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REVIEW

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Complexities in liver biopsy: the role of navigation and fusion imaging

Serah Jessy Mathew[1], Anchal Nayak[2], Sagnika Dash[1] and Sarada Prasad Dakua[1*]

Abstract
Liver biopsy is crucial to know if the tumor is benign or malignant. This paper has reviewed the literature clinically shedding lights on the present biopsy procedure, requirements, and potential challenges. This study has emphasized the role of navigation during liver biopsy. It has discussed the various imaging modalities used for biopsy. The potential limitations of imaging modalities have been discussed in detail. It is found that liver biopsy could be effective when fusion imaging is used instead of a single imaging modality.

Keywords Liver biopsy, CT, MRI, US, Navigation, Fusion imaging

Introduction

The anatomical structure of the liver is very complex, and under this circumstance, it is very difficult to locate a hepatic tumor. Furthermore, if the tumor size is small (say, less than 1 cm), it would complicate the biopsy procedure to know whether the tumor is benign or malignant [1, 2]. Navigation could probably be the ideal technology to assist the radiologists while performing biopsy on such small tumors or lesions. The general workflow of liver biopsy is provided in Fig. 1 for easy reference, starting from blood test until patient recovery. Since ultrasound (US) is usually preferred due to its low cost and no radiation nature, it is generally used for navigation. Whether it is biopsy or intra-operative US navigation, the liver architecture must be completely understood along-with the liver transection line. Clinical dependability on medical imaging systems has been on rise in recent years. However, the accuracy of the diagnosis or treatment outcomes is still limited because of its strong reliance on the operating clinician's knowledge/experience to use analyze US images [3]. This issue could be addressed by the real-time virtual sonography (RVS) [4]. In order to properly identify the safety margins protecting the nearby crucial hepatic vasculature, it is highly essential to locate the lesions as precisely as possible [5]. The identification of the lesions can be done in US but due to certain limitations of the US, visibility of the lesions might be challenging [6]. Furthermore, small lesions or vanishing lesions, in particular, need efficient techniques for localization. The navigation could enable the biopsy relatively easy for lesion localization in a biopsy or other interventional procedures such as ablation [5]. The use of image fusion, between two imaging modalities, can benefit biopsy or percutaneous thermal ablation. To elaborate on the benefits of image fusion, we could imagine the following scenarios: a very important risk for contemplation during a liver biopsy is accidental damage to nearby organs such as the gallbladder or lung causing hemorrhage because of the tissue properties [7–9]. A malignant lesion biopsy also carries the risk of tumor dissemination, typically along the biopsy tract [10]. These complications could potentially be addressed by enhanced visualization and imaging fusion could enable this. The aim of this review is to provide an overview of the potential advantages and limitations of computed tomography (CT) and ultrasound (US) imaging along with the impact of the fusion

*Correspondence:
Sarada Prasad Dakua
sdakua@hamad.qa
[1] Department of Surgery, Hamad Medical Corporation, Doha, Qatar
[2] Department of General Medicine, Charles University, Prague, Czech Republic

of real-time CT-US with navigation in liver biopsy procedures [11]. The abbreviations are provided in Table 1.

Importance of imaging modalities

Medical imaging modalities aim to visualize human anatomy exposing the internal structures beneath the skin and bones. This helps the clinicians in providing appropriate diagnosis and intervention. It also facilitates the patient follow-up to understand the prognosis of the disease. For intervention, imaging guidance helps in inserting the needle probe and identify the borders of ablation in thermal ablation procedures [12]. Imaging modalities like CT and MR (as shown in Fig. 2) help in establishing the groundwork; they provide high-resolution images of the organs [13, 14]. However, MRI is an expensive modality [15, 16], and it has lengthy examination time. At the same time, CT has high ionizing radiation, which neither the patient nor the clinician wants. In addition, they cannot be used intra-operatively [17], whereas the ultrasound comes out to be the open contender among these imaging modalities.

