the only views taken using a sagittal approach to the fetal thorax (Figure 5).[6] The AA view is best for demonstrating coarctation of the aorta and the DA view provides the only assessment for abnormality of the ductus arteriosus.[3]

Image of Optimization Techniques

Frequency

The imaging frequency used will determine the level of resolution vs penetration obtained in the produced image. A higher frequency setting is best for optimal resolution; but a low enough setting to penetrate to the maximum depth of the image is important (Figure 6). It is constantly a trade-off between resolution and penetration.[7]

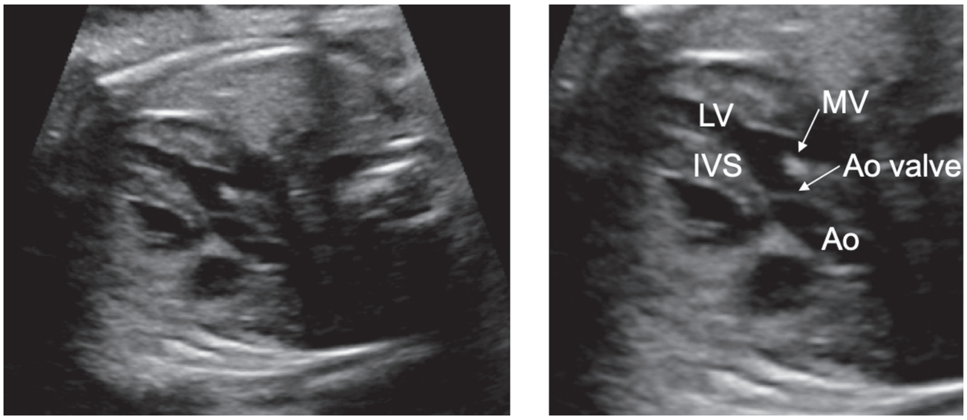

Figure 2. LVOT demonstrating continuity of interventricular septum with the aorta and orientation of the mitral valve with the posterior wall of the aorta. Size of aorta can also be measured in this view. LV= left ventricle; MV = mitral valve; IVS = interventricular septum; Ao = Aorta.[5]

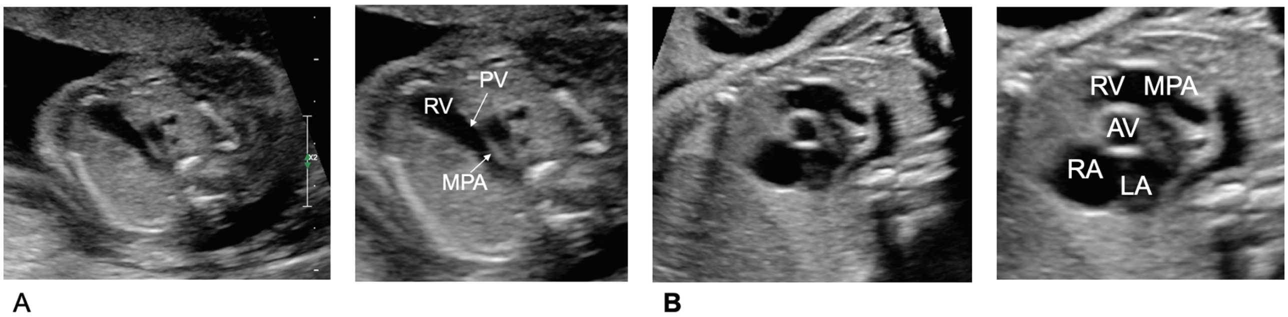

Figure 3. (A) Long axis RVOT demonstrating RV, PV pulmonary valve, and MPA main pulmonary artery. (B) Short axis RVOT demonstrating RV, MPA, AV aortic valve, RA, and LA. Both RVOT views assess the continuity of the RV with the MPA with visualization of the pulmonary valve. The short axis view further demonstrates the relationship between the Ao and MPA.[5]

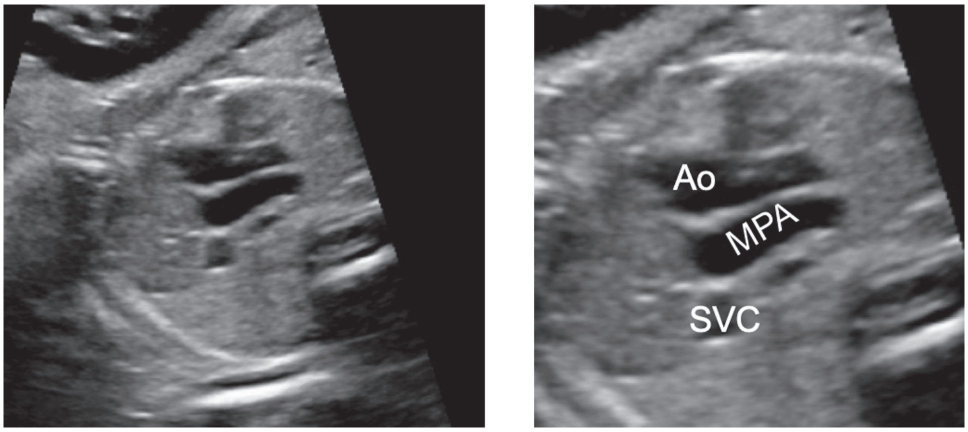

Figure 4: 3 vessel view (3VV) demonstrating the relationship of Ao, MPA, and SVC superior vena cava. The Ao lies anterior to the MPA with the SVC being the most posterior structure. The 3VV is used to rule out abnormalities of the Ao and MPA. Both should be approximately the same size and they should run parallel to each other in this view.[5]

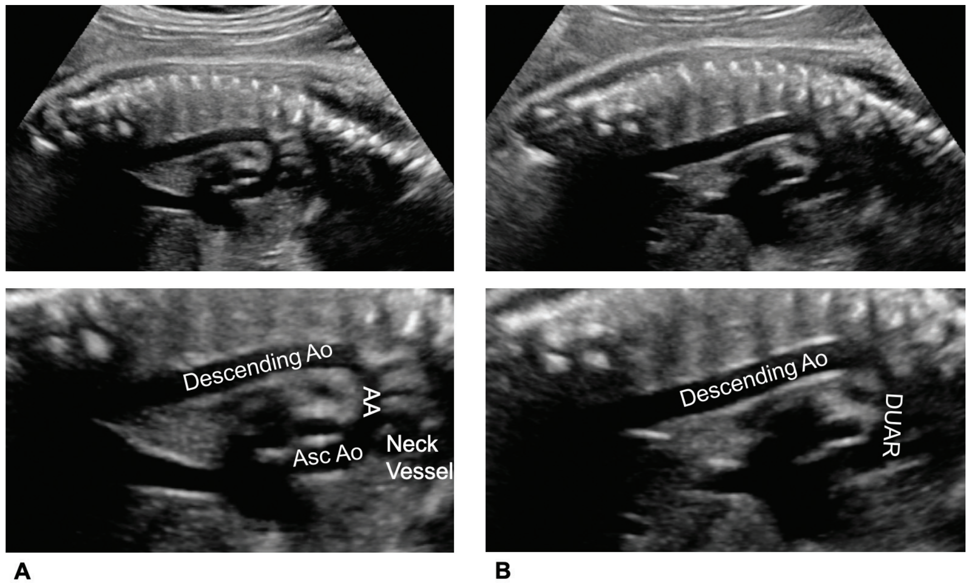

Figure 5. (A) Aortic arch demonstrating Asc Ao ascending aorta, AA aortic arch, and Descending Ao aorta. The aorta exits the LV anteriorly in a candycane-shaped arch that runs parallel along the fetal spine. The neck vessels are on the superior portion of the arch. (B) Ductal arch view demonstrating descending aorta and DUAR ductus arteriosus. The DUAR view demonstrates the connection of the MPA and aorta by the ductus arteriosus (DUAR) in the shape of a hockey stick. The DUAR is slightly larger in diameter than the aorta.[5]

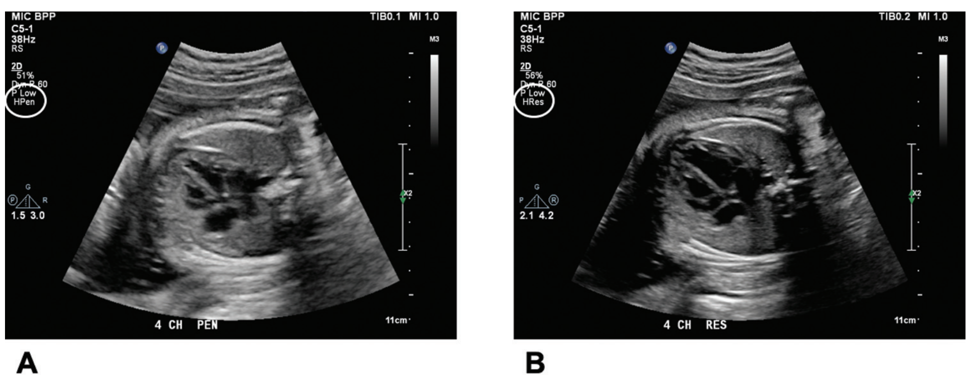

Figure 6. (A) This image was produced with the lowest frequency setting available with the C5-1 transducer (at the 1.5MHz end of the zone). Notice the over-penetration and lack of detail resolution. (B) The image was produced using the highest frequency setting available with the C5-1 transducer (at the 4.2MHz end of the zone). Superior detail resolution is demonstrated. It is important to note penetration has not been compromised and all of the deeper structures are well visualized. Both images utilized harmonics which is why the frequency range isn't a direct 1-5MHz relationship.[5]

Harmonics

The utilization of harmonics allows for optimization of image resolution. The theory behind harmonic imaging is quite simple. The beam is transmitted out at a low frequency and the return beam is received at 2× the transmitted frequency. This acts to improve detail resolution but maintain adequate penetration. There is a potential downfall; the received frequency may not maintain enough penetration to adequately demonstrate very deep structures.[7] However, all images should be attempted with harmonics to optimize the image (Figure 7).

Compression

The fetal heart is a structure that has a relatively high contrast. To best demonstrate this the dynamic range or compression setting of the machine should be optimized. High contrast equates to a low compression setting (low dynamic range) which means fewer shades of grey will be represented. Conversely, low contrast utilizes many shades of grey thus requiring a high compression setting (high dynamic range) (Figure 8).[7] The dynamic range optimal for the fetal heart should be low enough to demonstrate the chambers well but not too low to cause loss of information in the walls. In contrast, the fetal kidneys will be better visualized with a higher dynamic range as they have lower contrast with the rest of the abdominal structures. The preset for an obstetric scan will have a compression setting that is somewhere in the upper-middle range, a middle ground between the high and low contrast structures. A decrease in the dynamic range can be used to optimize for the heart. Conversely, if the goal is to visualize the fetal lungs the dynamic range would likely need to be increased.

Imaging Window

The maternal abdomen allows for the sonographer to place the transducer on various areas to optimize the approach taken to image the fetal heart (Figure 9).

