REVIEW ARTICLE

A station-wise approach to liver anatomy for linear EUS

CME

Radhika Chavan, MD, DNB, FISG, FASGE,[1,*] Dario Ligresti, MD,[2,*] Stefano Baraldo, MD,[3] Geri Keane, MD, PhD,[4] Yu-Ting Kuo, MD,[5] Giuseppe Mamone, MD,[6] Dario Quintini, MD,[7] Zaheer Nabi, MD, DNB, FISG, FASAGE,[8] Sanjay Rajput, MD, DM,[9] Ilaria Tarantino, MD[2]

Pune, Hyderabad, Ahmedabad, India; Palermo, Italy; São Paulo, Brazil; Baltimore, Maryland, USA; Taipei, Taiwan

Background and Aims: Linear EUS has emerged as a key tool for liver assessment and intervention. However, its adoption for liver segmentation remains limited because of the absence of fixed anatomical landmarks and overlapping views. This study proposes a station-wise approach to simplify liver anatomy interpretation during EUS, correlating these findings with computed tomography imaging for greater comprehensibility.

Methods: EUS examinations were conducted using a linear echoendoscope with the patient in a left lateral position under deep sedation. A systematic station-wise methodology was applied to identify liver segments, leveraging anatomical landmarks such as portal vein branches, hepatic veins, and the inferior vena cava. Images were evaluated from 6 different stations.

Results: The station-wise approach successfully delineated all liver segments. Stations 1 through 3 provided comprehensive visualization of the superior and inferior segments from the gastroesophageal junction and stomach. Stations 4, 5, and 6 enabled additional imaging of challenging segments (eg, caudate lobe and posterior right liver segments).

Conclusions: This study provides a practical framework for systematic liver evaluation using linear EUS. Incorporating this station-wise methodology into EUS training programs could expand its role in diagnostic and therapeutic endohepatology. (VideoGIE 2025;10:605-13.)

INTRODUCTION

EUS has been used increasingly for the evaluation and management of liver disorders over the last 1 to 2 decades. A detailed understanding of liver anatomy is crucial for the correct identification of liver segments for diagnostic purposes as well as therapeutic interventions. However, to date, liver EUS has not been prioritized by many EUS training programs.[1]

Unlike in pancreatic EUS, during examination of the liver, there are no fixed home bases.[2] Overlapping views and the absence of familiar landmarks make understanding liver anatomy difficult. We describe a station-based approach for EUS liver examination. The liver cannot be entirely scanned by EUS from 1 location. The left side of the liver is better visualized from the stomach and the right side of the liver from the duodenal bulb.[3] Right posterior liver segments are especially difficult to image fully by EUS, so in this work we also describe the limits of the EUS liver examination.

In this review, we aim to provide a comprehensive description of liver anatomy as visualized by a linear echoendoscope, which will add to the limited literature published to

Abbreviations: GB, gallbladder; GE, gastroesophageal; HV, hepatic vein; IVC, inferior vena cava; LHV, left hepatic vein; LPV, left portal vein; MHV, middle hepatic vein; MPV, main portal vein; PV, portal vein; RHV, right hepatic vein; RPV, right portal vein; UPLPV, umbilical portion of left portal vein.

*Drs Chavan and Ligresti contributed equally to this article.

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Current affiliations: Department of Gastroenterology and Endoscopy, Bharati Vidyapeeth Medical College, Pune, Maharashtra, India (1), Digestive Endoscopy Service, Department of Diagnostic and Therapeutic Services, IRCCS - ISMETT, Palermo, Italy (2), Institute for Teaching and Research, Barretos Cancer Hospital São Paulo, São Paulo, Brazil (3), Division of Gastroenterology and Hepatology, Johns Hopkins Medicine, Baltimore, Maryland, USA (4), National Taiwan University Hospital Bei-Hu Branch, Taipei, Taiwan (5), Radiology Unit, Department of Diagnostic and Therapeutic Services, ISMETT - UPMC Palermo, Italy (6), Gastroenterology Unit, Veneto Institute of Oncology IOV-IRCCS, Padua, Italy (7), Department of Advanced Endoscopy, AIG Hospital, Hyderabad, Telangana, India (8), Department of Gastroenterology and Endoscopy, Ansh Clinic, Maninagar, Ahmedabad, Gujarat, India (9).

Corresponding author: Dario Ligresti, MD, Digestive Endoscopy Service, Department of Diagnostic and Therapeutic Services, IRCCS-ISMETT, Via Tricomi, 5, 90100 Palermo, Italy. E-mail: dligresti@ismett.edu.

