Review Article

Practical approach to linear EUS examination of the liver

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ABSTRACT

EUS has become a substantial diagnostic and therapeutic modality for digestive tract conditions. The extent of endosonographic assessment is wide, and, among others, it allows for the evaluation of liver anatomy and related pathologies. Moreover, EUS assessment has proved more accurate in detecting small focal liver lesions missed by standard imaging examinations such as computed tomography or magnetic resonance. Endosonographically, various liver segments can be visualized by transgastric and transduodenal scanning following anatomical landmarks, thus providing arranged systematic examination. In addition, knowledge considering the correct position during examination is crucial for EUS-guided procedures such as hepaticogastrostomy, ablation of tumors, and measurement of portal pressure gradient. The evolution of EUS-guided intervention has contributed to the increasing importance of understanding the hepatic segmental anatomy during the EUS examination.

Key words: anatomy, EUS, linear, liver segments

INTRODUCTION

EUS plays an integral role in the evaluation of various liver pathologies that includes detection of lesions with a diameter smaller than 10 mm missed by transabdominal ultrasound or computed tomography (CT) scan.[1] Moreover, EUS has found an application for procedures including sampling by fine-needle aspiration (FNA) or fine-needle biopsy, endoluminal interventions such as different types of drainage, and ablative techniques.[2,3] Consequently, EUS examination of each liver segment is necessary to provide adequate information about various liver lesions, especially when conducting EUS-guided interventions or surgical resection. In this review, we will provide a practical approach to illustrate the normal anatomy of liver segments using linear EUS, with its applications in different disorders affecting the hepatobiliary system.

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ANATOMY OF THE LIVER SEGMENTS

According to Couinaud classification, the liver can be divided into eight segments (I–VIII), of which each is independent in terms of function based on the distribution of the portal vein (PV) branches and the hepatic veins within the liver parenchyma.[4] The liver is divided into left and right lobes by the middle hepatic vein (MHV). The falciform ligament and the left hepatic vein further divide the left lobe of the liver into medial (IVa above and IVb below the portal plane) and lateral (II above and III below the portal plane) segments. The right hepatic vein divides the right hepatic lobe into anterior (V below and VIII above the portal plane) and posterior (VI below and VII above the portal plain) segments. The caudate lobe (segment I) lies in the posterior compartment between the ligamentum venosum and the inferior vena cava (IVC) [Figure 1].

METHODS AND PLAN OF EUS EXAMINATION OF THE LIVER

The liver can be scanned from the stomach and the duodenum.

Scanning from the stomach

A linear echoendoscope is located just below the cardia; then, the scope is gently manipulated until our landmark is visualized which is the IVC and the right hepatic vein, which can be recognized by having the widest diameter at its joining part with the IVC with gradual tapering as it goes inside the liver parenchyma [Figure 2].

At this sonographic plane, segment I (caudate lobe) is localized between the tip of the echo-endoscope and IVC, segment VIII is localized between the IVC and the adjoining part of the right hepatic vein, while part of segment VII is located below the right hepatic vein [Figure 2].

On counterclockwise rotation, two structures will be identified: the first one is the ligamentum venosum that extends from the umbilical portion (UP) of the left PV to the IVC. The second structure is the MHV with a uniform diameter throughout its whole length and finally joins the IVC. Three hepatic segments are visualized in this view: segment I (caudate lobe), which is located between the scope and ligamentum venosum, segment IVa between the ligamentum venosum and MHV, and segment VIII lying below the MHV [Figure 3].

With more counterclockwise rotation, the left hepatic vein is visualized traversing the left lateral part of the left lobe, separating segment II (closer to the probe) from III [Figure 4].

