WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
Coden USA: WJPRAP Impact Factor 8.453
Volume 14, Issue 20, 101-115. Review Article ISSN 2277–7105

INFLUENCE OF ULTRASONIC COMPRESSION ON TISSUE BIOCHEMISTRY AND BIOPSY PRECISION: A REVIEW

Haneen T. Ali[1]*, Abdulsahib S. Jubran[2], Ali Faisal Madhloom[2], Ameer Yousif[2]

*[1]Al-Furat Al-Awsat Technical University, Najaf, Iraq.

[2]University of Alkafeel, College of Dentistry, Najaf, Iraq.

Article Received on 26 Sept. 2025,
Article Revised on 16 October 2025,
Article Published on 16 October 2025,
https://www.doi.org/10.5281/zenodo.17471630

***Corresponding Author**
Haneen T. Ali
Al-Furat Al-Awsat Technical University, Najaf, Iraq.

How to cite this Article: Haneen T. Ali1*, Abdulsahib S. Jubran2, Ali Faisal Madhloom2, Ameer Yousif2 (2025). INFLUENCE OF ULTRASONIC COMPRESSION ON TISSUE BIOCHEMISTRY AND BIOPSY PRECISION: A REVIEW World Journal of Pharmaceutical Research, 14(20), 101–115.

ABSTRACT

The pancreas is usually the same throughout and has the same echo pattern as the liver or is slightly more echoic. The spleen is a wedge-shaped organ that is less than 12 centimetres wide from head to toe and less than 5 centimetres thick at the midaxillary line. It is frequently situated parallel to the left tenth rib. Graded compression is used in imaging the gastrointestinal tract to get rid of obstructive bowel loops that are full of gas and faeces, bring the area of interest closer, and check how stiff the tissues underneath are. The stomach is examined longitudinally and transversely using subxiphoid methods. A lateral trans-splenic view shows the fundus well. The distal oesophagus in the epigastric area can be seen by pointing the transducer cranially and using the left liver lobe as an auditory window. We obtained demographic and procedural data from patient records.

1.1. Overview

The standard ultrasonic examinations use curvilinear transducers (3.5 to 5 MHz), but phased-array or micro convex transducers may be effective. You can examine the digestive tract with high-frequency transducers. HOLA scanning helps.[1] Figure 1 details the recommended abdomen imaging method. Hepatic lobes and right, middle, and left hepatic veins create the IVC in oblique subcostal views.[2]

The evaluation of the hepatobiliary system, pancreas, and spleen culminates in intercostal, subcostal, and flank views. The best way to see the spleen is from the left posterolateral

intercostal approach. To display essential arterial structures, mid-abdominal and alternative (flank) perspectives are utilised. It is feasible to meticulously examine the small intestine in parallel, overlapping pathways. A cross-sectional examination of the colon is more prevalent for identifying its primary components. In the presence of intraperitoneal fluid, bowel loops are the most prominent structures observed.[3] The liver parenchyma must exhibit homogeneity and be isoechoic or marginally hyperechoic relative to the renal cortex.[4] The length and width of the GB often measure under 10 cm and beyond 5 cm, respectively. It exhibits cystic characteristics, including a smooth-walled margin, an anechoic interior, and distal acoustic amplification. The thickness of the GB's front wall must be under 3 mm, measured from the lumen to the liver parenchyma.[5]

Intrahepatic bile ducts are sometimes seen as anechoic, narrow, cylindrical tubes that run in front of and parallel to PV branches. This is especially true in older people. Finding the splenic vein behind the pancreas is a good way to see the organ. An acoustic window may be created by a stomach full of fluid.