Importance of US

As mentioned in "Importance of imaging modalities" section, intraoperative US (IOUS) is crucial for hepatobiliary phase (HBP) surgery. The most familiar imaging guidance

Table 1 Abbreviations

Abbreviation	Full form	Abbreviation	Full form
3D	3-dimensional	RVS	Real-time virtual sonography
MRI	Magnetic resonance imaging	IOUS	Intraoperative US
HBP	Hepatobiliary phase	GUI	Graphical user interface
EMT	Electro-magnetic tracking	IF	Image fusion
CE-MRI	Contrast-enhanced MRI	CE-US	Contrast-enhanced US
US	Ultrasound	CT	Computerized tomography

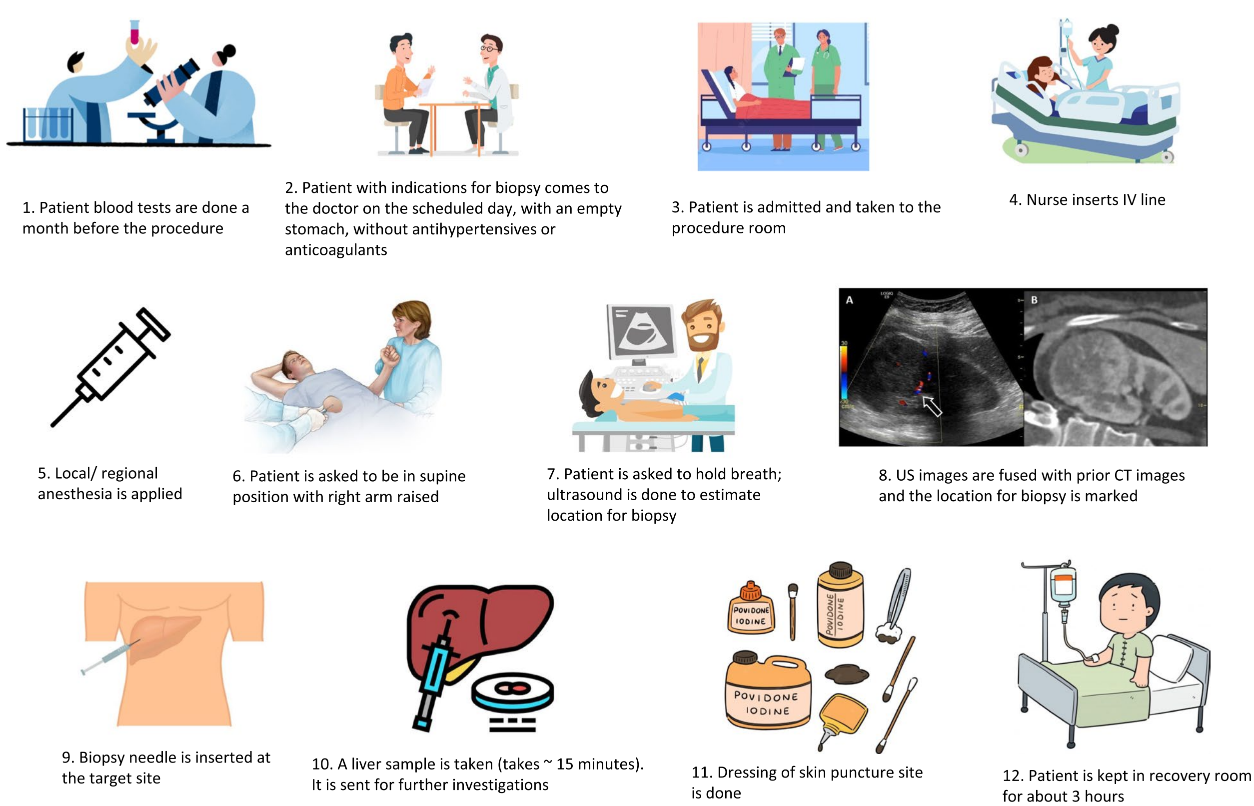

Fig. 1 General workflow of liver navigation

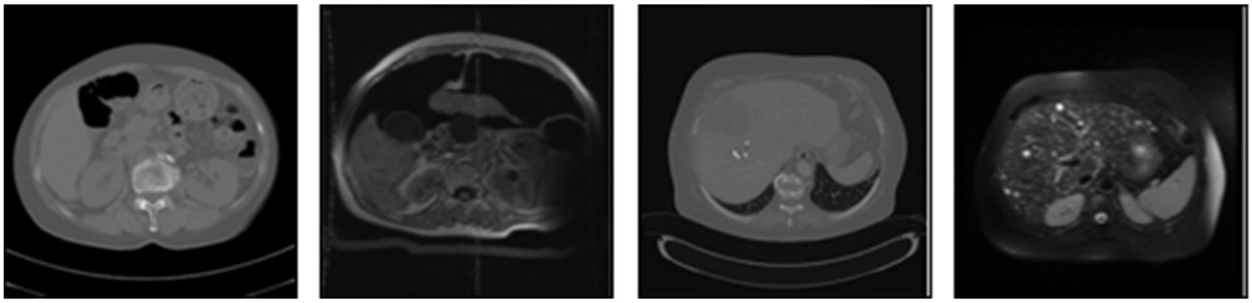

Fig. 2 Liver imaging modalities

modality seen for procedures of the abdomen is US [18]. The US generates two-dimensional images of the body and offers the advantage of multi-plane and multi-angle anatomical visualization [15]. It is readily accessible, does not emit ionizing radiations, and offers real-time imaging. US also offers a decent natural contrast between the tumors (although less than CT or MRI), parenchyma, cysts, etc. [19]. The positioning feedback offered by IOUS is crucial during hepatic surgery especially if small deep-seated lesions are involved, as it demonstrates the precise location of the surgical attempts when accompanied by 3D simulation. It is also useful to mark important anatomical landmarks that increases clarity of certain intra-hepatic vessels near the lesion that can be met with during the intervention and ensures proper surgical margins [18], and appropriate vessel segmentation is needed [20, 21]. Image-to-patient registration is also achieved by using IOUS [22], which aids in forming liver surface models.

Intra-operative navigation by US allows a visual representation of the spatial relationship with surgical equipment with regard to the hidden anatomical structures [23]. It can assist in real-time visual localization of the needle during the biopsy to ensure a safer procedure with minimal complications. To navigate the liver biopsy, a few trackers and markers are needed to facilitate the navigation as shown in the Fig. 3.

Importance of CT

CT imaging is needed during liver navigation and is helpful in visualizing the target location and associated structures [22]. The navigation involves a lot of risks and uncertainties; accurate reconstruction of 3D scenes from CT images helps in a precise strategy [18]. CT offers high quality spatial clarity and good contrast [19] and can visualize essential structures in the immediate vicinity. Segmentation of CT data and tumor (lesion) generates the boundary contours of the liver and tumor on which the biopsy is performed. The literature in image segmentation is quite rich [24–29] to determine the boundaries. The corresponding 3D liver and tumor models are constructed using surface rendering from the contours. The clinicians can manipulate the 3D models on the graphical user interface (GUI) in a variety of ways and execute various actions such as hiding, scaling, moving, viewing, etc., to grasp how the interior parts of the liver are related

