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CASE REPORT

Could transesophageal echocardiography be useful in selected cases during liver surgery resection?

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Abstract
Purpose Although only limited scientific evidence exists promoting the use of transesophageal echocardiography (TEE) in non cardiac surgery, several recent studies have documented its usefulness during liver surgery.
Methods and results In the present case study, through the use of color Doppler TEE, compression of the inferior vena cava and the right hepatic vein was clearly evident, as was their restoration after surgery.
Conclusion TEE should be encouraged in patients undergoing liver resection, not only for hemodynamic monitoring, but also for its ability to provide information about the anatomy of the liver, its vessels, and inferior vena cava patency.

Keywords Transesophageal echocardiography · Liver surgery · Hepatic angioma · Hemodynamic monitoring

Riassunto
Il fegato può essere coinvolto da una varietà di patologie, che vanno dalle lesioni benigne come l'angioma epatico, che possono necessitare di essere resecate, all'insufficienza epatica per la quale l'unica terapia possibile è il trapianto di fegato. Benchè ci siano solo limitate evidenze scientifiche che supportino l'utilizzo dell'ecografia transesofagea (TEE) nella chirurgia non cardiaca, alcuni studi hanno documentato la sua utilità durante la chirurgia epatica. Nel caso in studio, attraverso l'uso del color Doppler TEE la compressione della vena cava inferiore a della vena epatica destra erano visualizzate così come le loro dimensioni dopo l'intervento chirurgico. Per tale motivo l'utilizzo del TEE dovrebbe essere incoraggiato nei pazienti che vanno incontro a resezione epatica non solo come strumento di valuatzione emodinamica ma anche per la sua abilità di dare informazioni utili sull'anatomia del fegato dei suoi vasi e sulla pervietà della vena cava.

Introduction

The liver can be involved in a variety of pathologies ranging from benign lesions, such as angiomas that require hepatic resection, to the end stage liver disease for which the only therapy should be liver transplantation. Thanks to the advances made in surgical techniques, anesthetic management, and perioperative care, hepatic resections have become more common, complex, and with strikingly better outcomes. Nevertheless, controversy continues to exist in relation to the intraoperative monitoring of hepatic surgery patients and most institutions use protocols that are based on institutional common practice or the surgeon's personal preferences, but for which little or no evidence exists to support their use [1]. Intraoperative transesophageal echocardiography (TEE) is a minimally invasive monitoring technique that provides real-time visual information on ventricular function and volume status. While the use of TEE is a standard practice in cardiac surgical procedure [2] its application in non cardiac surgery has only recently become the subject of research [3, 4]. We wondered whether the TEE could give us real-time information about the liver surgery in a patient with inferior vena cava compression.