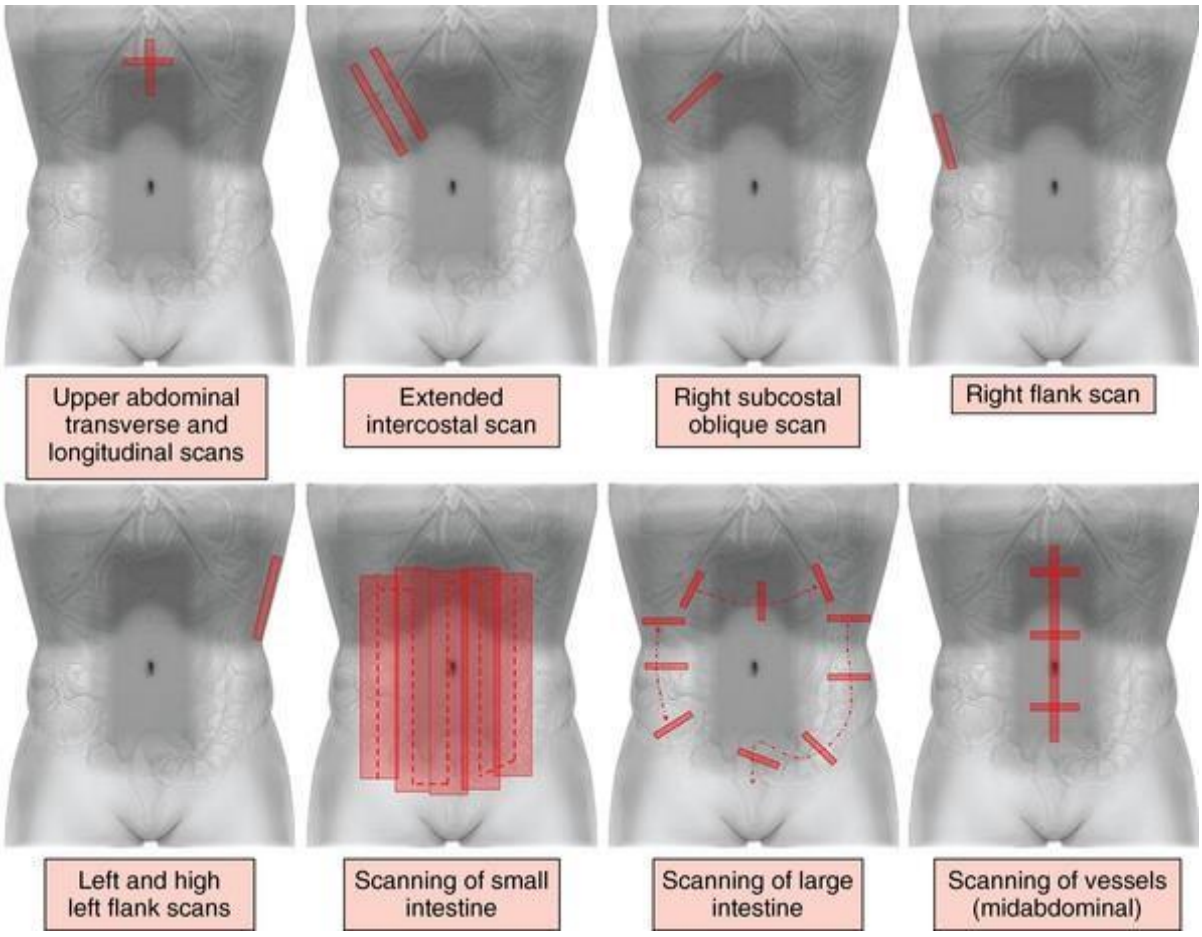

FIGURE 1: Conventional and additional abdominal imaging planes.

Compared to the liver, the pancreas is usually the same colour and has the same echo pattern. The spleen is an organ that looks like a wedge and is less than 12 centimetres wide from top to bottom and less than 5 centimetres thick from side to side (midaxillary line).[6] It is frequently orientated parallel to the left 10th rib. Graded compression is used to move gas and feces-filled bowel loops that are blocking the GI tract, bring the ROI closer, and check how stiff the tissues underneath. While the subxiphoid method scans the stomach longitudinally and transversely, a trans splenic view provides the best side view of the fundus. Turn the transducer head-on and listen to the left side of the liver to view the back of the oesophagus in the epigastrium. One useful instrument is the gastric tube. Part three of the pancreas is located between the aorta and the superior mesenteric artery, while the duodenum encircles the pancreatic head. Since it is physically impossible to scan the entire small intestine at once, it is instead scanned using lanes that are vertical, parallel, and overlapping.[7] A typical colonoscopy procedure begins with locating the cecum and continues with cross-sectional imaging of the colon until reaching the distal sigmoid. After much effort, the rectum is finally visible through the larger bladder. From the stomach all the way to the colon, the usual thickness of the bowel wall is around 2 to 4 mm, and it is composed of five concentric layers.

This is true for the part of the bowel that is farther away from the oesophagus. The small intestine is known for its strong peristalsis and valvulae conniventes (mucosal folds are easiest to see when the lumen is full of fluid). The large intestine has some important features, such as its constant position and haustra, which give the colon a segmented look, especially in the ascending and transverse parts.[8] The "3, 6, 9 rule" is a way to tell the difference between the small and large intestines and to find out if the intestines are getting too big. It says that the small intestine should be 3 cm, the colon should be 6 cm, and the cecum should be 9 cm. Doppler provides data on the principal mesenteric arteries and the overall vascularity of the gastrointestinal tract.[9]

1.2. Details regarding the technical aspects of abdominal ultrasound examination

Although phased-array or micro convex transducers may be more useful, standard ultrasonic exams usually use curvilinear transducers that operate at frequencies ranging from 3.5 to 5 MHz. The digestive system may be imaged using high-frequency transducers. Utilising HOLA scanning methods yields favourable results. Following a mostly sagittal course hypochondrium housing the right liver lobe, and finally, the main portal triad—the PV, CBD, and HA—with the PV situated posteriorly—this allows us to examine a number of

anatomical structures in sequence. You can also make out the liver, gallbladder (GB), right kidney, and Morison pouch. The inferior vena cava (IVC) is where the right and middle hepatic veins and lobes meet, as seen in oblique subcostal views. A thorough evaluation of the pancreas, spleen, and hepatobiliary system is completed using subcostal, intercostal, and flank views.[11] The spleen is best visualised using the left posterolateral intercostal approach. By using midabdominal and alternate flank views, one may discern major blood arteries. In contrast to the colon, which is often examined cross-sectionally to identify its primary segments, the small intestine is methodically studied in lanes that overlap and run parallel to one another. When fluid is present in the peritoneal cavity, bowel loops may be more easily seen.[12]