Although transducer placement/orientation improves images, sonographers frequently fail to utilize this

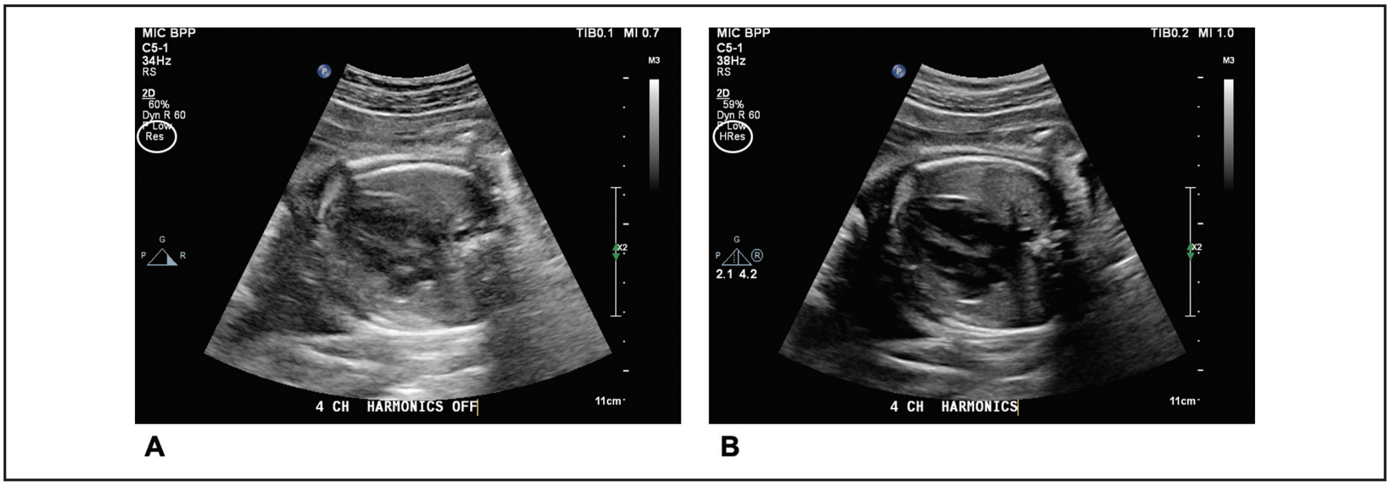

Figure 7. (A) No harmonics, (B) Harmonics utilized. There is a substantial improvement in the detail resolution in image B without impairment of penetration.[5]

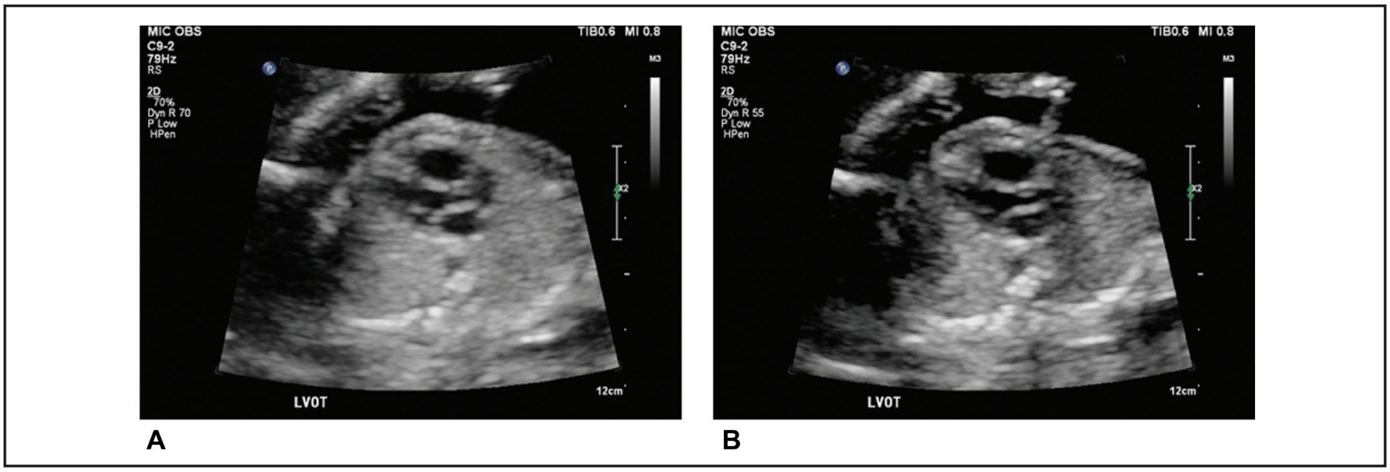

Figure 8. (A) Higher compression setting utilized (dynamic range 70DB), heart structures are not well defined. (B) Optimal compression setting for the fetal heart (dynamic range 55DB) providing a good balance between an optimal resolution of the heart walls and also of the chambers (the actual values of dynamic range will vary between ultrasound systems).[5]

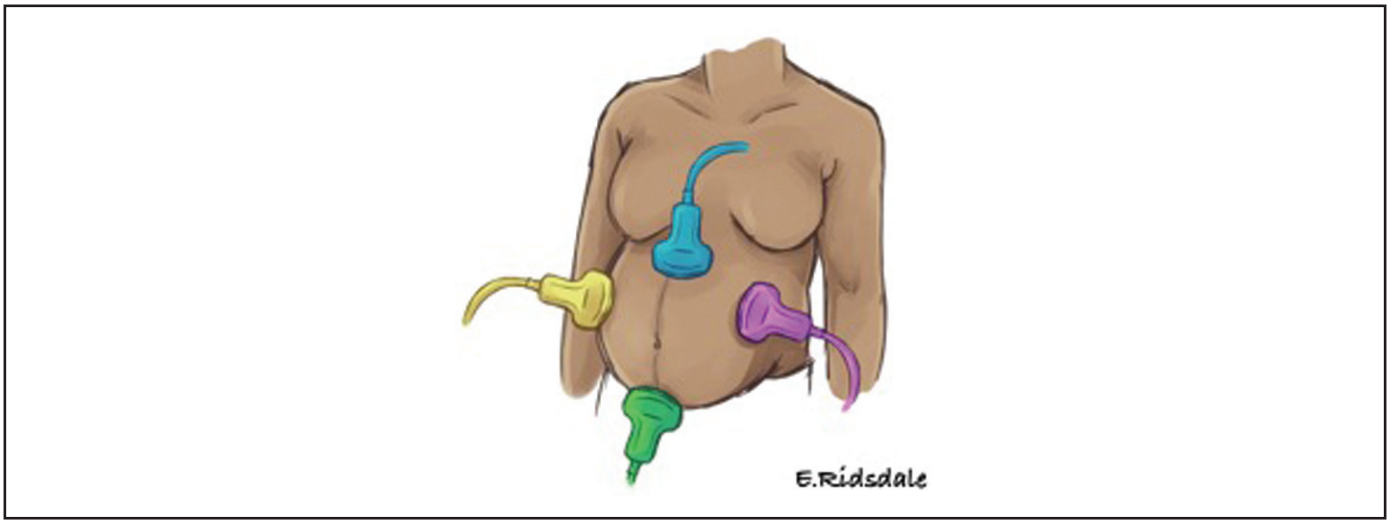

Figure 9. Diagram demonstrates the many different locations the transducer can be placed on the maternal abdomen. Image created by Em Ridsdale and included with permission.

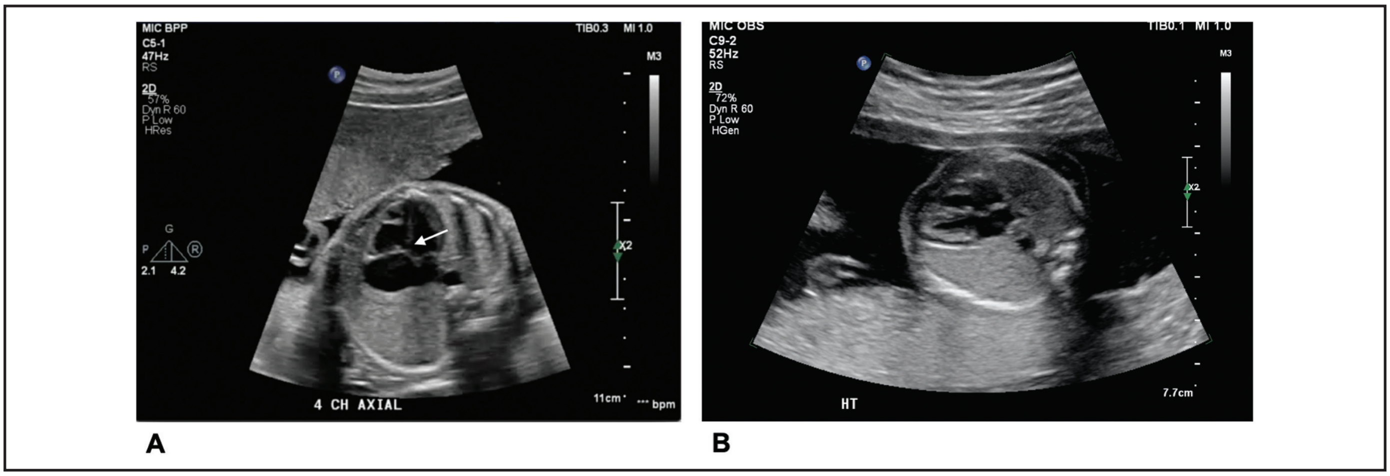

Figure 10. (A) Image taken from a window that orients the fetal heart in an axial lie. The MV, TV, and chambers are well demonstrated, but the IVS is poorly assessed and appears to have a possible septal defect (indicated by white arrow). (B) Image taken from an alternate window that orients the heart horizontally allowing for optimal visualization of the IVS, FO, and chambers, however, the MV and TV are poorly demonstrated. Note the possible septal defect seen in the apical window is now proven to be artefactual.[4]

optimization strategy resulting in suboptimal imaging (Figure 10). To obtain optimal images in 2-D the ultrasound beam should be oriented perpendicular to the reflectors desired.[7] Different parts of the heart will be imaged with the best resolution possible by using different windows.

The LVOT and RVOT views are also best demonstrated with the heart closer to a horizontal lie on the screen. The reason behind this is maximum detail resolution is achieved when the beam is perpendicular to the structure of interest, utilization of the specular reflection principle.

Colour Doppler imaging and pulsed wave Doppler imaging follow different rules due to the process by which the information is obtained. The Doppler angle requires there to be an angle of incidence less than or greater than 90° to register flow direction.[5] Optimization for Doppler will be achieved by scanning with the incident beam at an angle other than 90°.

Depth

Optimizing your imaging depth improves visualization of the heart by making it larger and improving the perceived resolution. It also increases the frame rate resulting in improved temporal resolution. Good temporal resolution allows us to better appreciate the fetal heart in real-time accounting for its very fast motion. By decreasing the depth, the beam has to travel, the sound beam can get to the max depth quicker. This decreases the line time, which decreases the time it takes to produce each frame.[7] The result is an increase in the frame rate (number of frames that can be produced per second). The faster frame rate means better temporal resolution (Figure 11).

Focus

The best detail resolution is achieved at the focus, or point where the beam is at its narrowest.[7] Current ultrasound systems have a focal zone (not a single point) that has variable size and can be placed at variable depth. To optimize the detail resolution of the fetal heart you need to maximize not only the location of the focus but also the size of the focal zone (Figure 12). This will give you the best possible detail resolution for the imaging situation.

Sector Width

Sector width is another tool that can be used to improve both detail resolution and temporal resolution. Utilizing a narrow sector width decreases the number of lines required to produce

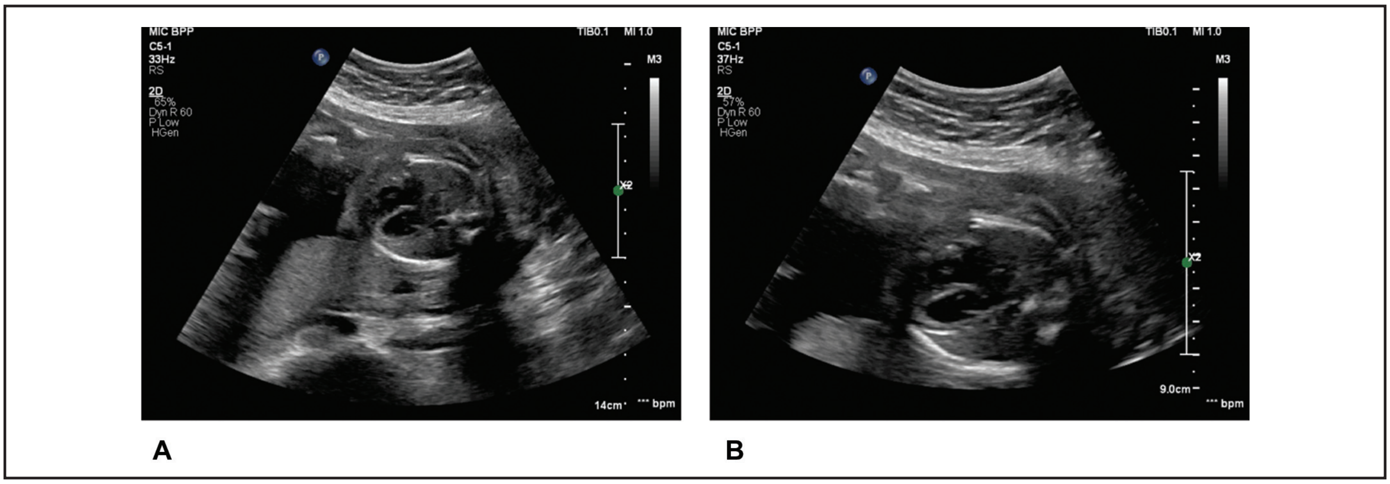

Figure 11. (A) Maximum depth set at 14 cm. (B) Maximum depth set at 9 cm. By utilizing a maximum depth that only includes the most posterior aspect of the fetal thorax the size of the fetal heart is maximized. There is also an improvement in the perceived resolution because distracting structures at deeper depths have been removed from the image. Note: the frame rate increased from 33Hz to 37 Hz an increase of 3 frames per second.[5]