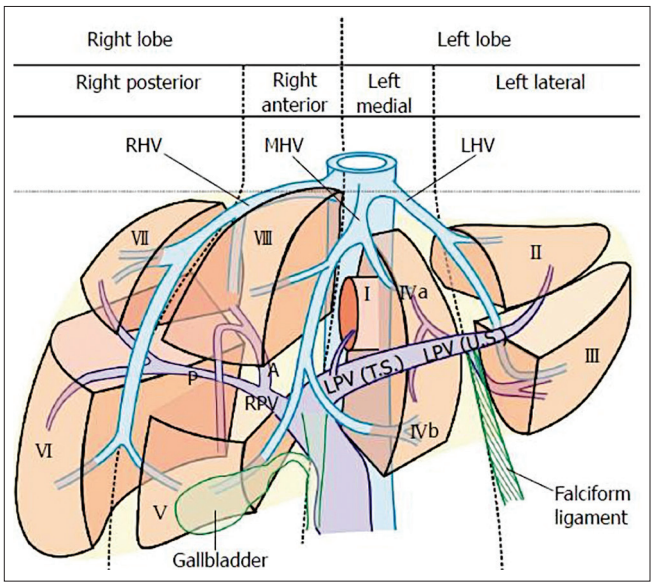

Figure 1. Segmental anatomy of the liver. MHV: Middle hepatic vein; RHV: Right hepatic vein; LHV: Left hepatic vein; PV: Portal vein; IVC: Inferior vena cava.

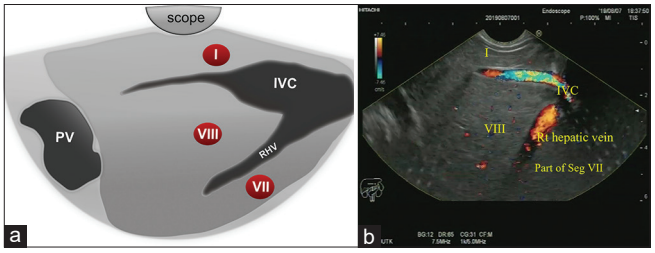

Figure 2. (a) Diagram of EUS segmental anatomy at the level of inferior vena cava and right hepatic vein. (b) Linear EUS segmental anatomy at the level of inferior vena cava and right hepatic vein. PV: Portal vein; IVC: Inferior vena cava.

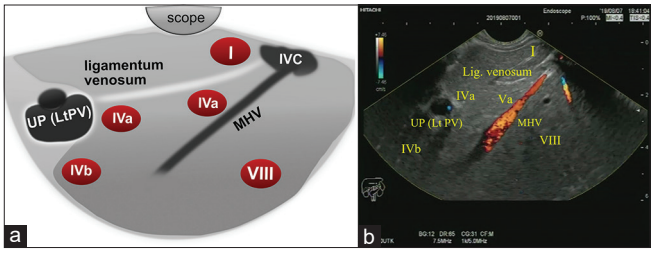

Figure 3. (a) Diagram of EUS segmental anatomy at the level of inferior vena cava and middle hepatic vein. (b) Linear EUS segmental anatomy at the level of inferior vena cava and middle hepatic vein. UP: Umbilical portion; IVC: Inferior vena cava; MHV: Middle hepatic vein.

The UP of the left PV represents a significant landmark (fish eye appearance) that can be located by tracing the ligamentum venosum from the IVC to the UP of the left PV by pushing the scope downward with slight counterclockwise rotation. At this point, segment IVa is located above, and IVb is located below the junction of the ligamentum venosum and UP of the left PV [Figure 3]. Further pushing the echoendoscope forward will lead to visualization of the ligamentum teres. Segment IVb is visible below this structure, while segment III is located between it and the echoendoscope [Figure 5].

The hepatic hilum

As the ligamentum venosum is identified, the hepatic hilum can be viewed by pushing the echoscope and turning it in a clockwise direction. The PV will be located very close to the probe at the hepatic hilum. In this view, the hepatic artery will be seen between the PV and the bile duct [Figure 6]. If the echoscope is rotated counterclockwise with an upward deflection, the gallbladder will be visualized, and segment V might be seen in this view [Figure 7].

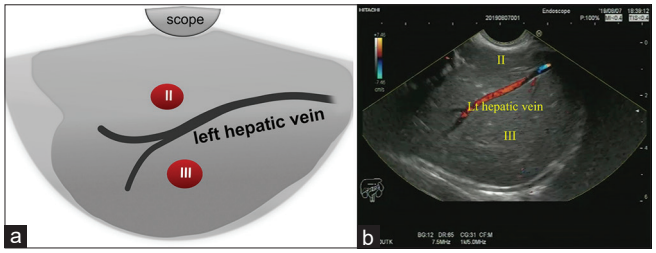

Figure 4. (a) Diagram of EUS segmental anatomy at the level of inferior vena cava and left hepatic vein. (b) Linear EUS segmental anatomy at the level of inferior vena cava and left hepatic vein