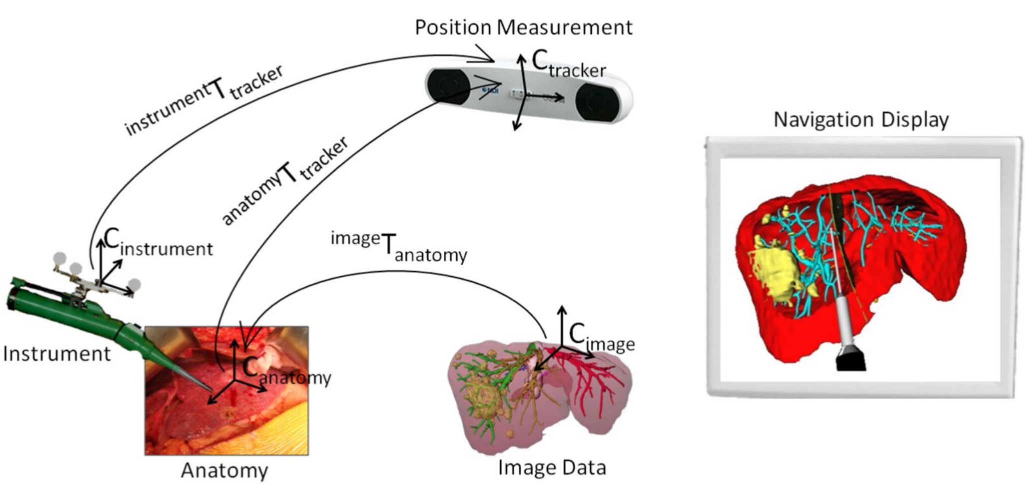

Fig. 3 Technical flow of liver biopsy

spatially [30]. This can aid in forming a surgical plan, which can ameliorate surgical skills and safety. It can also be executed for assessing the precision of targeting. Furthermore, multi-planar and 3D reconstruction is enabled by CT that can assist in further additional planning for the surgery [31]. However, intra-operative CT imaging is not possible although it provides an enhanced three-dimensional depiction of the needle, target, and electrode for biopsy [32] because of radiation mainly.

Liver biopsy, requirements, and challenges

Liver biopsy

Liver biopsy is a procedure, where a sample is taken from the liver and used for diagnosing certain liver conditions such as cancer, infections, enzyme abnormalities, and unexplained hepatomegaly. The indications for a liver biopsy include persistent pain in the abdomen, palpable mass in the right upper abdominal quadrant, certain digestion issues, and abnormal lab results pointing to a liver problem. There are two broad approaches to perform liver biopsy:

i. Percutaneous: This is the most common way of doing a liver biopsy. It can be done as a blind procedure by percussion or by a more preferred image-guided procedure with the help of ultrasound. This procedure is done with the patient in a supine position with their right hand placed below their head and a local anesthetic injected in the area of the biopsy. The biopsy needle is inserted in the seventh or eighth intercostal space, above the lower rib margin through a cut on the skin into the liver parenchyma transecting the liver capsule. The patient is asked to hold their breath and then exhale during deeper needle penetration.

ii. Transvenous or transjugular: This is used in patients with a risk of bleeding or bleeding abnormalities, ascites, small or shrunken liver, etc. It is an angiography-guided method where the biopsy needle is introduced via the jugular vein or the femoral vein and into the liver via hepatic veins, thus not damaging the liver capsule and lowering the bleeding risk.

Requirements

Some of the prerequisites for performing a liver biopsy are as follows:

- Sterile and stable environment, without any distractions and sufficient amount of light
- Supine position of the patient
- Operator and operator experience. Liver biopsy is usually performed by a gastroenterologist, hepatologist, or radiologist. However, it can now can also be performed by skilled nurse specialists and physician assistants. Statistically, there was no major difference in the rate of complications, when the biopsy was done by physicians with experience in performing fewer than 20 patients' biopsies as opposed to biopsies done by doctors with experience of more than 100 biopsies [33]
- Anesthesia. Appropriate regional anesthesia is administered to the patient before the biopsy to avoid pain.
- Accurate placement of needle at lesion site done with the help of guided imaging like US or CT. Image guidance can help choose the most suitable site and angle for insertion of the biopsy needle, thereby reducing later complications while improving sample adequacy [34]
- Type and size of biopsy needle and familiarity with the device. A more adequate sample is obtained using full-core biopsy needles as compared to traditional cutting needles, although animal studies have shown that the use of larger gauge needles increases the risk of bleeding [35]. But larger needles have proven to get more technically adequate samples and hence, more accurate diagnosis [34].
- Needle gauge and number of passes. An improved diagnostic yield is achieved with an increased number of needle passes, but more than three passes increase the risk of complications and morbidity [36], although the number of passes do not determine the severity of complications severe complications are related to age, hepatic malignancy, increased INR, etc.
- In order to get a result, the minimum length of the biopsy sample is 20 mm long, and it is usually gotten by a 16 gauge needle [37, 38]

Challenges

Some of the challenges that need to be kept in mind during a liver biopsy are as follows.