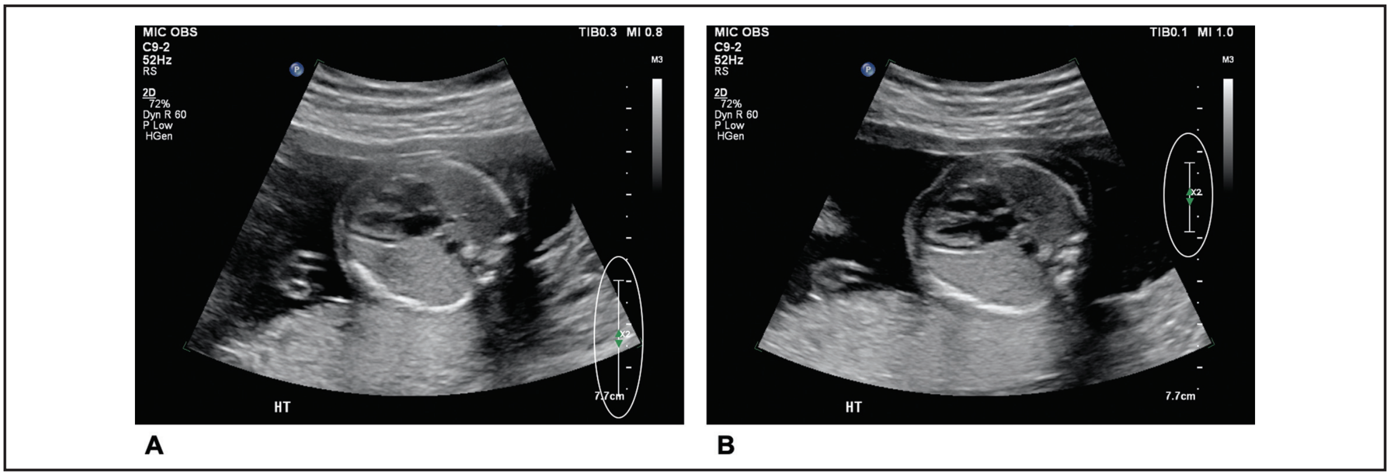

Figure 12. A. Focus (circled on image) set too deep and too large. B. Improved detail resolution is demonstrated with the focus set to the size of the fetal heart with a small buffer (these babies don't always hold still) and the deepest part of the zone is placed at the posterior border of heart.[5]

the image, this decreases the frame time thereby increasing the frame rate and improving temporal resolution.[7] Due to the high rate of motion of the fetal heart improved temporal resolution is very important for real-time observation of its rhythm. Detail resolution is improved by the increased line density created by using the narrower sector width (Figure 13). The perceived image resolution is also improved by removing extraneous information from the image allowing your eyes to focus on the fetal heart.

Advanced Image Optimization Techniques

Read versus Write Magnification (Zoom)

There are two different methods utilized by the ultrasound system to achieve magnification of the image. Each method has different effects on image resolution. Read magnification is performed by simply enlarging each pixel in the image increasing the size of the entire image, original image resolution remains unchanged. Write magnification is a more complex process. The sonographer selects an area to be magnified and then the ultrasound system

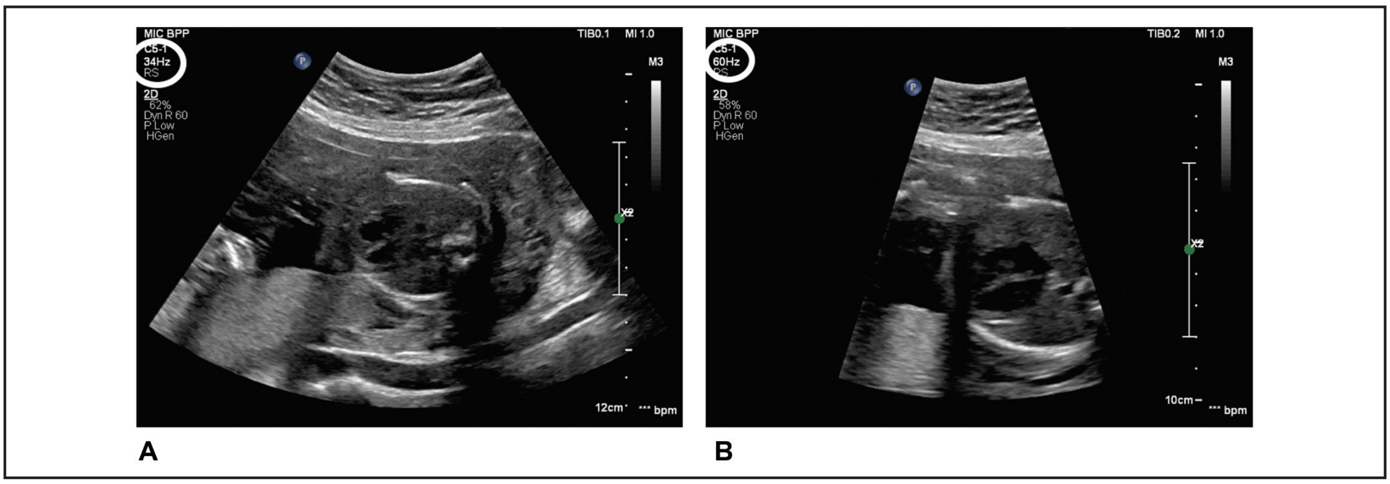

Figure 13. (A) Wide sector width with frame rate 34 Hz. (B) Narrow sector width with frame rate 60 Hz. Image B demonstrates improved detail resolution, both actual and perceived, with a significant increase in frame rate (improved temporal resolution would be appreciated in real-time).[5]

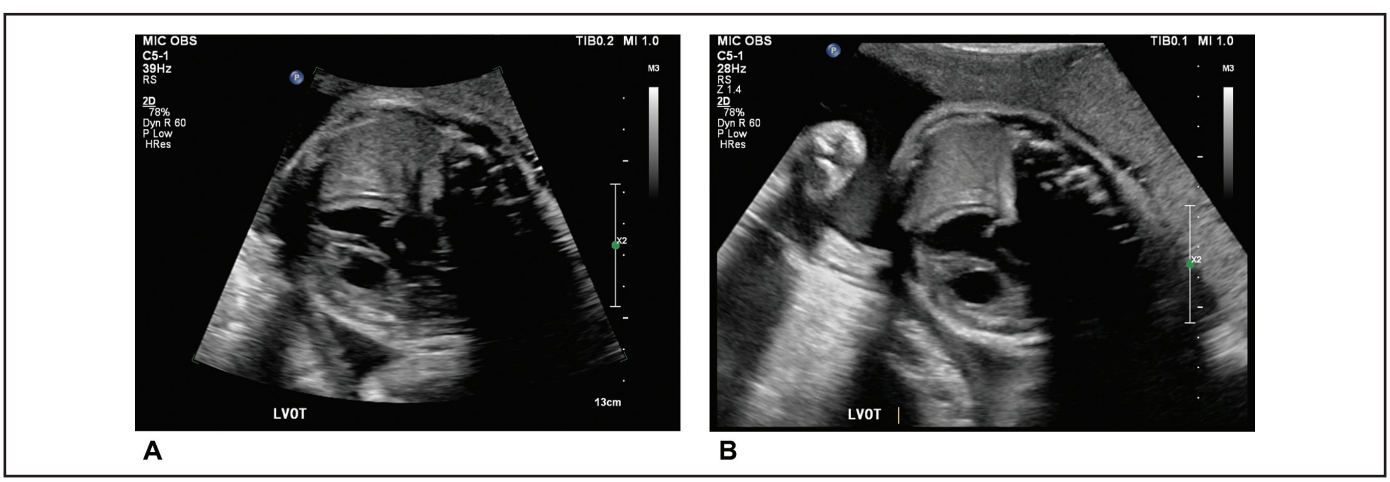

Figure 14. (A) Write magnification was used to zoom in on the LVOT demonstrating the heart structures larger and with improved image resolution. (B) Read-only magnification was used to enlarge the entire image including the heart, the actual resolution is maintained but the perceived resolution is much worse resulting in a larger but less clear image.[5]

will rescan the new smaller area but with the line density utilized for a whole image. The increased line density over the smaller area results in improved detail resolution.[7] Given the improved resolution achieved with write magnification it follows that the fetal heart would benefit greatly from the utilization of write magnification, especially in the first and second trimesters (Figure 14).

Averaging / Persistence

Smoothing is an averaging technique where neighbouring pixels are averaged together (Figure 15). This will act to accentuate pixels occurring in most sample spaces and decrease the visualization of pixels in only 1 or a few pixel spaces. Both the colour overlay and 2-D image are affected. This averaging technique is very effective for imaging structures that are not moving or moving at a relatively consistent rate. The result is a smoother image with better image quality.[7]

Another averaging technique used to improve image quality is persistence. Persistence averages frames together with more weight assigned to later frames. This can result in loss of information for events that occurred early in the frame cycle as well as information that occurred in only a few frames.[7] Since the fetal heart is beating at such a fast rate; image quality will be optimized by utilizing a lower persistence setting. For 2-D imaging, smoothing and persistence settings are typically set much higher as it is optimal to try and average out motion of structures from breathing and referred motion from vessel movement.

Colour Imaging / Priority

To produce diagnostic colour Doppler imaging of the fetal heart the sonographer must first optimize the size of the colour box, set a colour scale to minimize aliasing, and increase or decrease the colour gain to appropriate levels (Figure 16). Occasionally the

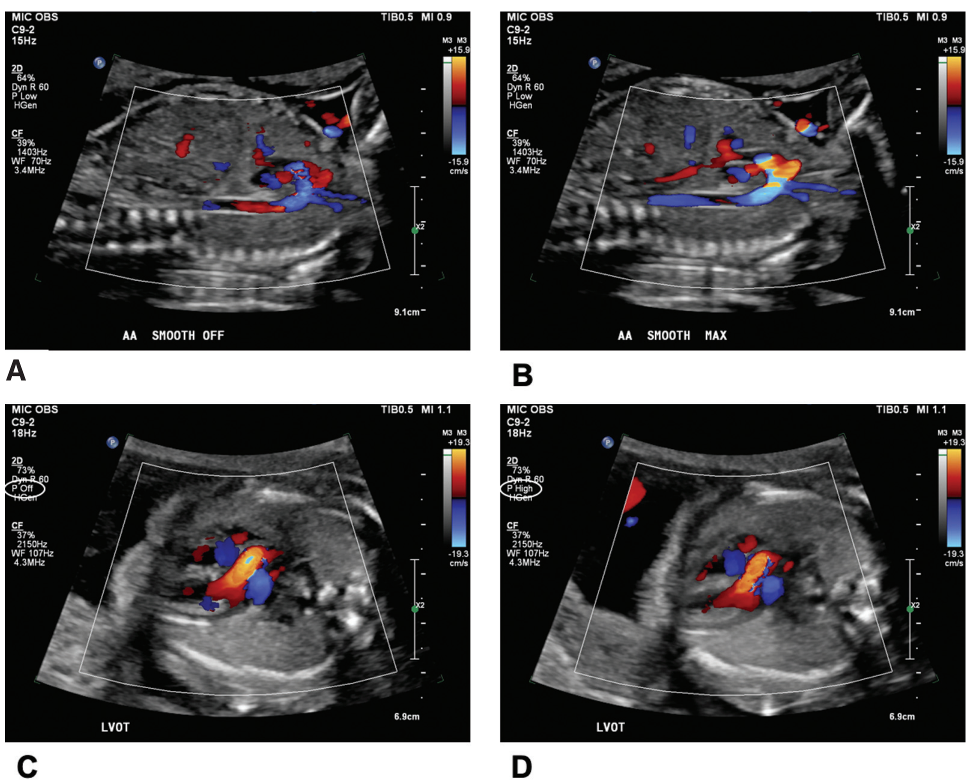

Figure 15. (A) Smoothing turned off. (B) Smoothing turned on demonstrating a smoothed image where flow velocity information is more clearly demonstrated. (C) Persistence off (circled on image). Notice the aliasing demonstrated through the aortic valve. (D) The image was obtained with persistence set at its maximum level (circled on image), the aliasing is not demonstrated. It was a short-term event early in the frame cycle which resulted in it being averaged out.[5]