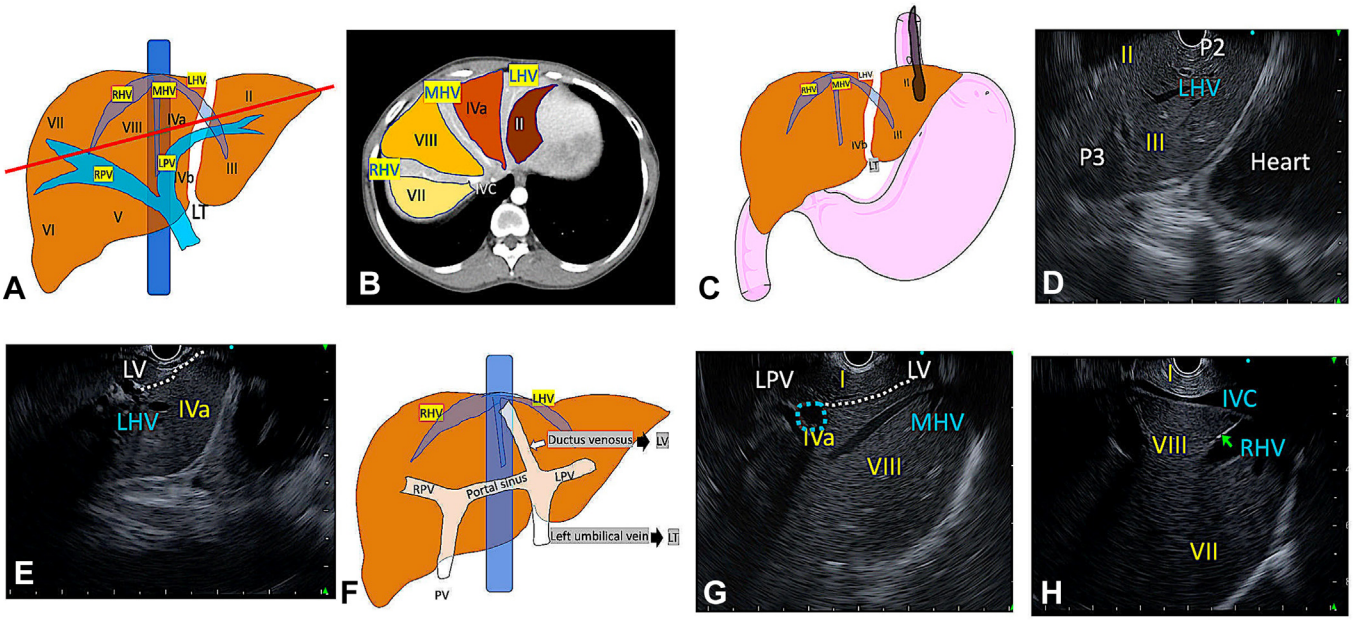

Figure 1. Station 1: Superior segment visualization from the gastroesophageal junction. **A,** Illustration showing scanning plane (*red line*) for superior segments (II, IVa, VIII, and VII). **B,** Corresponding contrast-enhanced computed tomography image of superior segments. **C,** Illustration showing respective echoendoscope position for visualization of superior segments and hepatic veins. **D,** In neutral position, the segments II and III are visualized along with left hepatic vein (LHV). **E,** On clockwise rotation, segment IVa starts appearing with ligamentum venosum (LV). **F,** Illustration showing relation of LV (ductus venosum in fetus) and ligamentum teres (umbilical vein in fetus) to the left portal vein. LV is a broad ligament that starts from the left portal vein (LPV), which converges over the inferior vena cava (IVC) at the junction of LHV and the middle hepatic vein (MHV). **G,** On clockwise rotation, the MHV along with the LV and transverse portion of the LPV are seen. In this plane, ligamentum venosum separating I from IVa, and MHV separating IVa from VIII can be seen. **H,** On further clockwise rotation from MHV, the IVC is visualized along with right hepatic vein (RHV). Segment I is visualized near the transducer. RHV separates segment VIII from VII. *LT*, Ligamentum teres; *PV*, portal vein; *RPV*, right portal vein.

date.[3-6] We also correlate EUS images with computed tomography images, which are regularly used to assess liver disease and will be familiar to most hepatologists and endosonographers. In this comprehensive review, we will simplify EUS liver anatomy to allow more endosonographers to expand their practice to include diagnostic and therapeutic endohepatology.

Liver anatomy overview

The liver is divided into 2 hemilivers (right and left), 4 lobes (right lobe, left lobe, caudate lobe, and quadrate lobe), and 8 segments (I-VIII) on the basis of surface and deep landmarks (Video 1, available online at www.videogie.org). (The round ligament or ligamentum teres is a surface landmark, which separates left lobe from right lobe.)

As per the Couinaud's classification, the liver is divided into 8 functionally independent segments.[7] The inflow of blood to the liver comes from the portal vein (PV) and hepatic artery branches, whereas hepatic veins (HVs) act as outflow. Each liver segment has its own portal pedicle consisting of the branch of the PV, hepatic artery, and bile duct, with an independent outflow tract from the HVs. The caudate lobe (segment I) receives blood supply from both lobes and drains into the inferior vena cava (IVC) directly. An imaginary Cantlie's line, containing the middle hepatic vein (MHV), passes through the IVC posteriorly and gallbladder (GB) fossa anteriorly, dividing the liver into the left and right hemilivers. The left hemiliver comprises segments II, III, and IV, whereas the right hemiliver comprises V, VI, VII, and VIII. The left hemiliver is again classified into left lateral (segments II and III) and left medial (segment IV) sector by the left hepatic vein (LHV), whereas the right hemiliver is separated into the right anterior (segments V and VIII) and right posterior sector (segments VI and VII) by the right hepatic vein (RHV).

During linear EUS examination, PV branches, ligaments, the IVC, HVs, GB, and the right kidney are used as anatomical landmarks to identify the liver segments.[3,4] The PV branches and HVs transect each other in a perpendicular plane. Therefore, on EUS when the HV appears as a longitudinal structure, the PV branch appears as an oval/round-shaped structure, or vice versa. PV branches divide the liver horizontally into superior (II, IVa, VII, and VIII) and inferior (III, IVb, V, and VI) segments, whereas HVs divide the liver vertically into left and right liver segments.[8] As the result of anatomical variation in HV origins, the PV and its branches are used for liver segment identification. The right PV (RPV) branches into the right anterior and right posterior vein. The right