- Hepatic distortion or deformation is caused due to patient movement, breathing, movement of adjacent organs, and needle insertion [18]. Deformation affects image registration and fusion which in turn affects adequate visualization of the lesion. Registration is the matching of two imaging data sets spatially to each other, which also enhances the alignment of anatomical structures [39]. It can be either rigid or non-rigid registration [40]. Preoperative CT is usually obtained in the supine posture and any change from this positioning during the procedure may result in the inaccuracy of registration. This causes an impact on the precision of navigation and its accuracy [41]. Deformation during a biopsy can be reduced by marking the virtual resection borders and landmarks prior to situating and mobilizing the patient [18]. Exceptional accuracy can be attained by both deformation correction and breathing adjustments [42]. Respiratory gating techniques [22] and controlled breathing techniques such as intubation or conscious breath holding [12] and continuous tracking of the liver using sensor placements [5] can help compensate for deformation as well. Non-rigid registration is preferably required if considerable deformation occurs or if the lesion is situated in the liver periphery [5]. Devices with automatic registration and recognition and breathing synchronization in accordance with hepatic vasculature are being developed [12]

- Needle accuracy in 3D space while using one image modality. There are certain fundamental aspects to take into account in relation to fusion navigation. Accuracy in the localization of landmarks can allow for an effective registration procedure to take place, which can allow for a precise fusion of both imaging modalities which assists in the proper visualization of liver anatomy. External sensor coils, fiducials, and anatomical landmarks can be used to perform the registration procedure between the imaging methods [22]. Registration can be possible either manually, known as free-hand registration, or automatically [43]. Electromagnetic tracking of the US probes and needles by sensors is an auxiliary data point that can improve registration and bring about fusion more effectively. Spatial accuracy during navigation is very important as well that can provide certain clinically pertinent information through image guidance allowing extreme accuracy and success in surgical outcomes. Needle position during a biopsy can be directed to an optimistic precision and accuracy by the union of standard intra-operative US, preoperative CT image guidance, and navigation system. After the needle is inserted and placed, a CT scan (recommended 1–5 only) can be performed intra-operatively for confirmation whenever clinically indicated [32]. This image can be correlated with the preoperative CT scan obtained with the selected targets, which can allow proper guidance, navigation, and precision of needle to the target [32]. A study by Krucker et al. demonstrates that CT guidance alone for positioning the needle is not feasible and the use of navigation along with confirmation CT is needed to allow proper orientation of the needle position [32]
- When the lesion is small
- When the case is complicated due to bleeding

Limitations of US

IOUS in laparoscopic hepatectomy is limited by certain obstacles such as the following: there is limited visibility of the abdominal space since the probe is observed through the laparoscopic screen. In addition, the placement and angulation are crucial as they are exacerbated by the hand-eye coordination [18]. Some lesions may not be visible in US effectively, for example, the target lesions that are of small size and with miniature. In addition, the resolution of the US image is low and the lesion gets further obscured by interfering anatomical structures such as gut, diaphragm, etc. causing the absence of multi-planar depth information. IOUS is also limited to address these problems, because it is unable to grasp the precise vasculature of the liver and the actual relationship between hepatic veins and arteries [44]. Thus, sole use of IOUS may not be be trusted for appropriate liver navigation. Furthermore, Jungo Yasuda et al. have found that the operation time is greater when using IOUS alone for navigated surgery [44]. Fusion imaging reduces the constraints of each independent imaging modality and increases procedural viability along with the technical outputs [12]. The fusion provides improved clarity of the lesion over the standard US or CEUS [15].

Fusion imaging and navigation

The primary aim of fusion navigation is to appropriately approach the target lesion providing an unbiased and precise phenomenon. In general, the fusion of medical imaging has already proven to be effective in assessing cancer in patients by gaining enhanced knowledge on the genomic and proteomic characteristics of the tumor and aiding in its different aspects, such as proper diagnosis, disease progression, monitoring, and individualized therapy [45]. The fusion of different imaging modalities can improve the visibility of minor discrepancies than from conventional imaging [19, 45]. A crucial element in the fusion of medical imaging is the spatial alignment of the images, i.e., image registration. The precise fusion of these images largely depends on the accuracy of registration, where the preprocedural image sets are spatially aligned with the image sets acquired during or after the procedure. Registration allows the association of similar features to each other; this is integral for high precision fusion. There have been several success criteria for the success of registration; it may be achieved by the usage of markers [46]. Markers can be either extrinsic or intrinsic. The extrinsic markers are known as fiducials and are placed on the patient, which can be detected on the images. Intrinsic markers are anatomical structures that can be utilized as landmarks to determine the location of the target on the images from various imaging modalities