Ultrasound of the upper abdomen. The pancreas, left liver lobe, and midabdominal arteries are all visible in longitudinal views that go from front to back. The aorta and its proximal branch, the superior mesenteric artery, are situated in the middle (left). The inferior vena cava can be seen by slightly angling the transducer to the right. Bottom Looks from the side. The pancreas and midabdominal arteries may be imaged via the acoustic window that is the left liver lobe. There is a downward orientation to the transducer. The splenic vein by SpV, and the stomach by St, in particular the gastric antrum, are all parts of the anatomy of the anatomy of the body.[13]

Extended intercostal inspection. Gap or under the costal arch, both laterally and longitudinally to the midline. Because of their close proximity to one another, the three tubular constructions known as the "parallel channel sign"—the CBD, PV, and HA—are so named. The gallbladder (GB) can be seen in the longitudinal section (right) by repositioning the scan along the costal arch in the same direction. Bottom A scan of the right subcostal area taken at an angle. A small angle is formed between the transducer and the right costal arch when it is placed beneath the arch. At a point slightly under the right side of the diaphragm, the hepatic veins—labeled as LHV, MHV.[14]

Bottom The transducer is orientated upwards to see the spleen (SPL) in longitudinal section for left and high left flank (intercostal) scans, which include positioning it in an intercostal gap above the left flank. At the left side splenic hilum, you may find the spleen's length and thickness. The splenorenal space may be examined by moving the transducer caudally from the high flank scan, which visualises the left kidney (LK) in the longitudinal section posterior to the spleen.[15]

Using parallel overlapping lanes allows for a systematic examination of the small intestine. Small intestinal loops are better seen when intraperitoneal fluid (F) is present. Bottom While scanning the ascending colon in a longitudinal plane reveals its typical haustration, a cross-sectional examination of the colon delineates important colonic parts, such as the cecum and ileocecal valve. Commonplace images of the abdominal arteries taken in the middle of the belly. You may see the aorta, inferior vena cava, coeliac axis, and superior mesenteric arteries at the front of the spine when you look at the abdomen from the side or the top. With Ao being the aorta and CA the coeliac artery and HA the hepatic artery and IVC the inferior vena cava structures in the body. Scan the abdominal vessels from the side. Alternative right flank views in supine patients in the critical care unit may be used to visualise major abdominal vessels when midabdominal scanning is not possible due to trauma, aerosol presence, or surgical circumstances. In order to see the aorta and inferior vena cava (IVC), the transducer and scanning plane need to be tilted and rotated according to the patient's position.[16]

While ultrasound isn't always the best way to gauge liver size, a healthy liver should have a right lobe diameter of less than 16 cm when measured at the midaxillary line. In contrast to The gallbladder (GB) has a pear-shaped shape and a length and width that are similar; the length is usually less than 10 cm and the width is more than 5 cm. Cystic features, such as an anechoic interior, smooth margin wall, and distal acoustic amplification, are shown by the entity. The thickness of the gallbladder's front wall, as measured between the liver parenchyma and the lumen, should not be more than 3 mm. Though it may grow to 10 mm in the elderly or 12 mm after a cholecystectomy, the CBD typically has a maximum diameter of around 7 mm. Slender, anechoic cylindrical structures running anterior to and parallel to the branches of the portal vein are intrahepatic bile ducts, which are more often seen in elderly persons. To find the pancreas, look for the splenic vein that runs behind it. An acoustic window may be created by filling the stomach with liquids. Typically, the pancreas looks the same as the liver, which is isoechoic or slightly hyperechoic.[17]

The presence of gas and faeces may obscure imaging of the gastrointestinal system, although graded compression can help move the bowel loops out of the way. This measures the underlying structures' stiffness while decreasing the distance from the return on investment. The subxiphoid approach allows for a transverse and longitudinal examination of the stomach; a lateral trans splenic view is ideal for visualising the fundus. One way to see the oesophagus's distal end in the epigastric area is to it encircles the pancreatic head. Although it

is not possible to inspect the whole small intestine at once, a broad evaluation may be carried out by using lanes that are vertical, parallel, or overlapping. It is standard practice to carefully trace the ascending, transverse, and descending portions of the colon to the distal sigmoid inside the pelvis in order to examine it in cross sections once the cecum has been identified. The rectum may lastly be seen via an enlarged bladder.[18]

The normal bowel wall consists of five closely arranged layers (distal to the oesophagus), with a consistent thickness ranging from 2 to 4 mm from the stomach to the colon. The small intestine differs from other body parts due to its robust peristalsis and the presence of valvulae conniventes, which are mucosal folds that are most visible when the lumen is filled with fluid. The large intestine comprises significant components, such as its fixed position and haustra, which create a segmented appearance, particularly in the ascending and transverse regions. The "3, 6, 9 rule" assists in identifying intestinal dilatation and differentiating the small intestine from the large intestine by indicating the maximum normal diameters: small intestine ≤3 cm, colon ≤6 cm, and cecum ≤9 cm. Doppler provides insights into the primary mesenteric vessels and the overall vascularity of the gastrointestinal tract.[18,19]