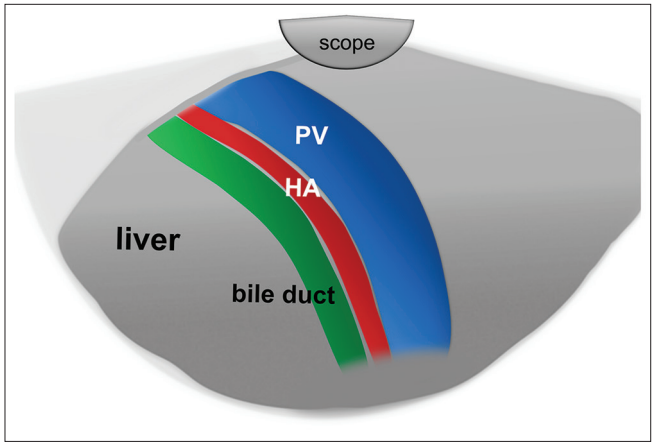

Figure 6. Diagram of EUS segmental anatomy at the level of the liver hilum showing the hepatic artery between the portal vein (nearest structure to the scope) and the bile duct. PV: Portal vein; HA: Hepatic artery.

Scanning from the duodenal bulb

The whole right lobe, including segments V, VI, VII, and VIII in addition to segment IV of the left lobe, can be visualized from the duodenum.

The landmark in the duodenal bulb is the portal venous confluence formed by the superior mesenteric vein coming from the right side of the screen to join the splenic vein coming from below to form the main PV going up and to the left of the screen. Then, slow and gentle forward pushing of the echoendoscope against the superior duodenal angle will form a J-shaped configuration [Figure 8a]. By gradual and gentle counterclockwise rotation with slight upward deflection, the main PV can be traced till its bifurcation into the right branch going up and the left one going down away from the scope, with segment IV located in between the two branches [Figure 8b and c]. Further counterclockwise rotation allows tracing the right branch of the PV on the upper part of the screen to its anterior branch observed on the left part of the screen (with segments V up and VIII down), while the posterior branch will be observed on the right part of the screen (with parts of segment VI up and VII down) [Figure 8d]. By more gentle counterclockwise rotation in the bulb, the gallbladder can be displayed, and the liver

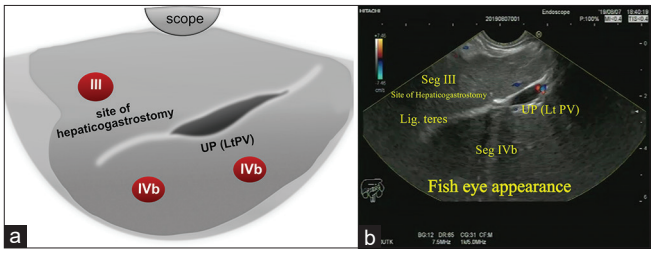

Figure 5. (a) Diagram of EUS segmental anatomy at the level of the left portal vein (fish eye appearance) and ligamentum teres. (b) Linear EUS segmental anatomy at the level of the left portal vein (fish eye appearance) and ligamentum teres. UP: Umbilical portion.

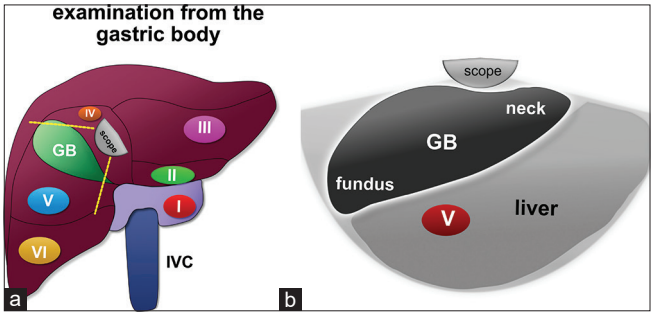

Figure 7. (a) Diagram of EUS segmental anatomy of the liver and the gallbladder as seen from the stomach. (b) Diagram of linear EUS anatomy of the gallbladder and segment V of the liver as seen from the stomach. GB: Gallbladder.

parenchyma located directly below it belongs to segment IV [Figure 9a-c].