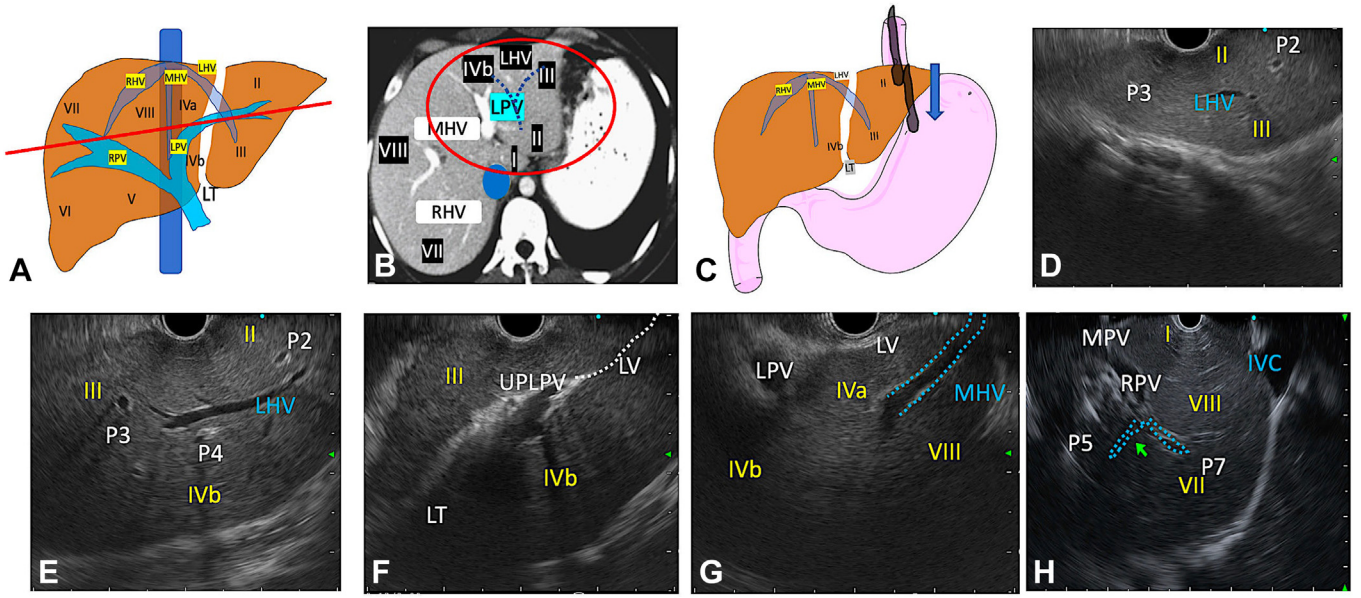

Figure 2. Station 2A: Visualization of umbilical portion of left portal vein (UPLPV) from the cardia. **A,** Illustration showing scanning plane going through the left portal vein. **B,** Corresponding computed tomography image of that plane. **C,** Illustration showing echoendoscope needs to be pushed down from the gastroesophageal junction into the cardia for proper visualization of the UPLPV. **D,** EUS showing segments II and III, with LHV (periphery/branch) seen traversing through it. Portal vein branches (P2 and P3) to the respective segment also are seen. This image is achieved by close approximation of the transducer with the liver. **E,** On clockwise rotation, LHV separating left lateral (II and III) from left medial (IVb) segments is seen. **F,** On further clockwise rotation, UPLPV is seen clearly. Segment III is seen near the transducer and IVb below the umbilical portion. **G,** On further clockwise rotation, transverse portion of LPV along with MHV are visualized. In the same frame, segments IVa, IVb, and VIII are seen. **H,** On minimal clockwise rotation, MPV along with the RPV giving branches to segments V and VII can be seen. *LHV*, Left hepatic vein; *LPV*, left portal vein; *LT*, ligamentum teres; *LV*, ligamentum venosum; *MHV*, middle hepatic vein; *MPV*, main portal vein; *P*, portal vein branch; *PV*, portal vein; *RHV*, right hepatic vein; *RPV*, right portal vein.

anterior PV branch is further divided into segmental branches for segment V and segment VIII and the right posterior portal branch into segment VI and segment VII.

The left PV (LPV) runs horizontally along the transverse portion and then ascends vertically as the umbilical portion of the LPV (UPLPV). The transverse portion only sends small branches to segment IV and to segment I. All the larger branches arise from the UPLPV beyond the attachment of ligamentum venosum. The left side of the UPLPV supplies branches to segments II and III, and the right side supplies segment IV.[9]

METHODS

EUS examination was performed with the patient in the left lateral position under deep sedation (propofol with or without midazolam). A linear echoendoscope (GF-UCT180; Olympus, Tokyo, Japan) was used for the examination. "Cranial to the right side" orientation was used during imaging. The basic principles, maneuvers required, and the terminologies used during linear EUS examinations have been previously described.[10,11] PV branches are labeled as P2, P3, etc, and the segments are labeled as Roman numerals.

TECHNIQUES OF LIVER SEGMENT VISUALIZATION ON EUS

EUS examination from the gastroesophageal (GE) junction and stomach

The left lobe of the liver can be visualized starting just below the GE junction from the proximal stomach, with the transducer facing anteriorly. The esophagus lies in the groove of the left side of the liver, which is adjacent to the caudate lobe.

All 3 major HVs and superior segments are very well visualized from the GE junction. To visualize other segments (III, IVB, and V) including the liver hilum, the echoendoscope needs to be pushed down into the cardia.

Station 1: Visualization of superior segments from the GE junction. At the GE junction, on minimal anticlockwise rotation, the segments II and III can be seen. By keeping the big knob up, a close approximation of the left lobe with transducer can be achieved. Segment II is visualized close to the transducer, and segment III is seen below the LHV. From segment II, rotate the scope in clockwise direction. The MHV, along with part of the LPV, is seen. The MHV is seen as tubular structure running from the right-upper part of the screen to the lower left. The MHV separates segment IVa from segment VIII.