1.3. Disorders affecting the hepatobiliary system, pancreas, and spleen

For the assessment of abdominal masses, as precision medicine has become more popular, percutaneous biopsy has become an even more important part of diagnosing, characterising, and treating a wide range of tumour types.[19] Radiology has long used imaging guidance for biopsies, which has made percutaneous treatments safer and more likely to work. A good biopsy should get the most information about the tumour while keeping the patient safe. To reach all of these goals, you need to carefully watch the target and figure out a safe way to get to it. The most common imaging guidance methods are CT and ultrasound (US). US is faster, easier to move around, and cheaper than CT. It also doesn't use ionising radiation.[20]

The system facilitates real-time imaging through a viewing window that can be rotated and tilted in six distinct orientations, corresponding to three Cartesian coordinates. Ultrasound may provide enhanced lesion visibility and tissue contrast relative to CT fluoroscopy, which is often conducted without the use of intravenous or oral contrast agents. Moreover, colour Doppler aids in the identification of vascular structures along the anticipated trajectory. CT guidance is increasingly employed for percutaneous biopsy in multiple sites due to the

operator-dependent nature of ultrasound, which can vary in effectiveness based on the operator's expertise and comfort with the procedure.

Certain operators may overlook US guidelines regarding biopsies in large patients or for accessing deep abdominopelvic targets[8]; however, this is not universally applicable. Prior research indicates that CT-guided biopsies may offer greater benefits for small, deep lesions. Ongoing advancements in American technology, particularly in US contrast agents that enhance visualisation and targeting, necessitate a reassessment of the topic. Returning to the US may prove to be cost-effective, efficient, and safe, particularly as the prevalence of image-guided treatments increases.[21]

When the transducer is compressed, the distance from the skin to the target may be shorter during biopsies. This makes the target easier to see and the needle more accurate. Also, compressing the abdominal tissue could move things inside, like the bowel and mesentery. These structures can be consistently repositioned to circumvent the biopsy needle's trajectory, thereby mitigating unnecessary harm and reducing complications. The goal of this study was to find out how well active ultrasound compression works to shorten the distance between the skin and the biopsy target compared to computed tomography (CT) and to find a safe way to do a percutaneous biopsy on deep tissues in the abdomen and pelvis.[22]

1.4. Guidance

Mechanical biopsy guide versus freehand. If the operator knows how to use either system, they both work well. The Freehand technique can help you see the needle better (more specular reflection if you choose the right angles), but it usually takes with simulated overlying ribs was utilised in a study. The authors determined that probe guides conferred a temporal advantage, particularly for novice operators.[23]

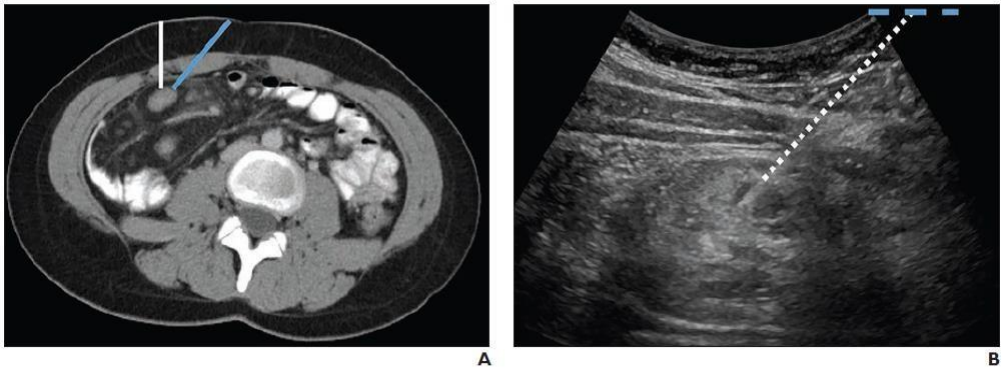

FIGURE 2: The white line shows that the shortest distance from the skin to the perpendicular node is about 4.4 cm. A oblique method (blue line) could have been used with CT to get a longer surgical core and avoid hitting the bowel and mesenteric blood vessels directly. About 6 centimetres separate the two points. An ultrasound picture taken during a biopsy with the tissue compressed and the needle in place shows a more angled approach (dotted line). Even though compression has been used, the gap is still about 6 cm. The dashed line shows where the skin is thought to be.

In our laboratory, a biopsy guide is utilised for the majority of deep abdominal biopsies; however, superficial biopsies, such as those performed on the thyroid, breast, or groin, are conducted freehand. It is important to recognise that a guide serves merely as a reference and does not guarantee outcomes, particularly when dealing with thin needles, cirrhotic livers, or any rigid structures adjacent to the liver, such as ribs, which may alter the needle's trajectory (Fig. 1). Should the trajectory consistently deviate to one side, it is possible to adjust the projected path outside the lesion to accommodate the extent of deviation, similar to compensating for wind or elevation factors in rifle aiming (Fig. 2).