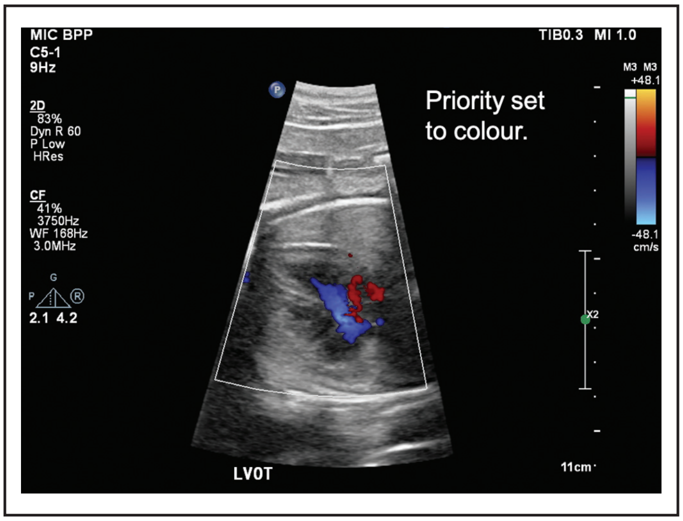

Figure 16. Set the colour box to the size of the heart with a buffer to allow for fetal movement. The colour scale is set to minimize aliasing. The colour gain is optimized to fill the chambers/ outflow tract fully without bleeding over. Colour priority is set to provide a good quality colour image of the LVOT proving there is no ventricular septal defect present. Note the 2-D image is not diagnostic for the structures demonstrated.[5]

aforementioned techniques do not result in optimal images; in this situation, it can be advantageous to alter the colour priority. Recall from ultrasound instrumentation a colour image is produced by overlaying colour Doppler information on a 2-D image. When the colour priority is increased the colour processing is weighted with higher importance improving colour visualization.[7] As there is only so much processing possible the cost is a loss of image processing for the 2-D image resulting in poor image quality of the 2-D component of the image.

OPTIMIZING M-MODE

M-mode imaging is used to determine the fetal heart rate (FHR) on every obstetric ultrasound performed. Utilization of the previously discussed factors before obtaining the m-mode trace will result in the best m-mode trace possible making it much easier to produce any necessary measurements. The information available by properly positioned and optimized m-mode is quite substantial. M-mode is essential to demonstrate arrhythmias (bradycardia, tachycardia, premature ventricular contractions PVC, premature atrial contractions PAC) (Figure 17). The placement of the fetal heart and orientation of the trace line

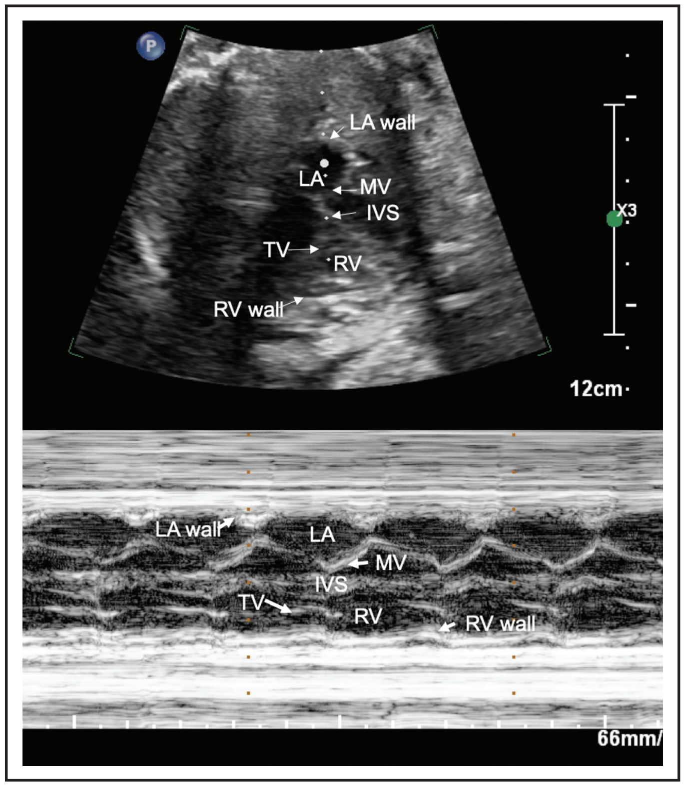

Figure 17. M-mode shows the motion of each reflector in a single scan line over time. The trace line shows the scan line represented on the m-mode trace. Each reflector in the 2-D image of the heart is represented on the m-mode trace.

must be considered to demonstrate these different arrhythmias (Figure 18).

M-mode can also be used to show pericardial effusion (Figure 19). Since a pericardial effusion will be best demonstrated with the heart lying horizontally on the screen, this is the optimal position for taking the m-mode trace. A measurement of the pericardial fluid will show if there is a pericardial effusion. Pericardial effusion is defined as a fluid collection >2mm measured on a m-mode trace.[8]

Summary

For easy patients, optimization techniques may seem irrelevant. The preset options provided by the ultrasound system often provide diagnostic images with a little adjustment on these patients though many of the discussed techniques will provide an even higher quality image. However, for technically difficult patients image optimization is essential to

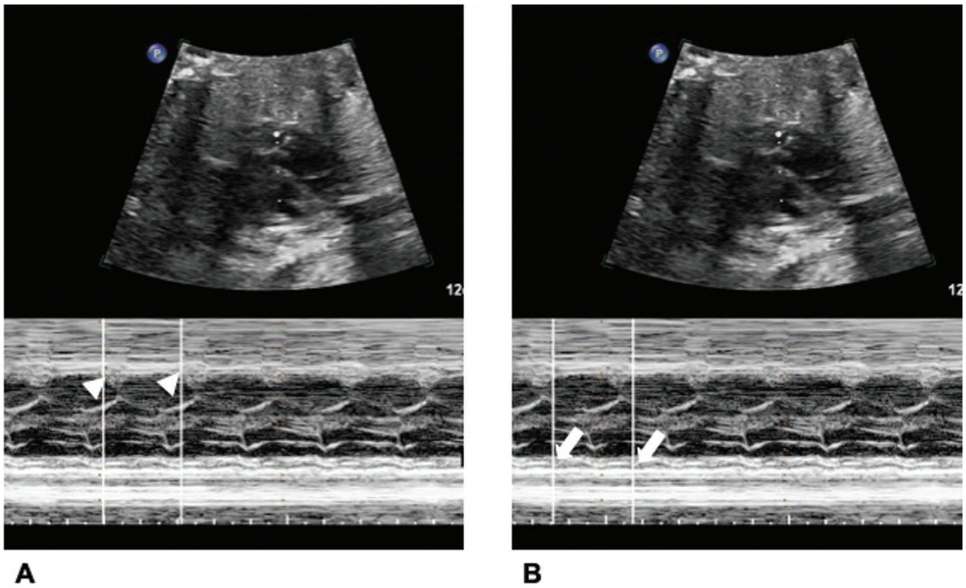

Figure 18. The trace line needs to traverse both an atrium and a ventricle to assess the timing of the beats on the same m-mode trace. This necessitates the utilization of an appropriate scan window. The rate of atrial contraction and ventricular contraction can be measured independently of the same trace. Trace line traverses the first atrium then ventricle. (A) Measurement of atrial heart rate, atrial wall noted with arrowheads. (B) Measurement of ventricular heart rate, ventricular wall noted with full arrows.[4]

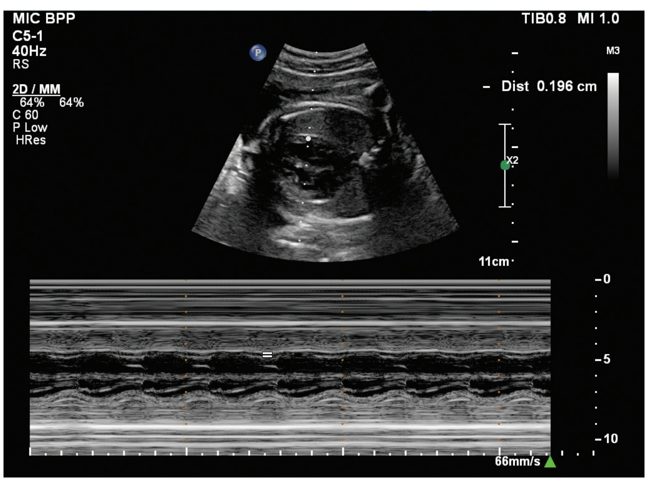

Figure 19. M-mode trace demonstrating measurement for normal pericardial fluid. The trace line goes through first the pericardial sac, pericardial fluid, myocardium of the LV, LV, IVS, RV, myocardium of RV then posterior pericardial sac. The wall most anterior in the image is seen best, therefore the best place to measure the fluid.[5]

produce diagnostic images and rule out pathology. The optimization techniques discussed throughout this article should provide the sonographer with multiple tools to help image the fetal heart with more speed, effectiveness, and better image quality.

Acknowledgements

The images in this article were graciously provided by MIC Medical Imaging in Edmonton, Alberta (through Cathy Ridsdale). Some images have been cropped to remove extraneous information.

Image created by Em Ridsdale and used with permission.

References

1. Hoffman J, Kaplan S. The incidence of congenital heart disease. J Am Coll Cardiol 2002;89:1890–900.
2. D'Vore G. The aortic and pulmonary outflow tract screening examinations in human fetus. J Ultrasound Med 1992;11:345–8.
3. Rumack CM, Wilson SR, Charboneau JW, Levine D. Diagnostic Ultrasound (4th Edition). Mosby Inc., Elsevier; 2011.
4. Sonography Canada National Competency Guidelines, Version 5.1, 2018.
5. Medical Imaging (MIC) Ultrasound Department – Century Park, Edmonton, Alberta; 2020.
6. Fetal Echocardiography Task Force; American Institute of Ultrasound in Medicine Clinical Standards Committee; American College of Obstetricians and Gynecologists; Society for

Maternal-Fetal Medicine. AIUM Practice Guideline for The Performance of Fetal Echocardiography. J Ultrasound Med 2013;32:1067–82.
7. Miele Frank R. Ultrasound Physics and Instrumentation (5th Edition). Miele Enterprises, LLC; 2013.
8. Yoo J, Min Y, Lee H. Normal pericardial fluid in the fetus: color and spectral Doppler analysis. Ultrasound Obstet Gynecol 2001;18:248–52.

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Article Name: Optimizing Imaging Techniques for the Fetal Heart: A Pictorial Essay

Author Name: Cathy Ridsdale, BSc, CRGS, CRVS, RDMS, RVT

1. What image technique optimizes temporal resolution by decreasing line time?

a) Compression
b) Frequency
c) Persistence
d) Depth

2. In which of the following situations could priority be used to optimize imaging of the fetal heart?

a) When assessing an arrhythmia with m-mode.
b) When using colour Doppler to demonstrate a ventricular septal defect.
c) When increasing the depth setting.
d) All of the above.

3. Increasing the system compression or dynamic range will result in which of the following?

a) Increased temporal resolution
b) Increased image contrast
c) Decreased image contrast
d) Both b and c

4. Which type of magnification will result in improved detail resolution?

a) Read magnification
b) Write magnification
c) Both a and b
d) None of the above

5. When performing m-mode the trace line should be place through both an atrium and a ventricle to diagnose which of the following?

a) Premature Ventricular Contraction (PVC)
b) Pericardial Effusion
c) Pleural Effusion
d) Ventricular Septal Defect (VSD)

Pictorial Essay

Babitha Thampinathan,
Marcello Seung Ju Na,
Jennifer Lam

Strain Imaging in Echocardiography Part 3: Cardiac Pathology and Patterns of Strain

About the Authors

Babitha Thampinathan HBSc, RDCS, CRCS (AE), is affiliated with Toronto General Hospital, Ted Rogers Center for Heart Research and Mohawk-McMaster University Institute for Applied Health Sciences.

SeungJu Marcello Na HBSc, RDCS (AE), MHI (Candidate), is affiliated with Women's College Hospital, St. Michael's Hospital and Mohawk-McMaster University Institute for Applied Health Sciences.