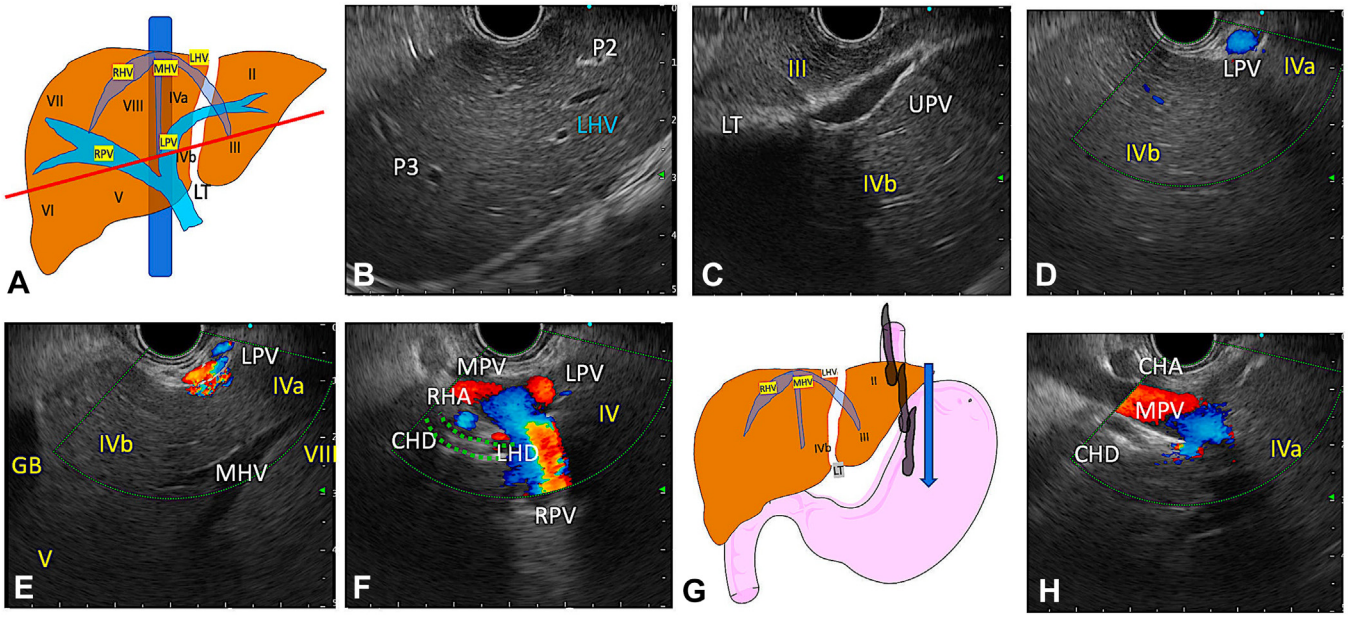

Figure 3. Station 2B: Visualization of the liver hilum from the cardia. **A,** Illustration showing scanning plane going through the division of portal vein (corresponding to liver hilum). **B,** EUS image showing segments II and III along with left hepatic vein from the cardia. **C,** On clockwise rotation, umbilical portion of left portal vein (UPLPV) is seen clearly along with the ligamentum teres (LT). Segment III is seen near the transducer and IVb below the umbilical portion. **D,** On further clockwise rotation, transverse portion of LPV is seen along with segments IVa and IVb. **E,** On further clockwise rotation, transverse portion of LPV along with the MHV (peripheral portion) are visualized. In same frame, segments IVa and VIII separated by MHV are seen. In some patients, part of GB along with segment V can also be seen. **F,** With rotation of the scope in clockwise direction while pushing down, liver hilum is visualized. **G,** Illustration showing the echoendoscope positioned to require further advancement in order to visualize the hepatic hilum. **H,** EUS image of hepatic hilum from the stomach. The main portal vein can be followed until portal vein confluence by maintaining clockwise torque while advancing the echoendoscope. *CHD*, Common hepatic duct; *GB*, gallbladder; *LHD*, left hepatic duct; *LHV*, left hepatic vein; *LPV*, left portal vein; *MHV*, middle hepatic vein; *MPV*, main portal vein; *P*, portal vein branch; *RHA*, right hepatic artery; *RHV*, right hepatic vein; *RPV*, right portal vein; *UPV*, umbilical portion of left portal vein.

The ligamentum venosum is a broad, dense fibrous band, remnant of ductus venosus that carries blood from the left umbilical vein to the IVC in fetal circulation. Therefore, the ligamentum venosum is seen between the superior pole of the UPLPV and IVC (merges over the MHV and LHV ostia). It separates segment I from segment IV, which lies superiorly/anteriorly to segment I.

On further clockwise rotation, the MHV disappears and the intrahepatic IVC is seen separating segment I from segment VIII. The RHV is also seen in that plane separating segment VIII from segment VII. At this point, the transducer is facing toward the right side and posteriorly. The RPV is also visualized in the same plane in the majority of patients along with branches to segment VII (Fig. 1).

Station 2A: Visualization of the UPLPV from the cardia (intra-abdominal esophagus). Push the echoendoscope down (1-2 cm) from the GE junction and maintain clockwise torque, and segment II and segment III can be visualized. The peripheral part of the LHV can be seen traversing through segments II and III. From this position, on a clockwise rotation, P2 and P3 can be seen converging into the UPLPV. From this position, the ligamentum teres is seen along with the UPLPV on the lower-left part of the screen.

A small portion of ligamentum venosum is also visualized along with the UPLPV on upper right. The UPLPV is connected to ligamentum venosum superiorly and to ligamentum teres inferiorly (Fig. 1). Segment III is seen near the transducer above the UPLPV, with segment IVb below the UPLPV.

On further clockwise rotation from the UPLPV, the transverse portion of the LPV is seen along with part of the MHV. Segment IVb is visualized above the MHV. The MHV appears as a long tubular structure, and it maintains its diameter throughout its course, unlike the LHV and RHV. Occasionally, a small accessory vein can be seen joining the MHV. On clockwise rotation, part of the hilum and RPV are seen along with segments VIII and VII (Fig. 2). On minimal withdrawal and clockwise rotation, the RHV is visualized along with segments VII and VIII.

Station 2B: Visualization of liver hilum from cardia (proximal stomach). Once the LPV is visualized on clockwise rotation from the UPLPV, with further minimal rotation of the scope in clockwise direction while the scope is pushed down, the liver hilum is visualized along with the main PV (MPV), right hepatic artery, biliary confluence, and the common hepatic duct. Avoid complete clockwise rotation from here, as it will mainly take the transducer posteriorly to the aorta.