In certain laboratories, the radiologist assists during the needle insertion procedure. This necessitates greater manual dexterity, yet it provides enhanced control over the needle's positioning. In our laboratory, sonographers perform scans and assist in typically the most effective technical scanners. The laboratory conducts approximately annually, providing sonographers with substantial experience and expertise, despite the continual turnover of residents and fellows. This enables the provision of more consistent quality. The division of labour allows individuals to concentrate on specific tasks, with sonographers handling the probe and guidance, while sociologists manage the needle and specimen collection. The most complex unfeasible for a single individual to perform.[24]

1.6. Data Gathering and Verification

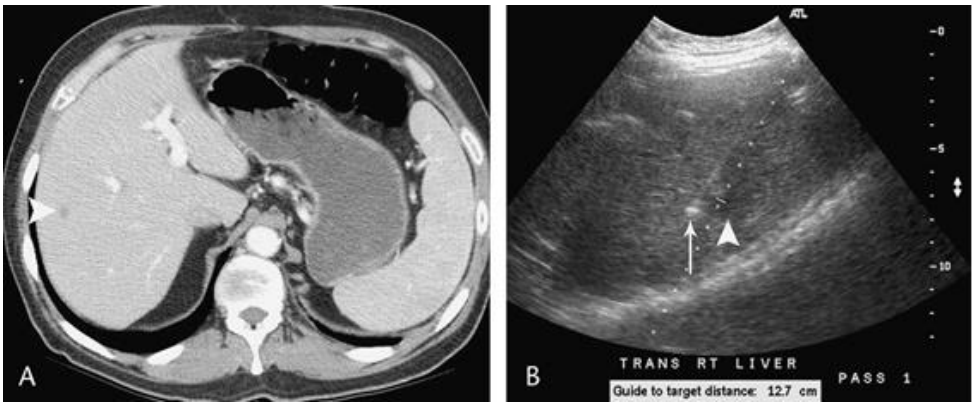

FIGURE 3: The needle deviates from the guidance. Metastatic pancreatic adenocarcinoma was diagnosed after three fine-needle aspirations of this lesion (arrowhead in CT [A]). Because the tissues above the 20-gauge needle drove it off course, the initial pass was lateral (B) to the lesion (arrowhead). Second and third passes (not visible) were inside the lesion and tumour, respectively. The arrow points to the needle tip.

The other measurement was the most likely path for the needle to take during a CT-guided biopsy (the most likely path). This needle path was made to stay away from any structures that could cause problems, like solid organs, bowels, and bones (Fig. 1). We thought about longer biopsy core lengths and drew needle paths that would let more tissue in with each pass. CT did not find a safe way for 4 of the patients (10%). A fellowship-trained abdominal radiologist who did US- and CT-guided biopsies checked the most likely needle paths for biopsy measurements.

The US pictures taken during the process measured the skin-to-biopsy target distances, including real-time compression. In this case, the ultrasonography may not have shown the needle's whole tissue path. Biopsy sonograms sometimes didn't reveal where the needle entered into the skin. Thus, the skin surface in the sonographic window was stretched horizontally until it crossed the needle route (Fig. 1) to approximate it. Medical students collected data under the supervision of a fellowship-trained abdomen radiologist who examined needle routes.

1.7. DISCUSSION

The study showed that qualitative ultrasound analysis can detect fatty liver disease and cirrhosis in human patients in experimental liver disease models. Ultrasound imaging on mice

is cheap, easy, and widely available. It simply needs a little sedation and abdominal shaving to get photos without immobility or apnoea.[39] A low-risk surgery. It is the most used method for liver disease assessment in people and small animals and is exact, safe, and non-invasive.[1,18–21]

Though ultrasound is subjective, its efficacy as a liver imaging technology has been well documented in humans, dogs, and cats. Rodent liver disease models are typically used in pre-clinical research, therefore we used one. Rats were used as a model because, in comparison to mice, their bigger size enhances ultrasound imaging. A homogenous parenchyma with minimal echogenicity and a regular liver surface was seen in healthy rats, as is the case in people, dogs, and cats.[21,23] Echogenicity in the liver was lower than in the right renal cortex, which is in line with canine research but contradicts human results. The degree to which normal cats' kidneys are echogenic varies. Liver homogeneity and widespread enhancement of echogenicity (a "bright liver") was at least as high as that of the right renal cortex in fatty liver disease rats. In contrast to humans, canines, and felines, the diaphragm and tiny peripheral arteries were more difficult to see, and the surface of the liver did not change.[21,23]

Liver echogenicity is increased[21,23] due to fatty infiltration and/or fibrosis, which alters the link.[21,22] Following prior research, this finding has (76.9%), a high sensitivity (90). Fatty liver disease may be positively predicted with a 96% to 100% positive predictive value by the elevated hepatic echogenicity, which has a sensitivity ranging from 60% to 82%.[1,23] Before utilising this approach, make sure you don't have any kidney issues.[23] We found no abnormalities in the liver ultrasound of three rats that had mild steatosis.[23] Ultrasound has a sensitivity of 90-91% for severe steatosis and only 30-64% for mild steatosis. A broad, coarse, and heterogeneous parenchyma connected to an uneven or nodular hepatic surface was associated with an 87.5% accuracy rate, 100% positive predictive value, 100% specificity, and 70.6% sensitivity in the diagnosis of cirrhosis in dogs and humans.[23] This factor verified cirrhosis since it did not provide any misleading negative results. So, in long-term studies, US imaging may successfully detect rat cirrhosis without the need to kill animals or do several liver biopsies.