Jennifer Lam BSc, RDCS, CRCS (AE), is affiliated with Women's College Hospital and Toronto General Hospital.

INTRODUCTION

With the recent advances in cardiac imaging, echocardiography remains as one of the most reliable and cost-efficient non-invasive tests when assessing left ventricular function. Strain echocardiography provides comprehensive and valuable information on subclinical left ventricular (LV) systolic dysfunction that would be otherwise be missed on visual LV ejection fraction assessments. The final section of this three-part strain imaging series will review the clinical application of strain, primarily focusing on indications and pathology where cardiac sonographers should be considering performing strain imaging. Prior to this stage however, it is important to understand the foundational concepts involved in strain imaging, image acquisition and post processing techniques which can be reviewed in part one and two of the strain imaging in echocardiography series.

Keywords: strain imaging, left ventricular deformation, global longitudinal strain, strain bull's eye plot, cardiac pathology

Normal LVEF and Normal Strain

Normal Cardiac Status	
Indication	• Cardiac assessment • LV function
Usefulness of Strain	• Strain can detect myocardial function and regional specific patterns of detecting ventricular function and possible underlying cardiac diseases.
Echo Strain Imaging Findings	• Normal strain graph curves and red bull's eye 'polar map'

LV = left ventricular; LVEF = left ventricular ejection fraction.

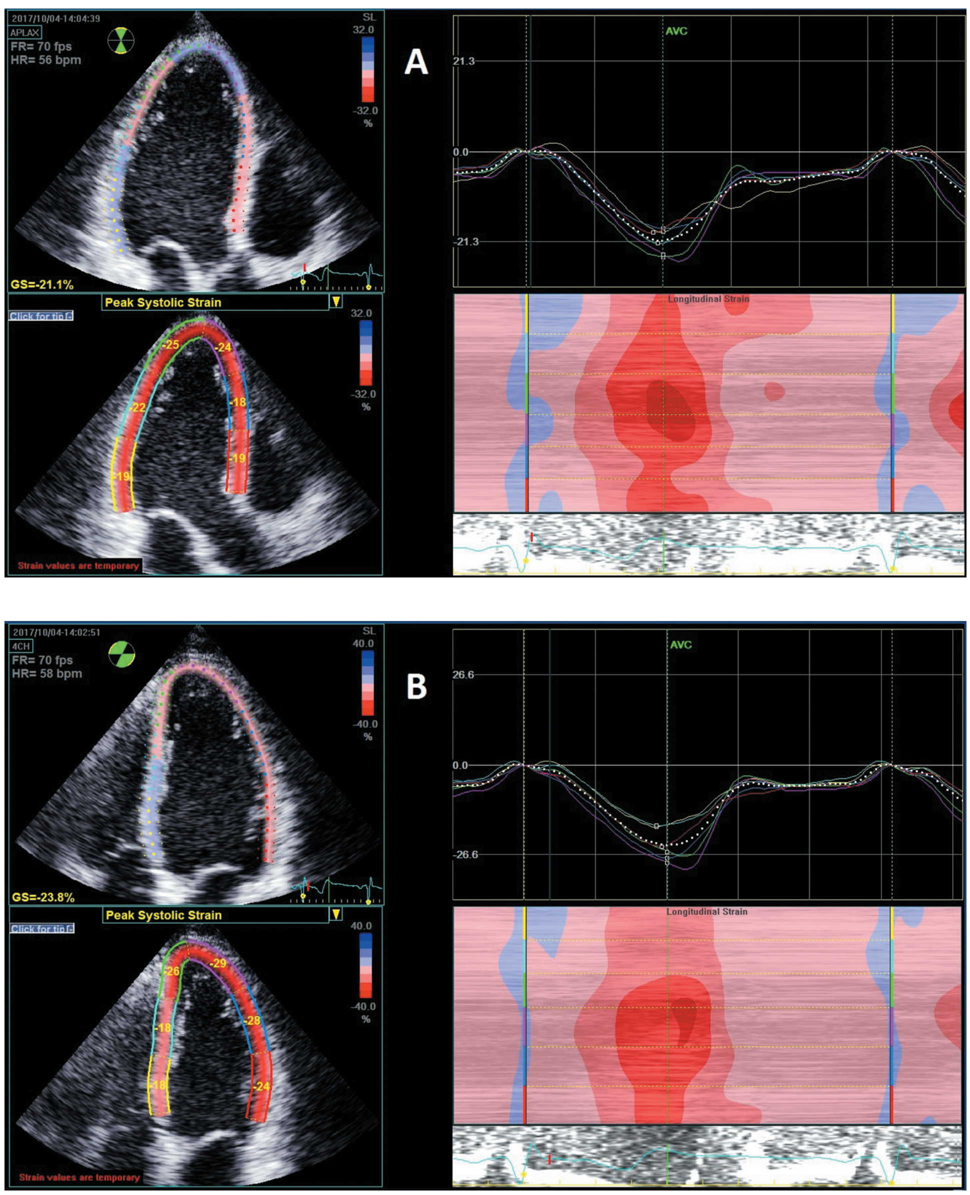

Figure 1. Apical 4 (A), apical 3 (B) and apical 2.

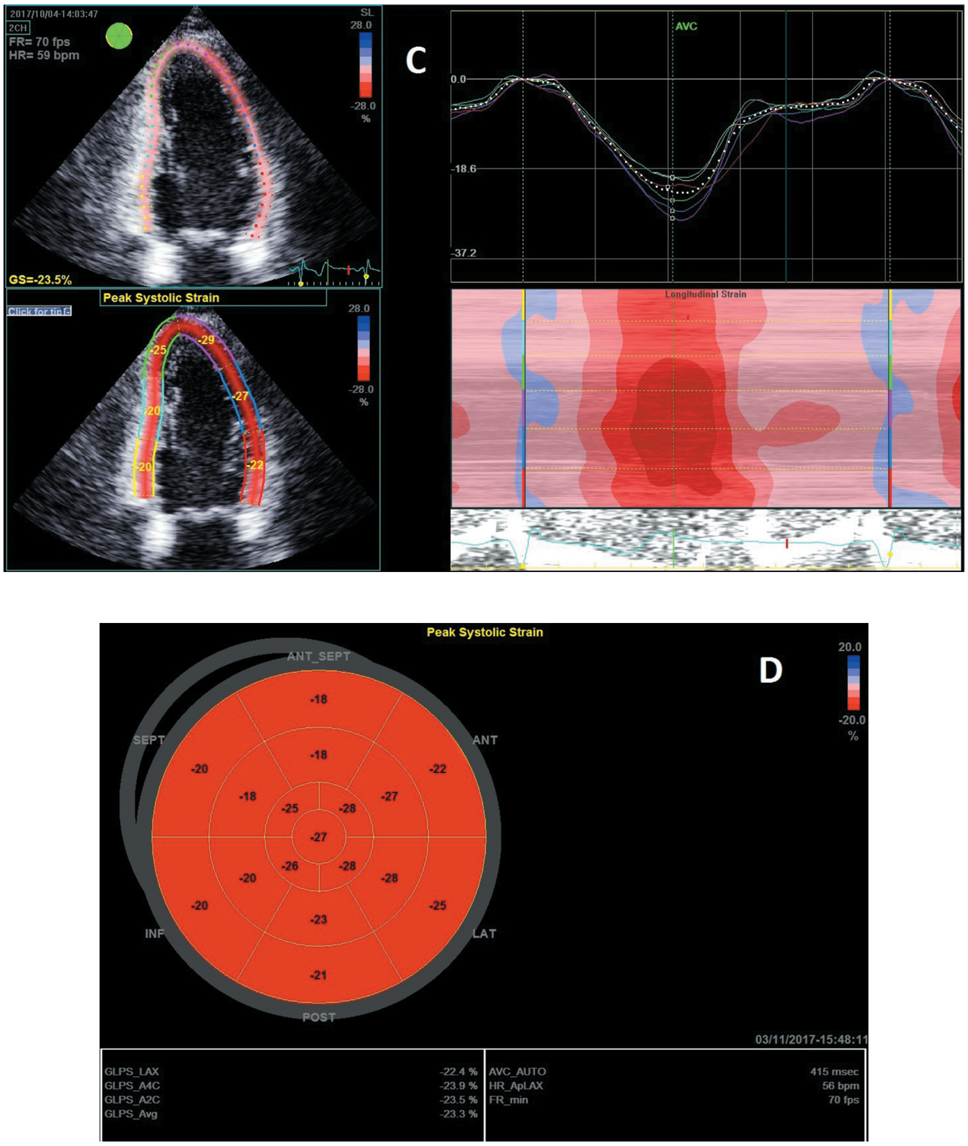

Figure 1. (C) chamber views with normal strain curves and bull's eye plot (D).

Normal LVEF and Abnormal Strain

LV Dysfunction: Regional Wall Motion Abnormalities	
Indication	• Myocardial infarct • Akinetic apex • Apical aneurysm
Usefulness of Strain	• Strain can detect myocardial dysfunction and regional specific patterns of ischemia, infarction and viability.
Echo Strain Imaging Findings	• Ischemic wall motion abnormalities is associated with passive motion and strain can pick up on mild reduction in systolic shortening in the absence of regional wall motion abnormalities or LVEF reduction.

LVEF = left ventricular ejection fraction.

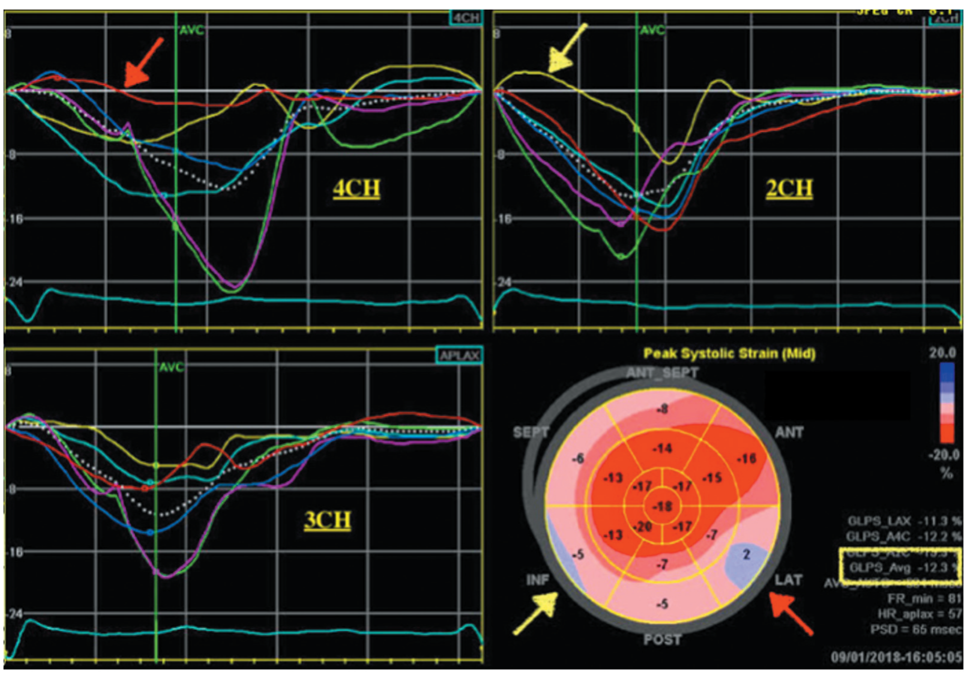

Figure 2. Bull's Eye Plot example with Regional Wall Motion Abnormalities.

Increased LV Wall Thickness and/or Mass

Hypertension	
Indication	• Hypertension • Increased wall thickness • Increased LV mass
Usefulness of Strain	• GLS can detect subtle changes in myocardium and monitor the progression of the changes in the presence of a normal LVEF.
Echo Strain Imaging Findings	• Isolated septal bulge with localized reduce longitudinal strain abnormality at basal part of septum indicates early signs of ventricular remodeling.[1,2] • Reduced strain patterns near basal and mid LV wall segments.[1] • Reduced average GLS.

GLS = global longitudinal strain; LV = left ventricular; LVEF = left ventricular ejection fraction.