[15]. In a study by Foster et al., it has been verified that external markers are easier to handle as they obtain better fusion quality and is less time consuming in contrast to internal markers [47]. If the relevant fiducial points from the different data sets are not appropriately recognized and paired, the position, size, shape, etc., of the tumor or “region of interest” would be be inaccurate. Rigid registration does not explain the discrepancies in deformation or shape and, therefore, maintains the internal structure in the images, whereas non-rigid or elastic registration modifies the images originally obtained by adjusting the image volumes to match each other, thereby jeopardizing the data integrity thereby increasing the capacity for error. Yet, elastic registration takes account of deformations, which may allow accurate registration. Instrument tracking is another aspect of real-time navigation. The fusion imaging enables the visibility of small or tiny lesions. Makino et al. report that the success of fusion relies on the additional nodules that can be visualized the help of fusion that are difficult to visualize by a single imaging modality and it varies from 1.7 to 15.4% [48].

Image fusion (IF) can also be utilized to direct the needle to the intended lesion intra-operatively. It can aid in reducing the multiple needle insertions and thereby, reducing the procedure time and risk. This fusion-imaging guidance system can enhance diagnostic evaluation capabilities during pre-, intra-, and post-intervention. It can also help raise the accuracy of the procedure and increase the confidence of the operating clinician.

The fundamental drawbacks of a typical surgical navigation system are inaccuracies in the precision of time and space throughout the surgery [13]. The fusion could potentially navigate and meticulously help pre-plan targeting the lesion. This could allow the early detection of the lesion and prevent from growing further [31].

Discussion

The clinicians usually mentally register the pre-operative CT with intra-operative ultrasound to determine the possible target lesions. However, this kind of registration cannot be optimal. Real-time fusion is the potential alternative of this. Anatomical landmarks located near the lesion are used as atlas points to facilitate the fusion of two imaging datasets spatially. It also assists in accurately detecting the target location in the deformation circumstance. The landmarks on both CT and US synchronize with the exact movement of the lesion. However, a certain level of knowledge and competence is required in the selection of appropriate landmarks, which is bit challenging and time-consuming [45]. Minami et al. show that the portal phase of CT scans might be the most appropriate for demonstrating a 3D link between hepatic vasculature and malignancies [49] (Tables 2, 3, and 4).

Preoperative CT datasets superimposed with the real-time US could improve the navigation during liver biopsy with the additional help of anatomical landmarks, which aids in finer real-time tumor targeting. The availability of multiple landmarks in the liver provides an improved registration process, which increases the quality of image fusion enabling lesion identification [15]. In overlapping ablations, navigation solutions could be helpful [40]. Qi-Zu et al. use of CT/US fusion imaging to discover the non-perfused areas that were not surrounding the target seen through contrast-enhanced US(CEUS) [50]. Therefore, fusion imaging with CT and US navigation could be useful in interventional procedures. Therefore, image fusion-based navigation during radio-frequency ablation or biopsy of hepatic lesions has been the subject of numerous investigations [50]. Takeshi Aoki et al. present a modified electromagnetic tracking/image fusion (EMT/IF-US) for laparoscopic liver resection using virtual real-time CT-guided volume navigation (VRCT). They conclude that image fusion by CT and US provides excellent resection plane evaluation, tumor and landmark detection, and operability. They have suggested that the accuracy requires further improvement though [18]. Ahn et al. report that FI technology could raise technical feasibility from grade 1 (not viable) to grade 2 or 3 (equivocally feasible or fairly feasible respectively) [51]. Sensors placed at the tip of the needle are found to contribute to better targeting accuracy as this enables the sensor to be proximal to the target [31]. Fusion imaging offers enhanced accuracy in the alignment of anatomy and improved visualization. Greater technical success rates are also observed using the fusion imaging modality with contrast enhanced CT and US.