To assess liver disease severity, portal hypertension is significant.[20,21] Widening of the portal vein is a key symptom.[20,21] A substantial difference in PVD was found between cirrhotic and non-cirrhotic rats ($p < 0.001$). An increase in its calibre of 2.1 mm or more is a significant ultrasonography finding for cirrhosis identification, with 100% sensitivity, 90%

specificity, 89.5% positive predictive value, and 100% negative predictive value. A rat with hepatic steatosis and fibrosis was the false positive. No rats with PVD less than 2.1 mm had cirrhosis, so there were no false negatives. PVD measures couldn't distinguish between normal and steatotic livers since normal and steatosis/fibrosis animals had equal PVD values. Fatty liver disease does not cause portal hypertension and portal vein dilatation, thus this is expected. We tried Doppler to examine the portal vein, but technological issues prevented it. We couldn't create apnoea, the calliper wouldn't hold stationary in such a small channel, and even normal rats had whirl flow, which switched between hepatorenal and hepatomegaly. Vörös et al. found that ascites, a marker of liver disease severity, can be detected even with minor peritoneal fluid accumulation. Ultrasound is best for ascites imaging.[6,21,23] It significantly linked with cirrhosis in histological analysis in our study, even though only 5 of 17 cirrhotic rats had ascites. Ascites only occur in decompensated cirrhosis, therefore this was expected. While splenomegaly CT is increasingly preferred for biopsy, especially at large academic institutes. This may be because it is more accessible, professionals are more familiar with it, and it is simpler than the US. US is tougher to show and document the needle inside the lesion than CT, which may deter some from utilising it. In precision medicine, when patients get more biopsies and passes per procedure,[23] a US-guided core biopsy is fast, safe, and cheap. Ultrasound using colour Doppler flow or ultrasound contrast helps pinpoint viable mass components for sophisticated testing like next-generation sequencing, where necrotic material is unsuitable. New ultrasound adjuncts like contrast administration and fusion software can improve visualisation and targeting.[24]

Finally, lesion 0–3 cm deep with solid and cystic features are biopsied frequently. Since the solid section of the lesion is optimal for sampling, US measurements were taken there. However, CT-guided measurements were performed from the lesion's closest area to the individual. Since the distance is short, US with compression can still help. For targeting and biopsy, transducer compression and pressure can pin or stabilise a movable omental lesion. Compression may also block the peristaltic bowel.[22,23-24]

We estimated skin distance by drawing a tangent line to the skin to get US measurements. All measurements were proxies for compression, which was hard to measure. Finally, two persons do US-guided biopsies at our hospital, allowing the sonographer to modify compression for optimal results. US and US-guided biopsies depend on the operator's

competence and experience, making it tougher to acquire the same results elsewhere. This hospital's radiologists have a wide spectrum of experience, and trainees routinely participate.