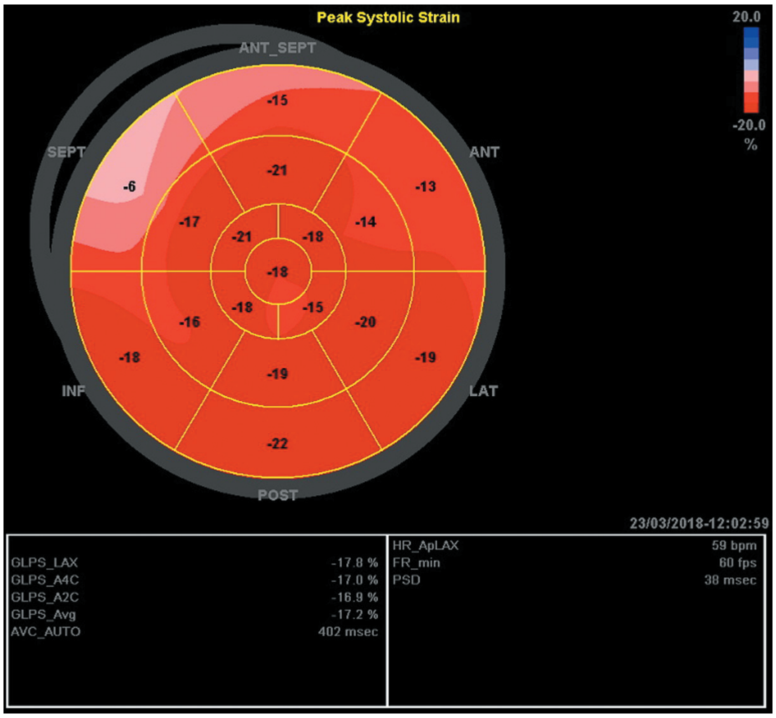

Figure 3. Bull's Eye Plot example for Hypertension.

Hypertrophy	
Indication	• Asymmetric hypertrophy • Hypertrophic cardiomyopathy • Extreme increase in LV wall thickness and/or LV mass
Usefulness of Strain	• Systolic function (EF) usually is normal because ventricle cavity volumes are reduced • Strain can identify regional segments that may be reduced due to hypertrophy[1,3]
Echo Strain Imaging Findings	• Overall average GLS is reduced. • Hypertrophied regions have reduced myocardial deformation, therefore producing low strain values. • Bull's eye plot will display shades of pale pink colours suggesting reduction in deformation[1,3].

EF = ejection fraction; GLS = global longitudinal strain; LV = left ventricular.

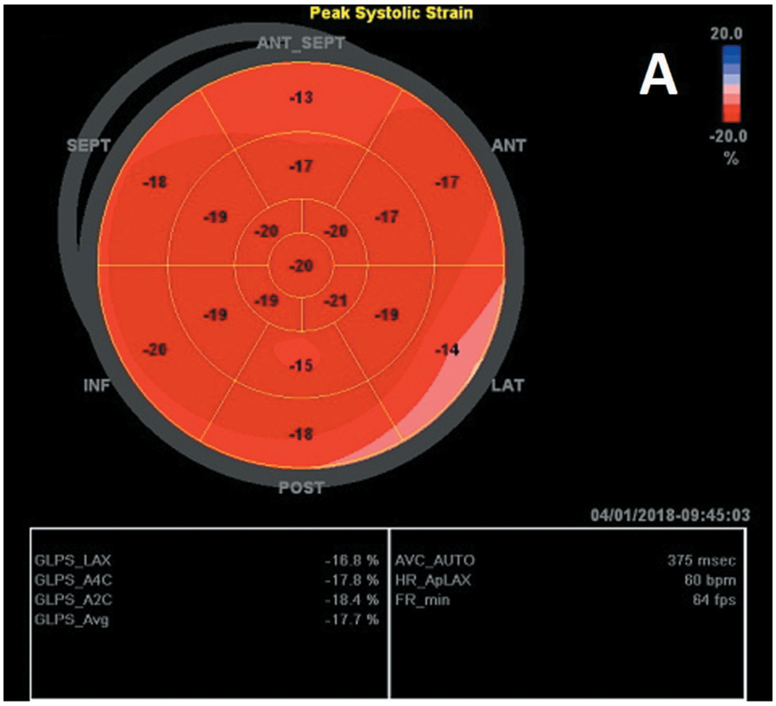

Figure 4. Bull's Eye Plot example for hypertrophy (A) and asymmetric hypertrophy (B). (*continued*)

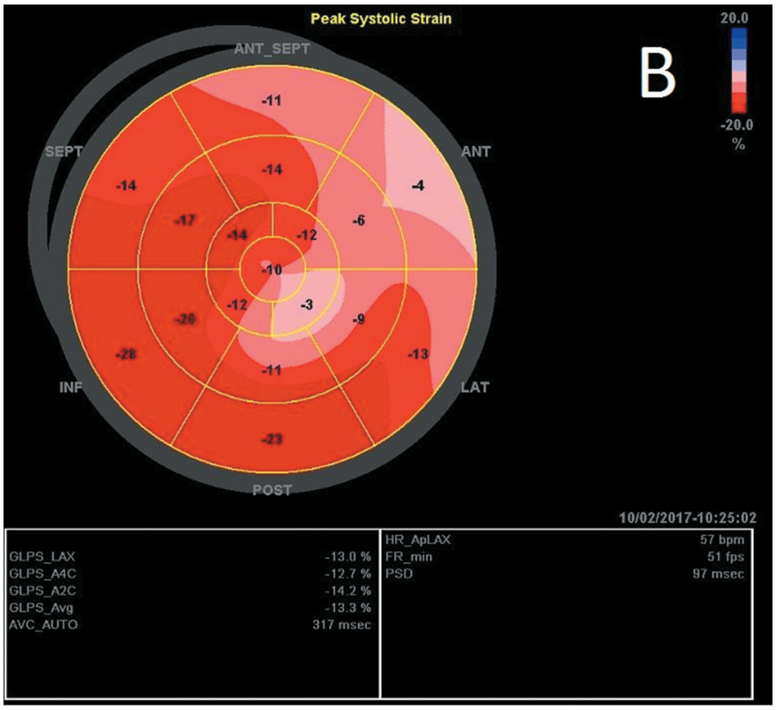

Figure 4. Bull's Eye Plot example for hypertrophy (A) and asymmetric hypertrophy (B).

Apical Hypertrophic Cardiomyopathy	
Indication	• Apical hypertrophy • Cardiomyopathy
Usefulness of Strain	• In cases of suspected apical HCM, it can be an alternative to contrast imaging or cMRI.
Echo Strain Imaging Findings	• Paradoxical strain: systolic lengthening in apical segments, correlating with ace of space shaped cavity.[4] • Bull's eye plot demonstrates blue/pale pink colour at the apex - indicating absence of longitudinal deformation.[4] • Basal and mid LV wall segments appear red on bull's eye plot with normal strain values.

cMRI = contrast magnetic resonance imaging; HCM = hypertrophic cardiomyopathy; LV = left ventricular.

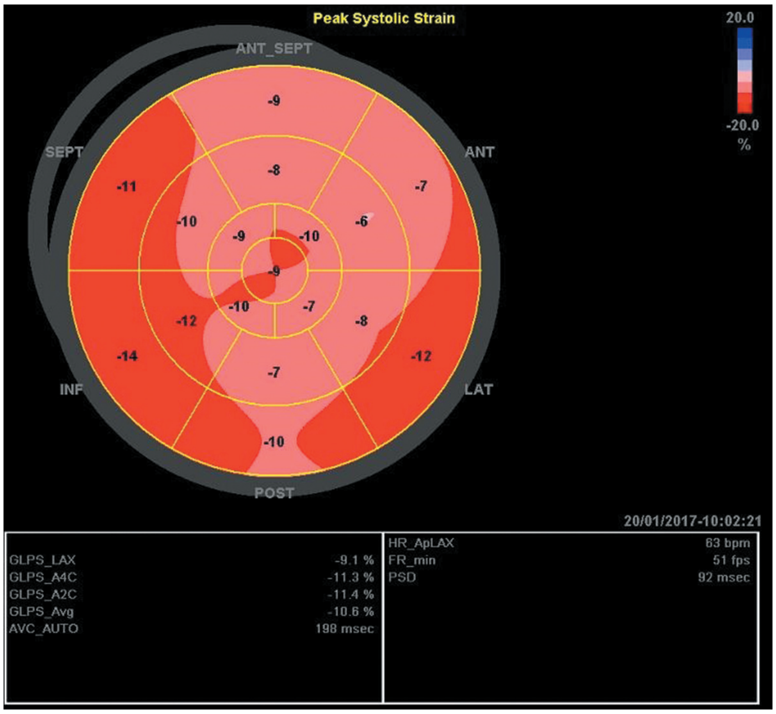

Figure 5. Bull's Eye Plot example for apical hypertrophy.

Amyloidosis	
Indication	• Infiltrative disease • Abnormal protein deposits in the myocardium
Usefulness of Strain	• GLS can detect early disease state within the myocardium, especially when there are no signs or symptoms of heart failure.
Echo Strain Imaging Findings	• 2-D echo shows 'ground-glass' or 'granular / speckle' appearance of myocardium. • Early stage: Preserved apical segments (preserved systolic strain). • Late stage: Strain pattern shows base to apex strain gradient on bull's eye plot (basal and mid segments have significantly reduced systolic strain).[3,5] • Apical sparing is specific to cardiac amyloidosis and can help differentiate from other pathologies that involve increased ventricular wall thickness.[3,5]

GLS = global longitudinal strain.

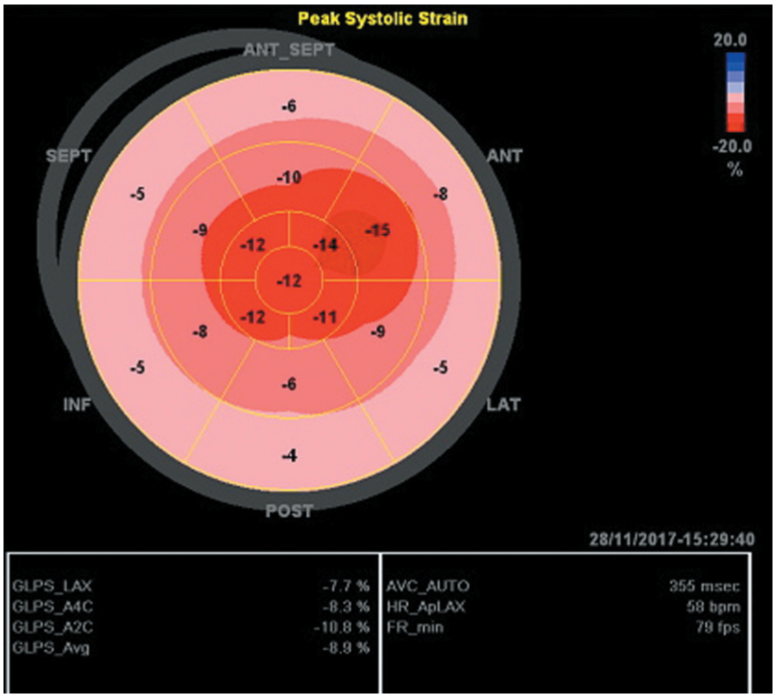

Figure 6. Bull's Eye Plot example for amyloidosis.

Fabry Disease	
Indication	• Storage disorder: Accumulation of glycolipid in the myocardium
Usefulness of Strain	• GLS can detect LV changes despite normal LVEF.
Echo Strain Imaging Findings	• Thick hypertrophied papillary muscles. • Reduced strain in the mid-lateral and posterior wall segments.[6–8] • Late stage: Average GLS is reduced, no longitudinal systolic deformation in basal and mid posterolateral segments because of thinning (caused by replacement fibrosis).[6–8] • Reduced strain is usually in lateral and posterior walls during the late stages of Fabry disease.[6–8] • Bull's eye plot shows normal EF and slightly reduced GLS.

EF = ejection fraction; GLS = global longitudinal strain; LV = left ventricular.