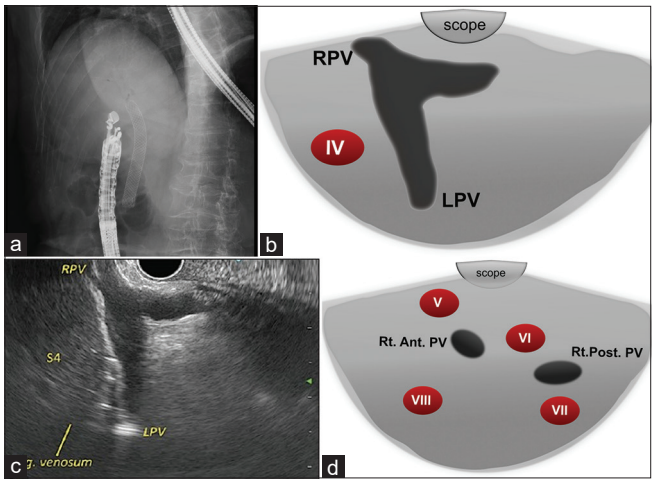

Figure 8. (a) Long position of the echoendoscope at the duodenal bulb for examination of the left and right portal veins and segment IV of the liver. (b) Diagram of the left and right portal veins and segment IV of the liver as seen from the duodenal bulb. (c) Linear EUS anatomy of the left and right portal veins and segment IV of the liver as seen from the duodenal bulb with counterclockwise rotation. (d) Diagram of the right anterior and right posterior portal veins and segments V, VI, VII, and VIII of the liver as seen from the duodenal bulb with counterclockwise rotation. PV: Portal vein.

Although the assessment of posterior segments (VI, VII) is challenging, searching the right kidney as a next landmark may help to visualize segment VI. After identifying the PV and pushing the scope gently against the superior duodenal angle, the IVC and then the right kidney can be displayed on the right side of the screen by gradual, gentle clockwise rotation and slight upward deflection. Segment VI will be anterior to the right kidney and the left part of the screen [Figure 9d].

APPLIED ANATOMY OF EUS EXAMINATION OF THE LIVER

Focal liver lesions

EUS is a useful adjuvant to CT and magnetic resonance imaging (MRI) in diagnosing and characterizing focal liver lesions (FLLs). Several studies have shown the superiority of EUS over CT in detecting FLLs, especially when they are small (<1.0 mm) or located in the left lobe or hilum.[5] Contrary to CT and MRI, EUS has become the most sensitive tool in detecting hepatic focal lesions. However, the successful evaluation depends on a careful, meticulous, and systematic