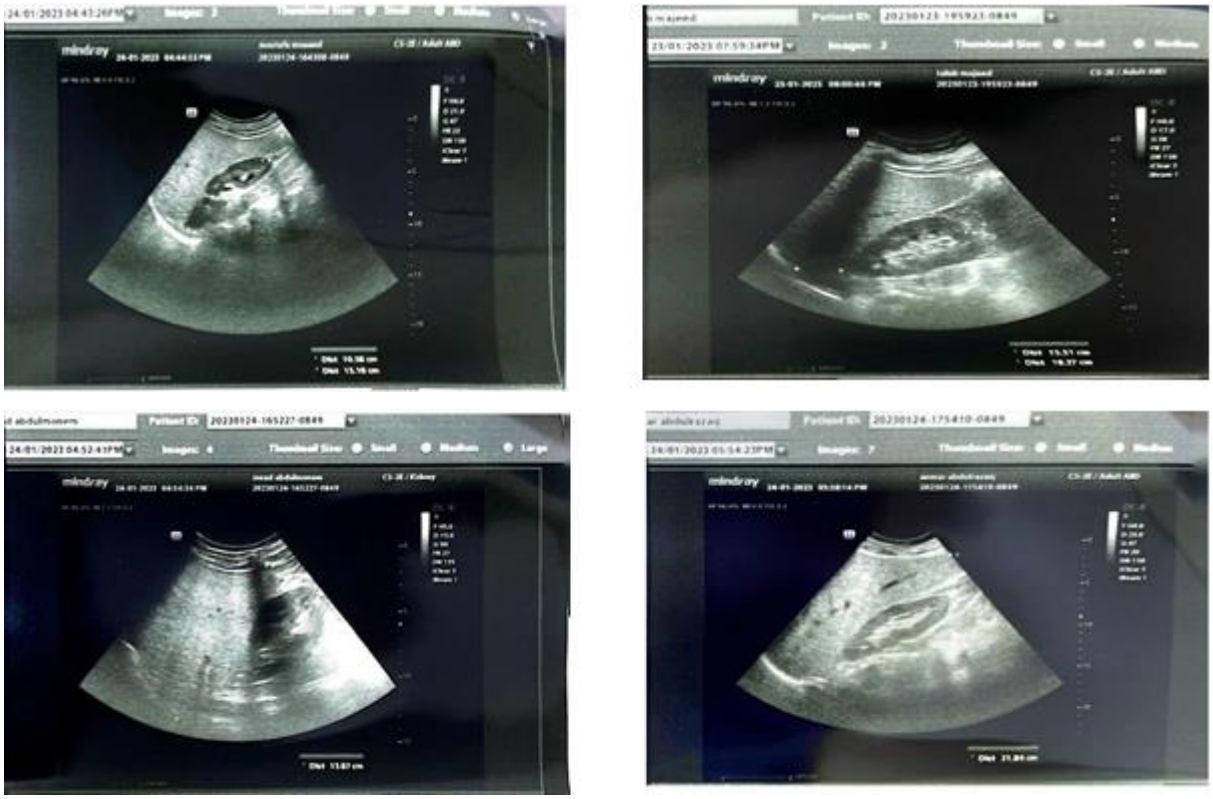

FIGURE 4: Examples of ultrasound sonar for a different patent with various liver diseases.

1.8. CONCLUSION

The majority of individuals with fatty liver are asymptomatic; clinical manifestations arise solely in the later stages of the condition. Even general practitioners don't know much about how to diagnose, treat, and manage NAFLD, so many patients with high-risk NAFLD go undiagnosed. Over-reliance on transaminase measurement for diagnosing fatty liver disease may lead to underdiagnosis of NAFLD. Liver biopsy is the best way to find out if someone has fatty liver, but it can't be done on everyone. Ultrasonography, a straightforward and noninvasive technique, can facilitate the early identification of fatty liver in asymptomatic individuals. This method can also be used to predict future comorbidities and help doctors suggest blood tests and talk to patients about how to manage their condition or take steps to avoid getting sick again.

REFERENCES

1. Kim JW, Shin SS. Ultrasound-guided percutaneous core needle biopsy of abdominal viscera: tips to ensure safe and effective biopsy. *Korean J Radiol*, 2017; 18: 309–322.
2. Sabir SH, Krishnamurthy S, Gupta S, et al. Characteristics of percutaneous core biopsies adequate for next generation genomic sequencing. *PLoS One*, 2017; 12: e0189651.
3. Ho LM, Thomas J, Fine SA, Paulson EK. Usefulness of sonographic guidance during percutaneous biopsy of mesenteric masses. *AJR*, 2003; 180: 1563–1566.
4. J.J. Park, C.K. Kim, B.K. Park, Ultrasound-Guided Transvaginal Core Biopsy of Pelvic Masses: Feasibility, Safety, and Short-Term Follow-Up, AJR Am J Roentgenol, 2016; 206: 877–882. https://doi.org/10.2214/AJR.15.15702 . - DOI - PubMed
5. S.K. Plett, L. Poder, R.A. Brooks, T.A. Morgan, Transvaginal Ultrasound-Guided Biopsy of Deep Pelvic Masses: How We Do It, J Ultrasound Med., 2016; 35: 1113–1122. https://doi.org/10.7863/ultra.15.08002 . - DOI - PubMed
6. S.G. Yarram, H.V. Nghiem, E. Higgins, G. Fox, B. Nan, I.R. Francis, Evaluation of ImagingGuided Core Biopsy of Pelvic Masses, American Journal of Roentgenology, 2007; 188: 1208–1211. https://doi.org/10.2214/AJR.05.1393 . - DOI - PubMed
7. G. Dadayal, M. Weston, A. Young, J.L. Graham, K. Mehta, N. Wilkinson, J.A. Spencer, Transvaginal ultrasound (TVUS)-guided biopsy is safe and effective in diagnosing peritoneal carcinomatosis and recurrent pelvic malignancy, Clin Radiol., 2016; 71: 1184–1192. https://doi.org/10.1016/j.crad.2016.06.119 . - DOI - PubMed
8. K.A. Scanlan, P.A. Propeck, F.T. Lee, Invasive Procedures in the Female Pelvis: Value of Transabdominal, Endovaginal, and Endorectal US Guidance, RadioGraphics., 2001; 21: 491–506. https://doi.org/10.1148/radiographics.21.2.g01mr21491 . - DOI - PubMed
9. S. Gupta, H.L. Nguyen, F.A. Morello, K. Ahrar, M.J. Wallace, D.C. Madoff, R. Murthy, M.E. Hicks, Various approaches for CT-guided percutaneous biopsy of deep pelvic lesions: anatomic and technical considerations, Radiographics., 2004; 24: 175–189. https://doi.org/10.1148/rg.241035063 . - DOI - PubMed
10. G. Kossoff, K.A. Griffiths, C.E. Dixon, Is the quality of transvaginal images superior to transabdominal ones under matched conditions?, Ultrasound in Obstetrics & Gynecology, 1991; 1: 29–35. https://doi.org/10.1046/j.1469-0705.1991.01010029.x . - DOI
11. I.A. Qureshi, H. Ullah, M.H. Akram, S. Ashfaq, S. Nayyar, Transvaginal versus transabdominal sonography in the evaluation of pelvic pathology, J Coll Physicians Surg Pak., 2004; 14: 390– 393. - PubMed.