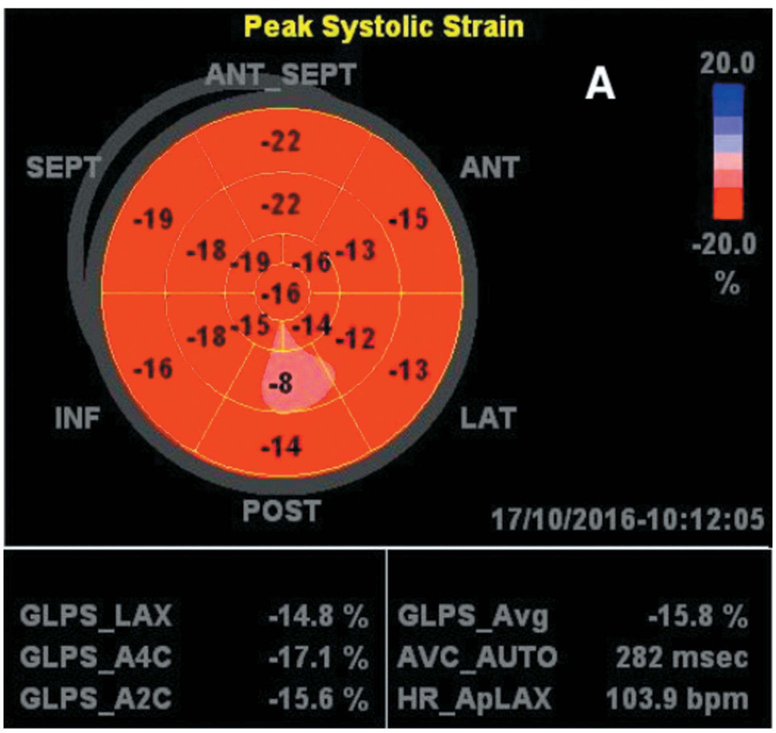

Figure 7. Fabry disease. (*continued*)

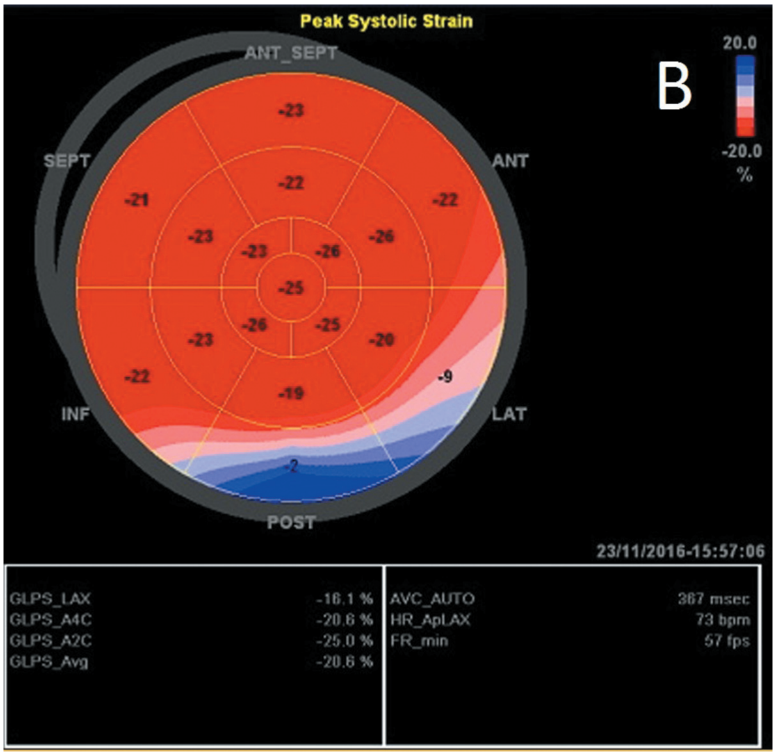

Figure 7. Fabry disease.

Valvular Heart Diseases	
Indication	• Valvular Stenosis or Regurgitation
Usefulness of Strain	• GLS can detect chronic myocardial changes earlier than Simpson's Biplane method. • Can provide useful information to physicians in regards to surgical intervention.
Echo Strain Imaging Findings	• Research studies have noted the value of detecting myocardial damage earlier on in patients that had asymptomatic aortic stenosis with a normal LVEF.[9] • The GLS values were markedly reduced in comparison to normal healthy volunteers.[9,10]

GLS = global longitudinal strain; LVEF = left ventricular ejection fraction.

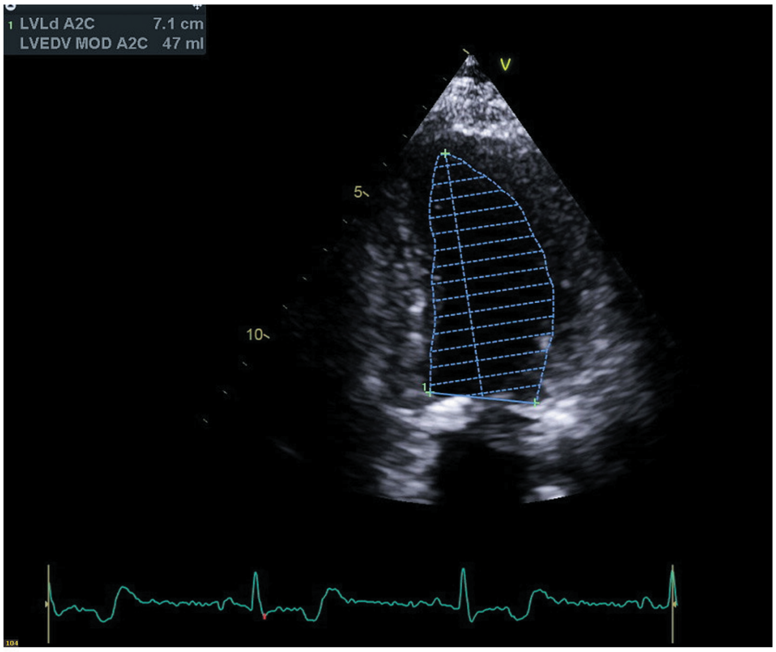

Figure 8. Valvular heart disease. (*continued*)

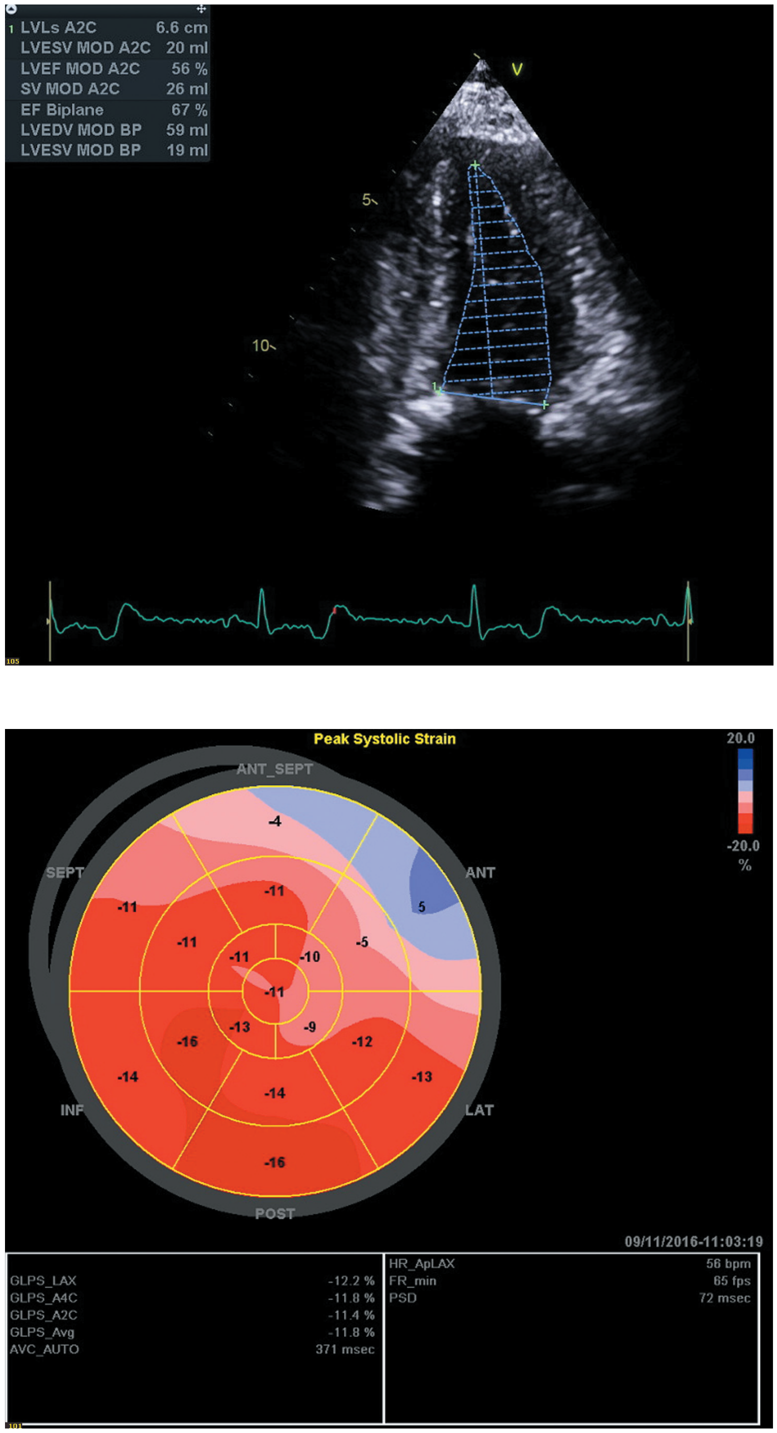

Figure 8. Valvular heart disease.

Dilated Cardiomyopathy	
Indication	• Heart failure • Dilated cardiomyopathy
Usefulness of Strain	• Dilatation causes impaired systolic function, which can be missed by LVEF alone. • GLS can detect changes in myocardium and monitor the progression of the disease process.
Echo Strain Imaging Findings	• LV dilatation causes thinning in the LV walls and/or increased LV mass and volumes leading to reduced strain values.[1,3]

GLS = global longitudinal strain; LV = left ventricular; LVEF = left ventricular ejection fraction.

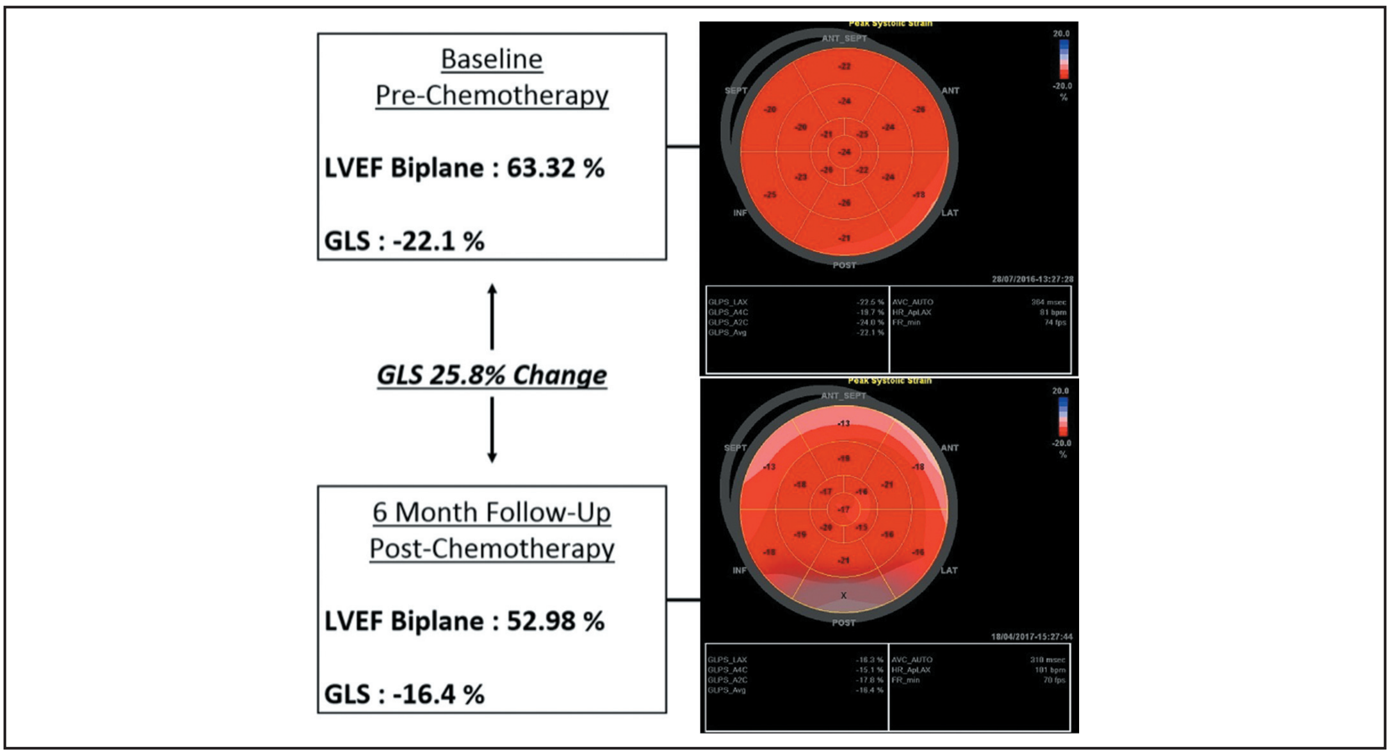

Figure 9. Abnormal LVEF and abnormal Strain.