Image fusion of modalities could be advantageous during surgery as well, where the localization matters significantly. Image fusion also aids in the detection of disappearing small lesions, which usually occur after chemotherapy. It also helps to perceive the lesions that are comprehended on preoperative imaging but not detected on IOUS [18]. Image-guided navigation system (IG-NS) is found to be more effective in laparoscopic surgery (LS) than in open surgery [44]. Imaging fusion-based navigation could allow the procedure more accurately and efficiently while minimizing the prevalence of complications and procedure time [30].

Limitations for the fusion imaging guidance system may arise due to uncertain difficulties of the imaging modalities. In a study by Fabrice et al., fusion imaging guidance has taken slightly longer than expected due to the difference in spatial orientation between the two input imaging datasets; this probably necessitates an

Table 2 Summary of methods

Authors	Procedure	Method	Results
Giesel FL et al. 2009 [45]	Radio-frequency ablation	Various imaging modalities were registered and merged + MIPAV software, different algorithms, and visualization tools were used for intra-modality and inter-modality picture registration	Spatial link of lesion anatomy and functional relevance was produced. Fusion axial images and segmentation 3D surface models were employed for treatment, planning, and post-RFA evaluation, optimizing needle placement
Zhao et al. 2020 [50]	Virtual navigation-guided radio- frequency ablation	Prospective study. Key factors were predicted using a multivariate Cox regression analysis, and the overall survival was then predicted using a nomogram with independent predictive factors	Technical feasibility: 86.4% success: 94.7% OS rate at 1-, 2-, and 3-year: 5.5%, 8.7%, and 14.0%, C-index of the OS nomogram: 0.737 no intervention-related deaths
Aoki et al. 2020 [18]	Virtual real-time CT-guided (VRCT) volume navigation during laparoscopic hepatectomies	27 hepatic neoplasms were removed laparoscopically while being monitored by VRCT. To accurately navigate, electromagnetic tracking of the surgical instrument was used	26 lesions (96.3%) with a mean diameter of 11 mm were successfully treated. Using VRCT, the surgeon navigates a liver transection with respectable accuracy
Yasuda et al. 2019 [44]	Laparoscopic surgery using image-guided navigation system	After registration, the 3D models were superimposed on the surgical field	Average registration error: 8.8 mm. The positioning of the tumor and the establishment of the resection line were made simple
Ahn et al. 2016 [51]	Radio-frequency ablation	Technical viability and visibility were evaluated by US imaging. With the use of a separable cluster electrode and a switching monopolar system, RFA was carried out with the aid of fusion imaging	RFA's technique efficiency for invisible tumors on B-mode US under fusion imaging guidance was comparable to that for visible tumors (96.1% vs. 97.6%, $p = 0.295$)
Minami et al. 2008 [49]	Radio-frequency ablation	Prospective virtual CT sonography was used to guide radiofrequency ablation on 51 patients with 65 hepatocellular carcinomas. 50 patients with 63 hepatocellular carcinomas treated under B-mode sonographic guidance served as a historical control group	CT sonographic group ablation was achieved in 92% and 8% of patients in one and two sessions respectively. B mode sonography group. Technical success was achieved in 72%, 24%, and 4% of patients in one, two, and three sessions respectively. Technical success rate after a single treatment session was significantly ($p = 0.017$) higher for the virtual CT sonography group