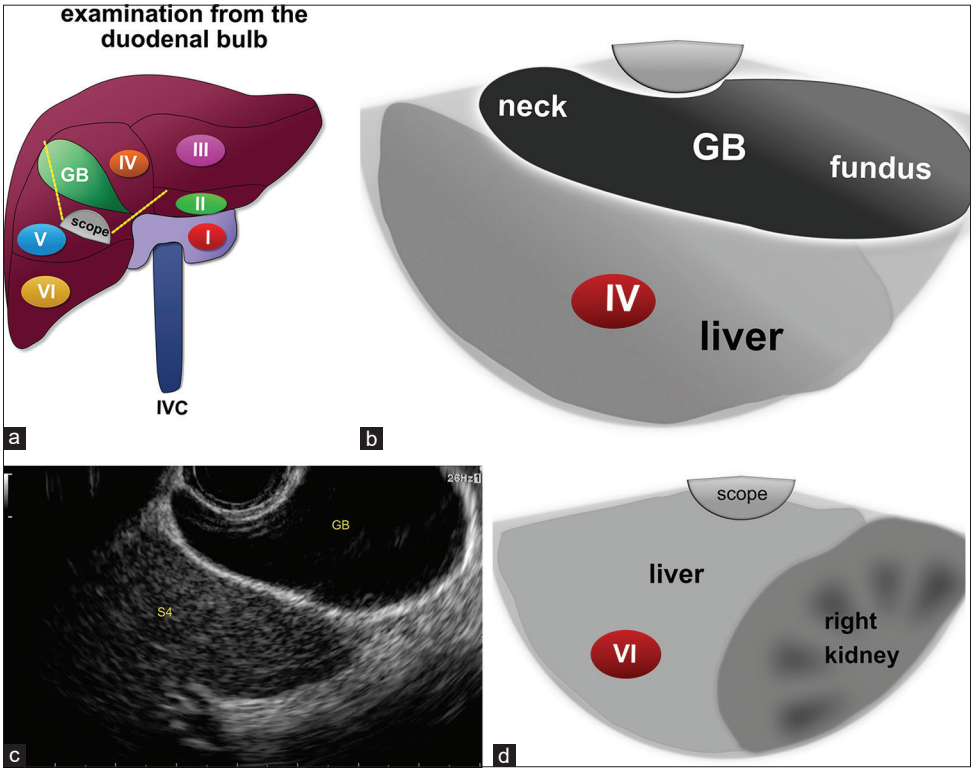

Figure 9. (a) Diagram of EUS segmental anatomy of the liver and the gallbladder as seen from the duodenal bulb with counterclockwise rotation. (b) Diagram of linear EUS anatomy of the gallbladder and segment IV of the liver as seen from the duodenal bulb. (c) Linear EUS anatomy of the gallbladder and segment IV of the liver as seen from the duodenal bulb. (d) Diagram of linear EUS anatomy of segment VI of the liver and the right kidney as seen from the duodenal bulb with clockwise rotation. GB: Gallbladder.

examination performed by an expert endosonographer, especially for lesions smaller than 20 mm. Furthermore, endosonographic assessment is useful in the staging of gastrointestinal and thoracic malignancies, as it provides data about the depth of invasion (T stage) and regional lymph node involvement (N stage), and allows for FNA and biopsy of such lesions. EUS can also be used to screen patients for metastatic disease, especially to the liver, and allows more accessible and safer tissue acquisition for confirmatory pathological diagnosis.[5]

Real-time EUS-elastography has been described as a valuable tool in detecting, characterizing, and differentiating benign and malignant FLL with sensitivity, specificity, and diagnostic accuracy of 92.5%, 88.8%, and 88.6%, respectively.[6]

Differentiation between various types of FLL can also be studied through vascular enhancement patterns with CE-EUS. Typical enhancement patterns include arterial hyperenhancement with subsequent rapid washout in hepatocellular carcinoma (HCC), arterial hyperenhancement with rim-like enhancement and the subsequent rapid washout in metastatic liver cancer, and peripheral nodular hyperenhancement with centripetal progressive fill-in in hemangioma.[7]

EUS-guided sampling is indicated if the pathological result is likely to affect patient management, the lesion is poorly accessible or not detected on percutaneous imaging, or a sample obtained via the percutaneous route repeatedly yields an inconclusive result.[8]

Liver cirrhosis

The real-time elastography, used in EUS, can be advantageous over trans-abdominal fibroscan in the detection of fibrosis, as it can estimate liver stiffness in all patients (either obese or not) and has the potential to differentiate between fibrosis and steatosis, as liver steatosis has a distinct appearance on real-time sono-elastography images, with low mean hue histogram values.[9]

If histological confirmation is needed, EUS-guided liver biopsy is a safe technique with a diagnostic yield for liver parenchymal disorders such as liver cirrhosis, primary sclerosing cholangitis, autoimmune hepatitis, and nonalcoholic fatty liver disease (NAFLD) between 91% and 100%, which is at least comparable to percutaneous or transjugular routes.[10]

Portal hypertension

There are several potential clinical applications of EUS in portal hypertension, namely evaluation of esophageal and gastric varices and collateral veins, assessment of hemodynamic changes (through EUS-guided PV catheterization), and prediction of variceal bleeding and rebleeding (through intravariceal pressure measurements).[11]

THERAPEUTIC ROLE OF EUS IN LIVER

EUS-guided liver tumor ablation/injection

Radiofrequency ablation (RFA) is an alternative low-risk minimally invasive therapy for HCC and liver metastases when resection cannot be performed or, in the case of HCC when transplantation cannot be executed. EUS-guided RFA with a prototype-retractable umbrella-shaped electrode array has been created for effective coagulation necrosis of large areas, minimizing the risk of gastric mucosal damage.[12]