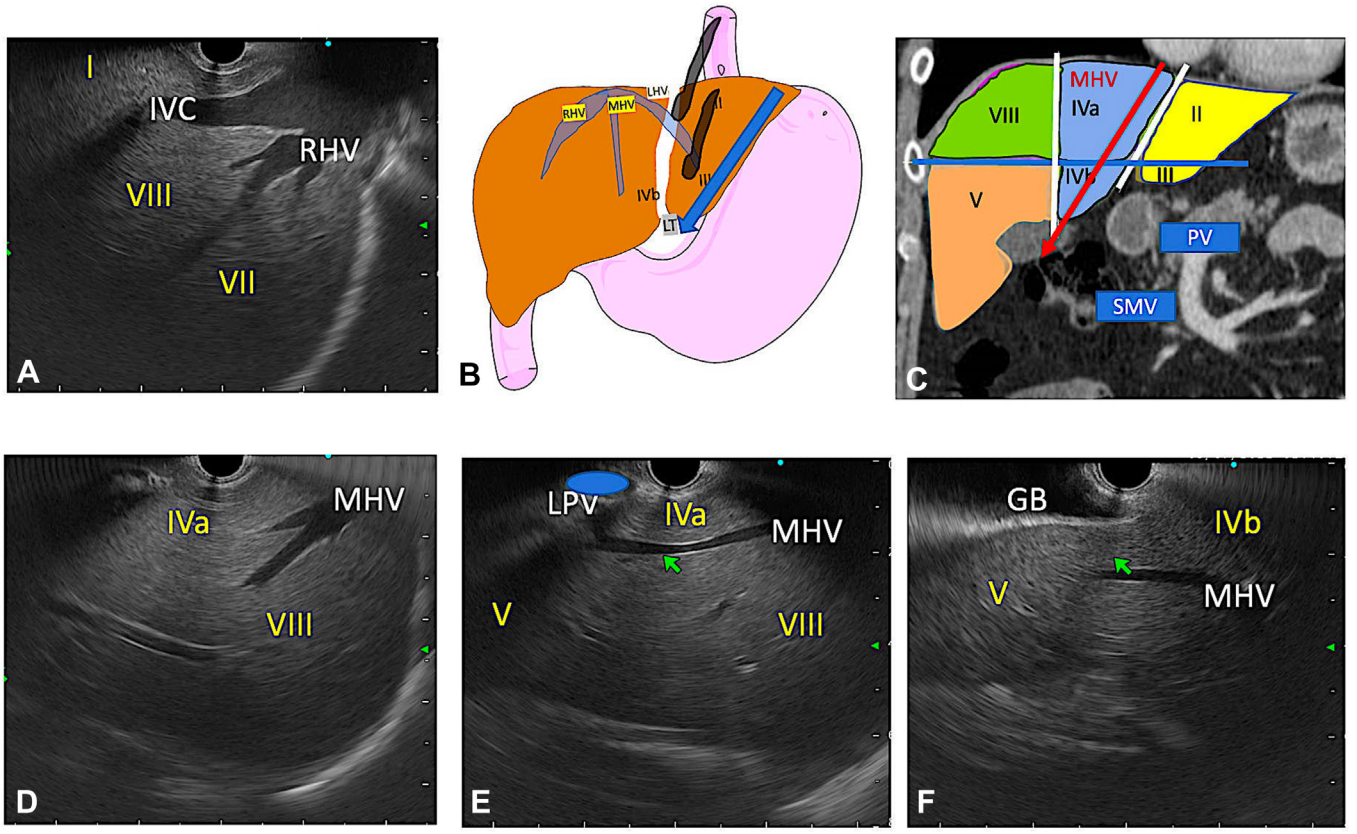

Figure 4. Station 3: Visualization of segment V by following the MHV from the mid-stomach. **A,** EUS image showing inferior vena cava (IVC) with the RHV from the gastroesophageal junction. **B,** Illustration showing echoendoscope needs to be pushed down to trace the MHV until segment V. **C,** Corresponding coronal image of contrast-enhanced computed tomography showing the direction of tracing segment V by following MHV or segment IV. **D,** On anticlockwise rotation from the IVC, the MHV is visualized. **E,** MHV can be traced by pushing down the scope by maintaining anticlockwise torque. Segment V starts visualizing. In same frame, MHV (near ostia) separating segment IVa from segment VIII is seen. **F,** Gallbladder is seen near the transducer, with the segment V lying inferior to it. *GB*, Gallbladder; *LHV*, left hepatic vein; *LPV*, left portal vein; *LT*, ligamentum teres; *MHV*, middle hepatic vein; *PV*, portal vein; *RHV*, right hepatic vein; *SMV*, superior mesenteric vein.

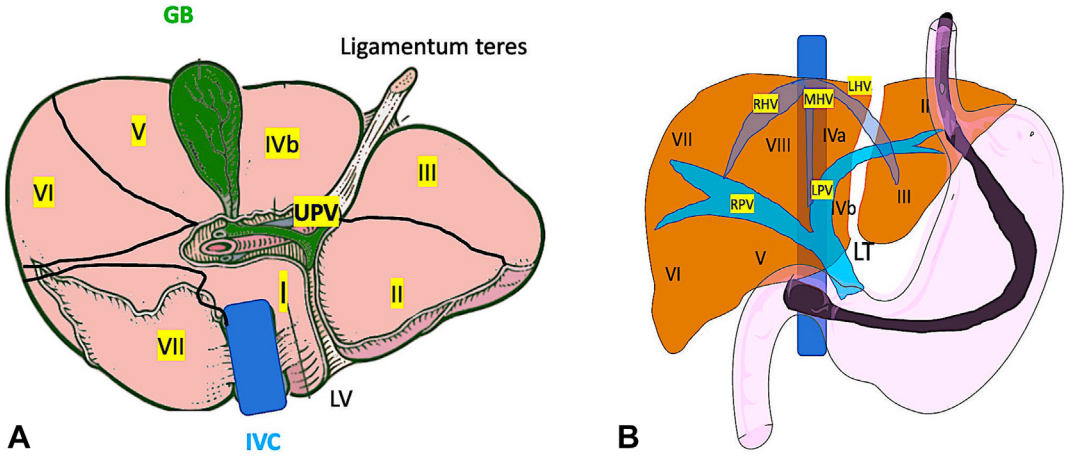

Figure 5. Inferior view of liver and echoendoscope position in duodenal bulb. **A,** Inferior view or view of the liver from the duodenal bulb. **B,** Illustration showing the echoendoscope positioned in the duodenal bulb in a long position, with scope directed posteriorly and superiorly. *GB*, Gallbladder; *IVC*, inferior vena cava; *LHV*, left hepatic vein; *LPV*, left portal vein; *LT*, ligamentum teres; *LV*, ligamentum venosum; *MHV*, middle hepatic vein; *RHV*, right hepatic vein; *RPV*, right portal vein; *UPV*, umbilical portion of left portal vein.