12. S. Nahlawi, N. Gari, Sonography Transvaginal Assessment, Protocols, And Interpretation, in: StatPearls, StatPearls Publishing, Treasure Island (FL), 2022; http://www.ncbi.nlm.nih.gov/books/NBK572084/ (accessed February 15, 2022).
13. M.J. O'Neill, E.A. Rafferty, S.I. Lee, R.S. Arellano, D.A. Gervais, P.F. Hahn, I.C. Yoder, P.R. Mueller, Transvaginal Interventional Procedures: Aspiration, Biopsy, and Catheter Drainage, Radio Graphics, 2001; 21: 657–672. https://doi.org/10.1148/radiographics.21.3.g01ma20657 . - DOI - PubMed
14. G. Zanetta, D. Trio, A. Lissoni, C. Dalla Valle, G. Rangoni, M. Pittelli, M. Marzola, A. Pellegrino, Early and short-term complications after US-guided puncture of gynecologic lesions: evaluation after 1,000 consecutive cases, Radiology, 1993; 189: 161–164. https://doi.org/10.1148/radiology.189.1.8372188 . - DOI - PubMed
15. A. Thabet, B. Somarouthu, E. Oliva, D.A. Gervais, P.F. Hahn, S.I. Lee, Image-Guided Ovarian Mass Biopsy: Efficacy and Safety, Journal of Vascular and Interventional Radiology. 25 (2014) 1922-1927.e1. https://doi.org/10.1016/j.jvir.2014.08.009 . - DOI - PubMed A. Leibman, B. Kruse, M. McSweeney, Transvaginal sonography: comparison with transabdominal sonography in the diagnosis of pelvic masses, American Journal of Roentgenology, 1988; 4.
16. M. Niazi, M.M. Kamal, N. Malik, M.A. Farooq, N. Wahid, Transabdominal Vs Transvaginal Sonography - Comparison in Pelvic Pathologies, Journal of Rawalpindi Medical College. (n.d.) 4.
17. S. Sugawara, M. Sone, C. Itou, S. Kimura, M. Kusumoto, T. Kato, K. Yonemori, Y. Yatabe, Y. Arai, Analysis of factors affecting the diagnostic yield of image-guided percutaneous core needle biopsy for peritoneal/omental lesions, Abdom Radiol (NY), 2021; 46: 4499–4508. https://doi.org/10.1007/s00261-021-03088-7 . - DOI - PubMed
18. W.J. Walker, K. Jones, Transvaginal ultrasound guided biopsies in the diagnosis of pelvic lesions, Minimally Invasive Therapy & Allied Technologies, 2003; 12: 241–244. https://doi.org/10.1080/13645700310015329 . - DOI
19. D. Sacks, T.E. McClenny, J.F. Cardella, C.A. Lewis, Society of Interventional Radiology Clinical Practice Guidelines, Journal of Vascular and Interventional Radiology, 2003; 14: S199–S202. https://doi.org/10.1097/01.RVI.0000094584.83406.3e . - DOI - PubMed
20. R.L. Faulkner, L. Mohiyiddeen, R. McVey, H.C. Kitchener, Transvaginal biopsy in the diagnosis of ovarian cancer, BJOG: An International Journal of Obstetrics & Gynaecology, 2005; 112: 991–993. https://doi.org/10.1111/j.1471-0528.2005.00619.x . - DOI

21. E. Volpi, P. Zola, T. De Grandis, A. Rumore, T. Volpe, P. Sismondi, Transvaginal sonography in the diagnosis of pelvic malignant recurrence: integration of sonography and needle-guided biopsy: Malignant recurrence and needle biopsy, Ultrasound Obstet Gynecol, 1994; 4: 135–138. https://doi.org/10.1046/j.1469-0705.1994.04020135.x . - DOI - PubMed
22. S.Y. Won, H.-S. Kim, S.Y. Park, Transrectal or transvaginal ultrasoundguided biopsy for pelvic masses: external validation and usefulness in oncologic patients, Ultrasonography, 2019; 38: 149–155. https://doi.org/10.14366/usg.18028 . - DOI - PubMed
23. N. Griffin, L.A. Grant, S.J. Freeman, M. Jimenez-Linan, L.H. Berman, H. Earl, A.A. Ahmed, R. Crawford, J. Brenton, E. Sala, Image-guided biopsy in patients with suspected ovarian carcinoma: a safe and effective technique?, Eur Radiol., 2009; 19: 230–235. https://doi.org/10.1007/s00330-008-1121-8. - DOI - PubMed
24. M. Elissa, M.G. Lubner, P.J. Pickhardt, Biopsy of Deep Pelvic and Abdominal Targets With Ultrasound Guidance: Efficacy of Compression, AJR Am J Roentgenol., 2020; 214: 194–199. https://doi.org/10.2214/AJR.19.21104 . - DOI - PubMed.