Cryothermal ablation (cool-tipped RFA) is a new flexible device with a hybrid probe that combines bipolar RFA with cryotechnology, allowing for more efficient tissue ablation in the setting of lower temperatures provided by the cooling cryogenic gas.[13]

Neodymium: yttrium-aluminum-garnet (Nd-YAG) laser ablation is a minimally invasive method for solid tumor destruction by directing low-power laser light energy into tissues. Its advantages are use of thinner needles, shorter application time, and the ability to reuse and re-sharp the needle, which can be used at different angles.[14]

EUS-guided fine-needle ethanol injection was developed to deliver therapeutic agents to a target site more precisely and minimize damage to nontumor tissues compared to that of the percutaneous approach.[15]

EUS-guided selective portal vein embolization

Preoperative embolization of PV branches causing atrophy of the hepatic segments to be removed and the subsequent compensatory hypertrophy of the remaining segments has proven to be safe and effective in patients undergoing extensive hepatectomy.[16]

EUS-guided cyst ablation

EUS-guided aspiration and lavage therapy with alcohol has been postulated as having the advantage of not requiring insertion of a percutaneous drainage catheter,

thus enabling alcohol lavage to be done with a one-step approach and has been considered the preferred approach to left-lobe cysts. There is a newer sclerosing agent used in EUS-FNA (1% lauromacrogol) that seems to have fewer side effects than that of traditional ethanol and can thus be used as a replacement.[17]

EUS-guided liver abscess drainage

EUS-guided liver abscess drainage has been developed with the advantages of doing one-step internal drainage (which has an obvious cosmetic benefit and avoids the risk of self-tube removal and peritonitis).[18]

EUS-guided therapy for portal hypertension

Esophageal varices can also be eradicated using EUS-guided sclerotherapy. This procedure seems to reduce the recurrence of esophageal varices after endoscopic therapy. Minor complications in EUS-sclerotherapy (as thoracic pain and self-limited bleeding) have been reported and do not seem to differ from that of the endoscopically induced complications.[19]

For eradication of gastric varices, EUS-guided cyanoacrylate injection with or without coiling with precise injection in the collateral veins can be valuable for achieving hemostasis during active bleeding.[20]

EUS-guided biliary drainage

EUS-guided biliary drainage (EUS-BD) has emerged as an acceptable alternative to percutaneous transhepatic biliary drainage (PTBD) or surgery when ERCP fails. EUS-BD has several advantages. First, it is minimally invasive and can be performed directly after a failed ERCP in the same session by the same endoscopist.[21] Second, drainage of both the intrahepatic and extrahepatic bile ducts may be achieved. Third, it is minimally invasive with minimal or no procedural pain. Fourth, as opposed to PTBD, there is no external drain that can disturb or limit patient's daily activities. In addition, a short hospital stay (similar to ERCP) is expected, and the reported adverse event rate is far lower than that for PTBD. EUS-guided hepatico-gastrostomy is better to be done through segment III, affording more stabilized position of the deployed stent with more safety against stent migration in addition to avoiding stent opening into the cardia if segment II was punctured, while EUS-guided hepatico-gastrostomy with antegrade stenting and rendezvous technique is better to be done through segment II of the left lobe of the liver which anatomically is in direct continuity with the biliary bifurcation, allowing easy and short-time maneuver for directing the guidewire with subsequent facilitation of antegrade stenting.[22]

EUS-guided antegrade biliary duct stone extraction

Postoperative patients especially with Roux-en-Y anastomosis presenting with intrabiliary duct stones continue to represent a challenge facing different endoscopic procedures. While enteroscopy-assisted ERCP has enabled access and therapeutic efficacy in such patients, the success rates range from 67% to 95%. Recently, EUS-guided antegrade stone extraction techniques, with preferably access through segment II, have emerged, showing an alternative feasible and safe therapeutic option in this category of patients.[23]

CONCLUSION

The rapidly expanding impacts of EUS diagnostic and therapeutic maneuvers in hepatobiliary disorders urge a deeper and a more meticulous understanding of the different EUS views of hepatobiliary anatomy with focus on liver segmentation, representing the cornerstone in advanced EUS interventions. We tried in this review to simplify this knowledge in addition to a practical and applicable step-based approach maintaining a thoroughly comprehensive EUS examination.

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Conflicts of interest

There are no conflicts of interest.

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