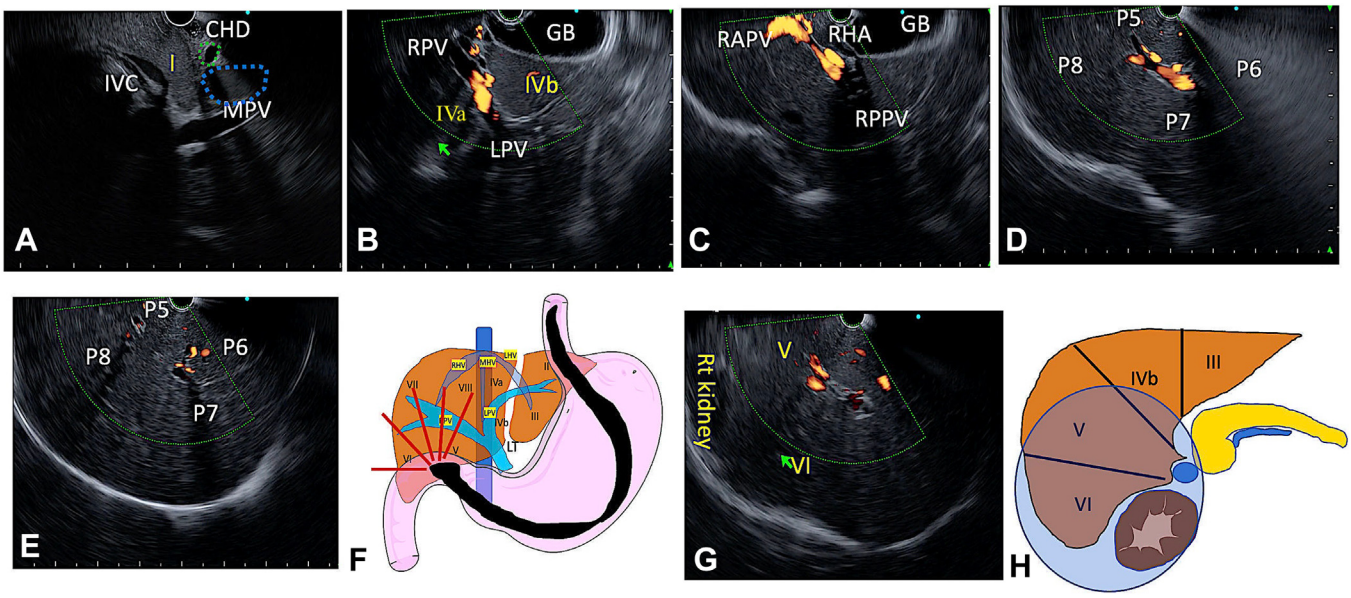

Figure 6. Station 4: Visualization of right segments from the duodenal bulb. **A,** Follow the main portal vein (MPV) on anticlockwise rotation to the hilum of the liver. EUS image showing common hepatic duct (CHD), inferior vena cava (IVC), and segment I. **B,** On anticlockwise rotation, the division of MPV into right portal vein (RPV) and left portal vein (LPV) is seen, along with the gallbladder. Segment IVb lies to the right of the LPV, and segment IVa to the left of the LPV. **C,** Follow the RPV with extreme anticlockwise rotation. The RPV is seen dividing into right anterior portal vein (RAPV) and right posterior portal vein (RPPV). **D,** On further anticlockwise rotation, branching of the RAPV to the anterior segments (V and VIII) and the posterior (VI and VII) segments are visualized. **E,** Portal vein branches to the respective segments are traced by further anticlockwise rotation. **F,** Illustration showing echoendoscope position in duodenal bulb with imaging area. **G,** On anticlockwise rotation, V and VI are seen along with right kidney. **H,** Illustration showing imaging area with segments V and VII and right kidney. *GB*, Gallbladder; *LHV*, left hepatic vein; *MHV*, middle hepatic vein; *P*, portal vein branch; *RHA*, right hepatic artery; *RHV*, right hepatic vein.

Along with the liver hilum, the RPV is seen running down in the lower part of the screen, away from the transducer. Portal branches to segments V and VII also can be visualized arising from the RPV in patients who are thin. Pushing down the scope by maintaining clockwise direction, the MPV can be followed until the PV confluence (Fig. 3).

The bile duct anatomy and biliary radicles are well appreciated when dilated. The left hepatic duct runs along the LPV. As the LPV disappears and the MPV starts, the left hepatic duct can be visualized joining the biliary confluence at the liver hilum.[11]

Station 3: Visualization of segment V from the mid stomach. For segment V visualization, the MHV should be traced to the periphery by maintaining minimal anticlockwise torque while pushing down the scope. Segment V can be seen adjacent to the GB. In patients with obesity, following the MHV and visualizing segment V along with the GB is challenging (Fig. 4).

EUS examination from the duodenal bulb

The duodenum is a compact space, so very fine movements are required to trace structures. Right lobe segments are better visualized from the duodenal bulb. Wedge the echoendoscope in the bulb (let the transducer touch the superior wall by keeping the big knob up). Follow the MPV in anticlockwise direction to the liver hilum. Inferior segments are visualized clearly as the transducer faces superiorly and posteriorly (Fig. 5). Inferior segments can be seen near the transducer (segments IVb, V, and VI). Visualization of superior segments is difficult from the duodenal bulb; however, PV branches to the respective segments can be identified.

Station 4: Visualization of the right segments by following the RPV from the duodenal bulb. For visualization of right segments, follow the MPV in anticlockwise rotation and release the big knob of the echoendoscope. The IVC is seen on anticlockwise rotation with segment I in between the MPV and IVC. Following the MPV in further anticlockwise direction, it divides into the RPV and LPV.

The RPV runs close to the transducer toward the left and in upward direction. The LPV runs away from the transducer in a downward direction. Segment IV is seen in front of MPV division. Rotate the scope in anticlockwise direction by extending the big knob down and follow the RPV. Along with the RPV, the right hepatic artery is also visualized. On tracing, the RPV division into the right anterior PV and right posterior PV is visualized. If not, turning the little knob counterclockwise and slightly pulling back the scope against the pylorus can help. The right anterior PV dividing into the branches to segments V and VIII and the right posterior PV into the branches to segments VI and VII can be visualized. Segment V is seen close to the transducer in the left upper quadrant, with segment VIII