Table 3 Summary of methods

Authors	Procedure	Method	Results
Hakime et al. 2010 [19]	Radio-frequency ablation	For image registration, a set of three landmark markers were selected on CT and US. The fusion imaging display mode was then used to overlay US and CT images. The lateral, anterior-posterior, and vertical axes were measured to determine the difference in the tumor's spatial placement between the US and CT images	Overall maximum difference (Dmax): 11.53 ± 8.38 mm. Dmax was 6.55 ± 7.31 mm with CT performed immediately before VNav versus 17.4 ± 5.18 with CT performed 1–30 days before ($p \leq 0.0001$), Dmax under general anesthesia =7.05 ± 6.95, and without anesthesia = 16.81 ± 6.77 ($p \leq 0.0015$)
Luo et al. 2020 [13]	Laparoscopic liver resection with AR-assisted navigation	An unsupervised convolutional network (CNN) framework uses stereo picture pairs from the laparoscope to assess depth and produce an intra-operative 3D liver surface. Preoperative CT images are segmented into 3D models of the patient's surgical field utilizing end-to-end predictive V-Net architecture. Live laparoscopic pictures are merged with preoperative 3D models to give the surgeon detailed knowledge of the anatomy	Five operating room in vivo pig trials and four laboratory ex vivo porcine liver tests were used to confirm the accuracy of the suggested navigation system. Re-projection errors (RPE) in ex vivo = 6.04?±?1.85?mm, and in vivo= 8.73 ± 2.43 mm
Aribas et al. 2012 [34]	Percutaneous ultrasonography-guided liver biopsy	In a biopsy cohort study of 1300 patients, 610 biopsies were performed with small size (20G) suction needles and 690 using big size (19G) cutting needles. Needles were evaluated for safety and diagnostic accuracy for a variety of focal liver diseases	Diagnostic accuracy in metastases: small needle group: 85%, big needle group: 96.9%, hepatocellular carcinoma: small needle group: 85.5%, big needle group: 97.9%, with regenerative nodules: small needle group: 75%, and big needle group: 98.9%
Chi et al. 2017 [36]	US-assisted liver biopsies with cutting biopsy needles	All sequential liver biopsies between 2005 and 2014, were included. Severe complications were those that required intervention or hospitalization for two days or longer	A total of 1806 liver biopsies were analyzed. Total complications: 102 (5.6%), severe complications: 31 (1.7%). The number of biopsy passes had no effect on the likelihood of severe complications (P*ge*0.24). Risk factors: hepatic malignancy (OR: 3.21; 95% CI: 1.18–8.73; $p = 0.022$) and INR 4.1 or more (OR: 7.03; 95% CI: 2.74–18.08; p*le*0.001)

Table 4 Summary of methods

Authors	Procedure	Method	Results
Bing F et al. 2019 [52]	Radio-frequency Ablation	In 23 individuals, the location of 23 spinal needles positioned at the edge of hepatic tumors before radio-frequency thermal ablation was done. The tumor's edge was reached with needle placement using CT-US fusion imaging. To compare the true (x, y, z) and virtual (x′, y′, z′) coordinates of the needle tip (D for distal) and a point on the needle placed 3 cm proximally to the tip (P for proximal), a control CT scan was performed	The mean Euclidian distances were 8.5 ± 4.7 mm and 10.5 ± 5.3 mm for *D* and *P*, respectively. The absolute value of mean differences of the 3 coordinates were 4.06 ± 0.9, 4.21 ± 0.84, and 4.89 ± 0.89 mm for *D* and 3.96 ± 0.60, 4.41 ± 0.86, and 7.66 ± 1.27 mm for *P*.

initial fusion. Areas like the lung and peripheral bone may present more difficulty to practice fusion due to the difficulty to locate anatomical landmarks in these areas [52].

Even though the fusion of US and CT could be useful for better depiction of lesions and navigation over all, the operating clinician should be more mindful of the actual and virtual coordinates of the needle used to access the tumor [52].

The integration of MRI-US was proven to be beneficial when performing liver biopsies or for therapy of liver abnormalities [53, 54].

Registration and preprocedural diagnostics, 3D models, etc., can assist to get a precise knowledge on the nearby vasculature leading to a better target localization and navigation. Navigation could assist targeting the lesion increasing the accuracy and operator's confidence. Studies show that navigation systems do improve confidence and accuracy of needle placement enabling a faster way to find out the angle of needle placement in contrast with standard imaging guidance. It may be noted that the size, shape, and insertion of the needle should be carefully planned and determined by a clinician.

The choice of certain landmarks could potentially influence the errors along with the patient respiration or hepatic distortion. Thus, the identification of landmarks is important in the accurate visualization of the lesion whilst experiencing the challenge of deformation of the liver. Deformation correction, breathing adjustments and controlled breaths, respiratory gating methods, and placements of sensors are the various techniques that help to compensate for liver distortion due to respiratory breathing, surgical manipulation, etc.

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Authors' contributions
Serah, Anchal, and Sagnika have participated in manuscript writing, literature review, and data analysis. Sarada has conceptualized the study and participated in design of the study, manuscript editing, and manuscript review.

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Availability of data and materials
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Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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