Cardiac-Oncology	
Indication	• Cardiotoxic agents / Drug therapy • Heart failure
Usefulness of Strain	• Detect early myocardial changes from cardiotoxic drug therapy in comparison to LVEF by Simpson's Biplane method [11]. • Readily detect regional abnormalities in LV function. • Improved measurement reproducibility.
Echo Strain Imaging Findings	• 10~15% value change from baseline values indicate some level of change in tissue deformation, which could lead to LV dysfunction.[7,11]

LV = left ventricular.

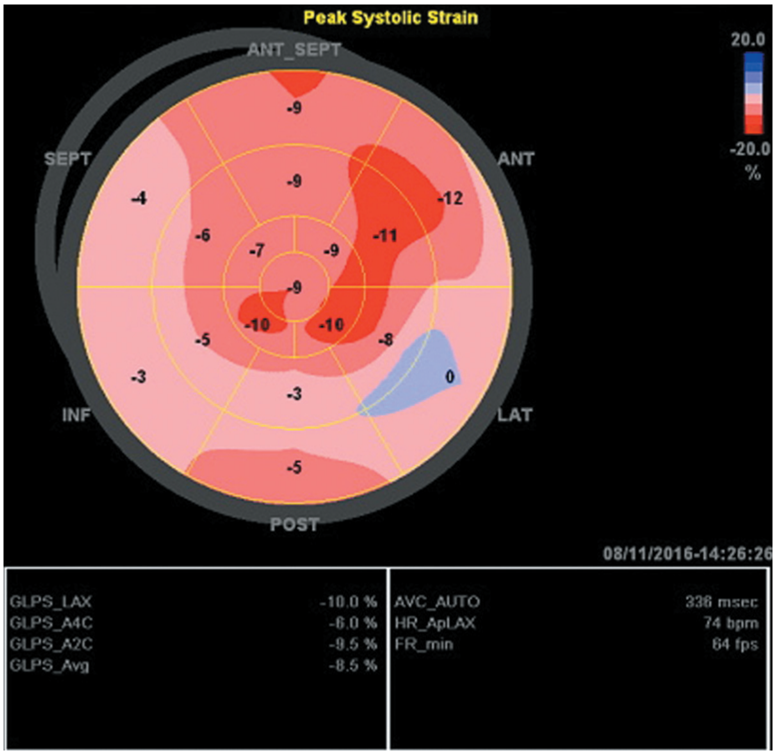

Figure 10. Cardiac oncology.

Conclusions

The most important clinical utility of strain echocardiography is its ability to detect early changes in myocardial dysfunction. As the diagnostic value of strain imaging grows, more emphasis will be placed on the clinical utility of this technique in routine practice. We hope that this three part series not only provides a better understanding of basic concepts and physics of the application, but serves as a primer for image acquisition, optimization and post processing for sonographers who wish to start performing longitudinal strain imaging.

References

1. Liu D, Hu K, Nordbeck P, et al. Longitudinal strain bull's eye plot patterns in patients with cardiomyopathy and concentric left ventricular hypertrophy. Eur J Med Res 2016;21:21.
2. Otto MC. Cardiomyopathies, Hypertensive and Pulmonary Heart Disease. Textbook of Clinical Echocardiography, 3rd ed. Elsevier Saunders. 2004; 227-59.
3. Sun JP, Steward WJ, Yang XS, et al. Differentiation of hypertrophic cardiomyopathy and cardiac amyloidosis from other causes of ventricular wall thickening by two-dimensional strain imaging echocardiography. Am J Cardiol 2009;103:411–5.
4. Reddy M, Thatai D, Bernal J, et al. Apical hypertrophic cardiomyopathy: potential utility of strain imaging. Eur J Echocardiog 2008;9:560–62.
5. Phelan D, Collier P, Thavendiranathan P, et al. Relative apical sparing of longitudinal strain using two-dimensional speckle-tracking echocardiography is both sensitive and specific for the diagnosis of cardiac amyloidosis. Heart 2012;98:1442–48.
6. Kocabay G, Muraru D, Peluso D, et al. Normal left ventricular mechanics by two-dimensional speckle-tracking echocardiography. Reference values in healthy adults. Rev Esp Cardiol 2014;67:651–58.
7. Negishi K, Negishi T, Haluska BA, et al. Use of speckle strain to assess left ventricular responses to cardiotoxic chemotherapy and cardioprotection. Eur Heart J – Cardiovasc Imaging 2014;15:324–31.
8. Urheim S, Edvardsen T, Torp H, et al. Myocardial strain by Doppler echocardiography: validation of a new method to quantify regional myocardial function. Circulation 2000;102:1158–64.
9. Tayyareci Y, Yildirimturk O, Aytekin V, et al. Subclinical left ventricular dysfunction in asymptomatic severe aortic regurgitation patients with normal ejection fraction: a combined tissue Doppler and velocity vector imaging study. Echocardiography 2010;27:260–68.
10. Lee JKT, et al. Early detection of subclinical myocardial damage in chronic aortic regurgitation and strategies for timely treatment of asymptomatic patients. Circulation 2018;137:184–96.
11. Thavendiranathan P, Poulin F, and Lim KD. Use of myocardial strain imaging by echocardiography for the early detection of cardiotoxicity in patients during and after cancer chemotherapy: a systematic review. J Am Coll Cardiol 2014;63:2751–68.

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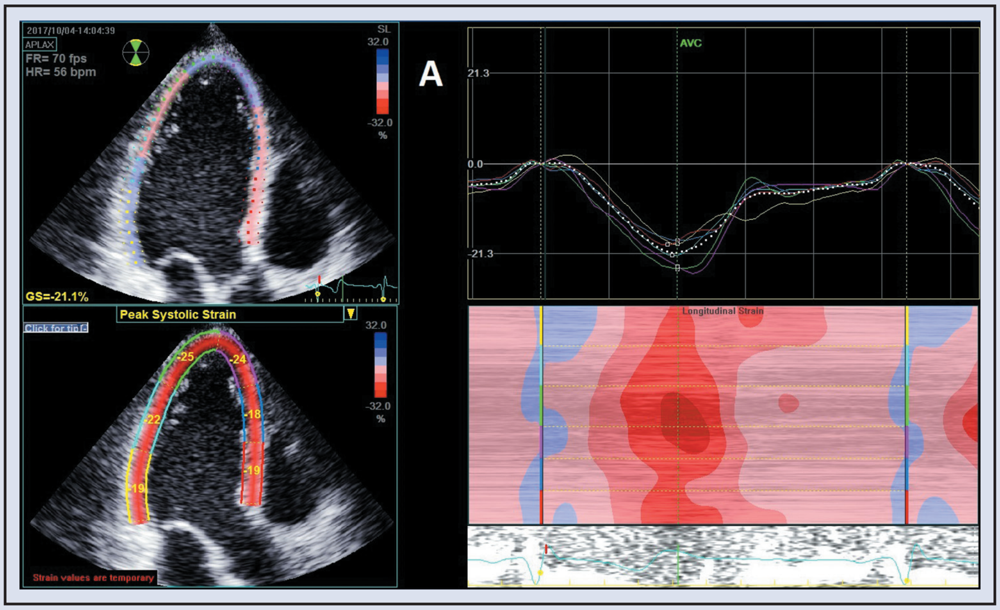
Article Name: Strain Imaging in Echocardiography
Part 3: Cardiac Pathology and Patterns of Strain

Author Names: Babitha Thampinathan, Marcello Seung Ju Na, Jennifer Lam

1. The image below demonstrates which of the following:



a) 3 chamber view with normal strain curves and bull's eye plot
b) 2 chamber view with normal strain curves and bull's eye plot
c) 3 chamber view with inferolateral wall motion abnormality and ischemia
d) 3 chamber view with increased wall thickness likely resulting from hypertension

2. When hypertensive findings are found via strain they can include all of the following except:

a) Overall average GLS is reduced
b) Thick hypertrophied papillary muscles
c) Hypertrophied regions have reduced myocardial deformation, therefore producing low strain values
d) Bull's eye plot will display shades of pale pink colours suggesting reduction in deformation

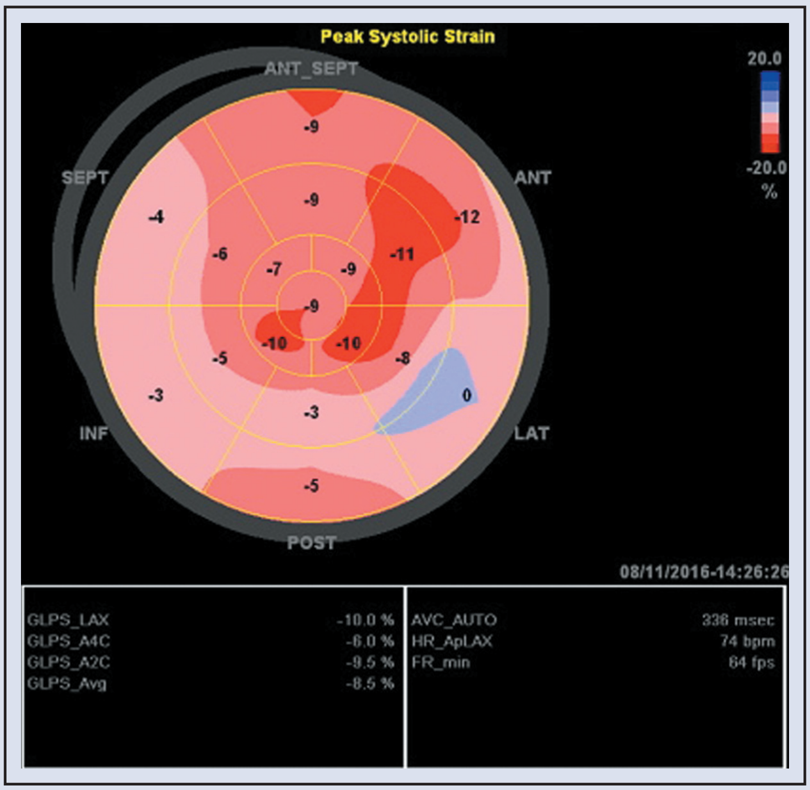
3. Reduced strain is usually in the ____________wall(s) during the late stages of Fabrys disease:

a) Anterior
b) Inferior
c) Lateral and posterior
d) Anterior and septal

4. Strain imaging has not been found to be useful in the assessment of valvular disease.

a) True
b) False

5. The following image demonstrates which pathology:



a) Amyloidosis
b) Valvular disease
c) Dilated cardiomyopathy
d) Ischemic wall motion abnormality

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Dr. Timothy Caulfield
Research Chair in Health Law and Policy, Professor in the Faculty of Law and the School of Public Health, and Research Director of the Health Law Institute at the University of Alberta

Relax Dammit: Healthy and Happy in the Age of Anxiety
In this presentation, Timothy Caulfield will explore all the things we all stress about in a typical day. We make, and worry about, a thousand big and little decisions during our waking hours. Too often these decisions are dictated by concerns or beliefs about our world that simply aren't true. These misperceptions impact our day-to-day decisions and, he will argue, unnecessarily stress us out and cause us to waste time and money.

CLOSING KEYNOTE

Paul Huschilt
Award Winning Speaker and Storyteller, Paul holds degrees in Management and Acting, a diploma in Career Counselling, training in Adult Education, and has sung with the Canadian Opera Company.

Everybody Stay Calm: Stress Strategies for your Changing World
We all need the tools to manage through dramatic shifts in our lives. Paul Huschilt takes us on an imaginative quest to fight workplace and other stress with humour. We'll learn positive solutions and tactics to deal with stress and change, and ways to stay resilient and healthy through difficult times. This virtual session is not only helpful – it's a lot of fun. You will laugh while you learn, and you may even find yourself breaking out in song.

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