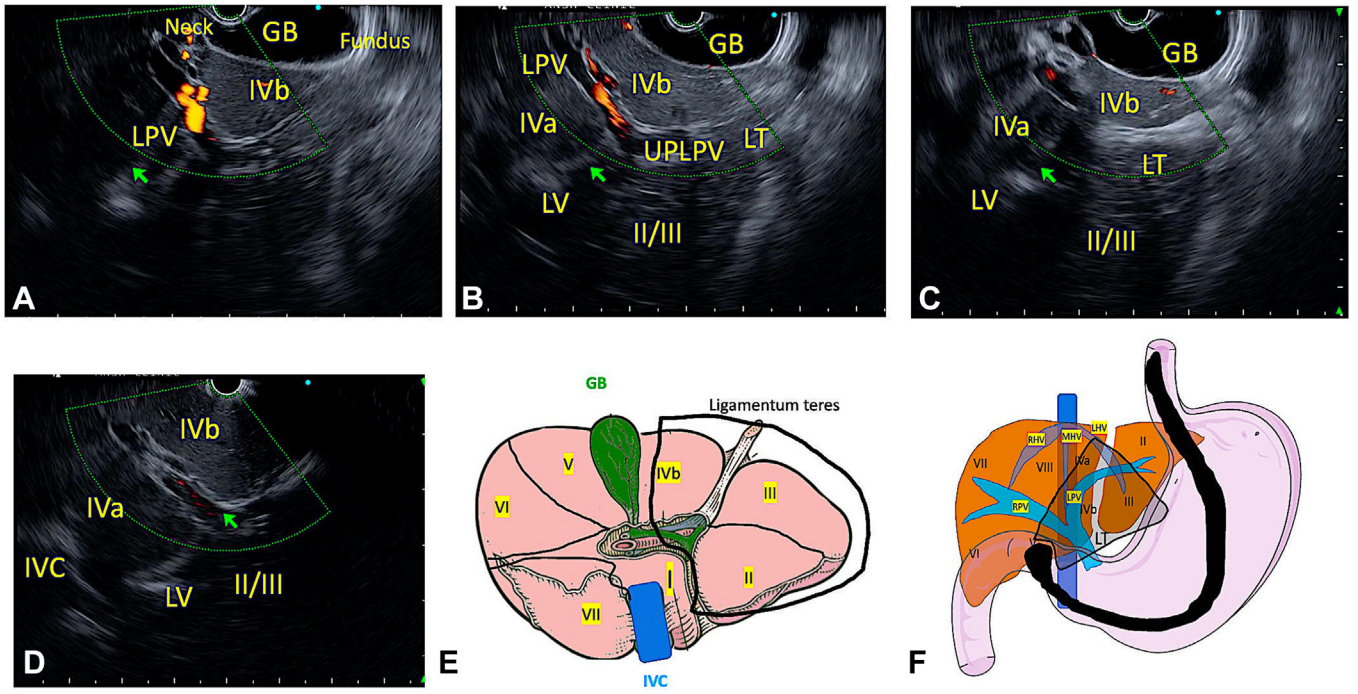

Figure 7. Station 5A: Visualization of left segments from the duodenal bulb (possible in thin patients) **A,** EUS image showing left portal vein (LPV) along with neck of gallbladder (GB) at the hilum. **B,** Follow the LPV by anticlockwise rotation (advancing the scope minimally). EUS image showing umbilical portion of left portal vein (UPLPV) with ligamentum teres (LT) and ligamentum venosum (LV). Segment IVb is visualized below the GB and above the UPLPV. **C,** On further anticlockwise rotation, the whole GB is visualized. Segments II and III are lined by the LT and LV. **D,** On further anticlockwise rotation, the inferior vena cava is also visualized along with LV. **E,** Illustration showing visualized segments at this point (marked by *black circle*). **F,** Respective echoendoscope position with imaging area. *LHV*, Left hepatic vein; *MHV*, middle hepatic vein; *RHV*, right hepatic vein; *RPV*, right portal vein; *UPV*, umbilical portion of left portal vein.

below (left lower quadrant). Adjacent to segment VIII is segment VII (right lower quadrant) with segment VI above, close to the transducer (right upper quadrant). The GB neck is visualized near segment V. On further anticlockwise rotation, the right kidney is seen along with segments V and VI (Fig. 6). The right hepatic duct can be followed by following the RPV.

Station 5A: Visualization of left liver segments by following the LPV from the duodenal bulb. Left liver segments are better visualized from the stomach and may not require examination from the duodenal bulb. Imaging these segments from the duodenal bulb is challenging.

For left liver segment visualization from the bulb, follow the LPV. To trace the LPV, come to the hilum again by clockwise rotation from the RPV. At the hilum, the LPV is seen running downward from the transducer. The LPV can be followed by anticlockwise rotation. Following the LPV, the ligamentum teres can be seen with segment IVb near the transducer and segment II/III below, in the lower part of the screen. When the ligamentum teres is seen along with segment IVb, on minimal anticlockwise rotation ligamentum venosum is seen along with the IVC and segment I (Fig. 7).

Station 5B: Visualization of the IVC and HV from the duodenal bulb. Similarly, visualization of HVs from the duodenal bulb is challenging. However, they can be visualized by following the IVC in patients who are thin. The LHV is seen in the left-sided liver, separating segments II and III from IV. In further anticlockwise direction, following the IVC (without any withdrawal of scope or knob movements), the MHV and suprahepatic IVC are seen. Rotate the scope extremely in anticlockwise direction, to visualize the RHV. In the same image, the RPV (near the transducer) and the suprahepatic IVC joining into the right atrium are seen in the lower quadrant. Rotating the scope in anticlockwise direction (below the patient level), segments V and VI are seen with the RHV traversing vertically through it (Fig. 8).

Station 6: Visualization of segments I and VI by following the IVC from duodenal bulb. Visualization of segments I and VI from the duodenal bulb requires a particular maneuver. Segment I is visualized following the IVC on anticlockwise rotation from the bulb. It is seen between the PV and IVC. For visualization of segment VI, rotate the scope in clockwise direction following the IVC. The right kidney comes into view, and with further clockwise rotation from the right kidney, segment VI is visualized near the transducer (Fig. 9).

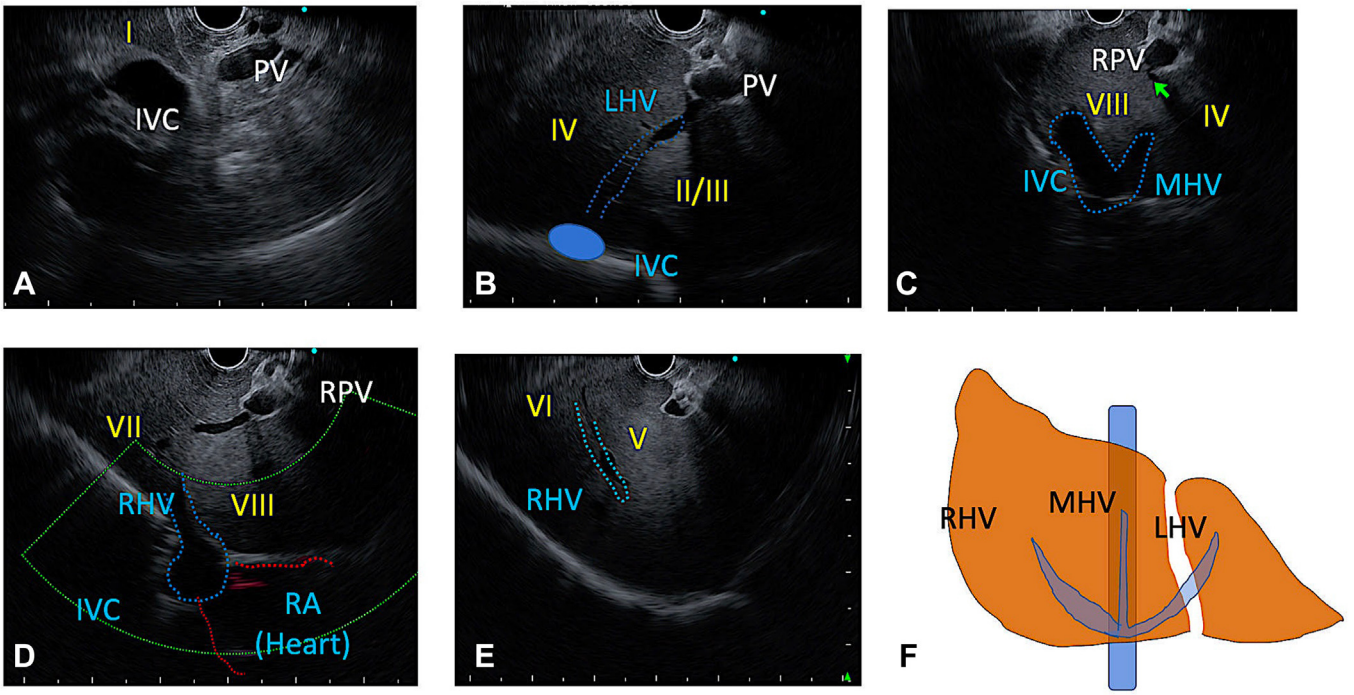

Figure 8. Station 5B: Visualization of hepatic veins following the inferior hepatic vena cava (IVC) from the duodenal bulb (possible in patients who are thin). **A,** Follow the IVC from the bulb. Segment I is visualized between the portal vein and IVC. **B,** On anticlockwise rotation (while advancing the scope), follow the left hepatic vein (LHV). Segments II/III and IV are visualized. **C,** On further anticlockwise rotation, the middle hepatic vein (MHV) is visualized. Segments IV and VIII are seen. **D,** On further anticlockwise rotation, right hepatic vein (RHV) is visualized along with segments VIII and VII. **E,** On anticlockwise rotation, segments V and VI are seen along with peripheral part of RHV. **F,** Illustration of liver orientation corresponding with EUS image. *RA*, Right atrium; *RPV*, right portal vein.

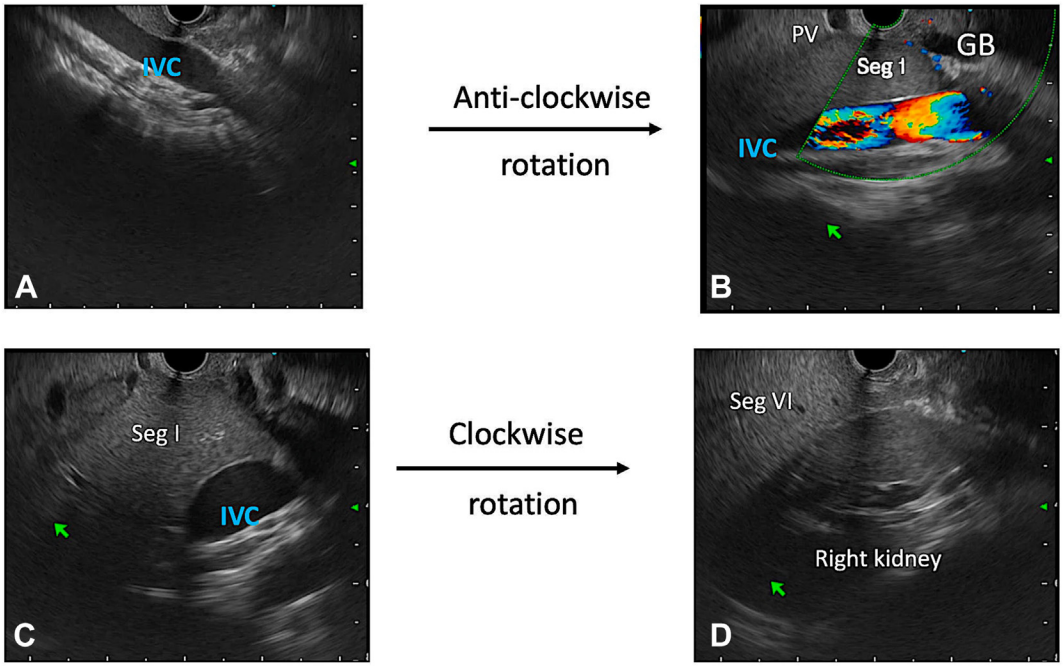

Figure 9. Station 6: Visualization of segments I and VI by following the inferior vena cava (IVC) from the duodenal bulb. **A,** EUS image showing the IVC from duodenal bulb. **B,** Segment I is visualized by anticlockwise rotation from the IVC. Segment I is seen between portal vein (PV) and IVC. **C,** EUS image of segment I along with IVC from duodenal bulb (seen by advancing the scope while rotating in anticlockwise direction from the main portal vein). **D,** With a clockwise rotation from IVC, right kidney is visualized with segment VI above, on the upper-left part of the screen. *GB*, Gallbladder.

CONCLUSION

The expanding scope of endohepatology has highlighted the increasing importance of EUS in liver assessment and intervention. Therefore, incorporating EUS examination of the liver into EUS training programs and routine biliary anatomy studies is essential. Understanding liver anatomy using a linear echoendoscope can significantly enhance EUS-guided interventions. However, recognizing liver segments with linear EUS remains challenging due to overlapping segments and the absence of fixed (familiar) anatomical landmarks. A station-wise approach to liver anatomy on linear EUS can facilitate segmental identification and improve correlation with corresponding computed tomography/cross-sectional images. By following stations 1 to 4, all liver segments can be accurately identified. Although stations 5 and 6 are useful, examination of these may not be required, because they can be adequately visualized from other stations.

PATIENT CONSENT

Complete written informed consent was obtained from the patient for the publication of this study and accompanying images.

DISCLOSURE

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