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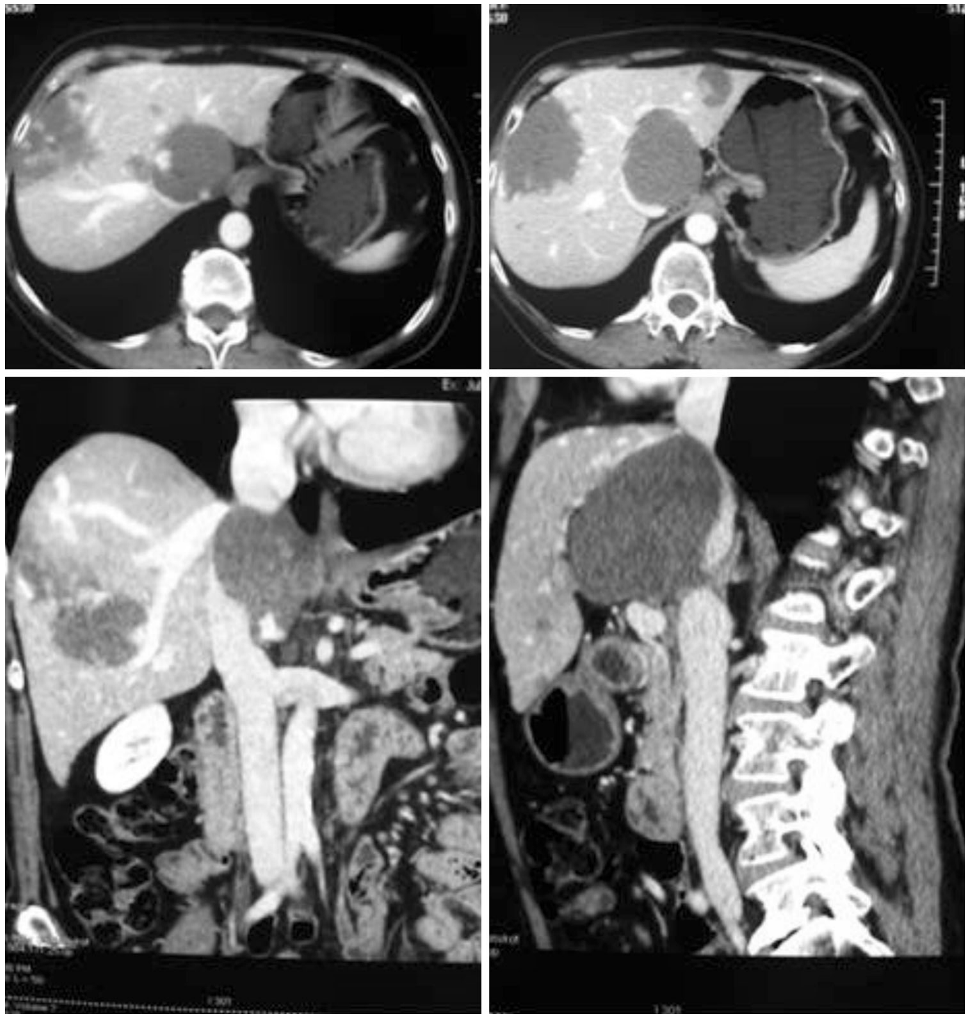

Fig. 1 Contrast-enhanced computed tomography scan (CT) of the liver revealed its increased size, with a right lobe diameter of 18 cm, and multiple roundish formations, which suggested the presence of multiple angiomas. Two major lesions were located in the eighth hepatic segment, one of which extended into the fifth segment, with an axial diameter of 7.7 cm, and the other extended into entire first, second and part of the fourth segment, with axial diameter of 6.1 cm. The CT scan also revealed multiple stenoses of the inferior vena cava as well as confluence of the right and middle hepatic veins

Case report

A 64-year-old female with a history of insulin-dependent diabetes mellitus, hypercholesterolemia, and recurring pain in a left abdominal site was admitted to hospital. Her previous medical history reported some episodes of cardiac palpitations and intermittent mild leg edema, for which electrocardiography (ECG) investigations had been performed revealing negative results, whereas an abdominal ultrasound showed multiple heterogeneous hepatic lesions. Patient work-up included a contrast-enhanced computed tomography (CT) scan of the liver. The examination was performed with and without contrast enhancement (Iomeprol 400 mg/mL, Iomeron® 400, Bracco, Milan, Italy). The liver appeared increased in size (right lobe diameter of 18 cm) but with regular morphology. Multiple roundish formations, presenting early peripheral enhancement of globular centripetal type with a tendency to fill in the equilibrium phase, suggested the presence of multiple angiomas. Two major lesions were located in the eighth hepatic segment, one of which extended into the fifth segment, with an axial diameter of 7.7 cm, and the other extended across the first, second and part of the fourth segment, with an axial diameter of 6.1 cm squeezing the hepatic tract of the inferior vena cava (Fig. 1).

In the case reported, the patient suffered from some episodes of cardiac palpitation and intermittent leg edema probably due to inferior vena cava compression. After a careful explanation of risk benefit ratio, the patient was scheduled for the resection of the angioma in the first hepatic segment and enucleation of the lesions across the V, VII and VIII segments. The surgery was performed with the necessity of cross-clamping of the hepatic pedicle (Pringle maneuver), respectively of 17 and 15 min.

Anesthesia monitoring consisted of 2-lead electrocardiography (leads II and V5), pulse oximetry, temperature and invasive arterial blood pressure measurement (IntelliVue MP70, Philips, Boeblingen, Germany), and multigas analysis (Dräger zeus, Lübeck, Germany). Hemodynamic monitoring of cardiac output (CO), pulse pressure variation (PPV), and stroke volume variation (SVV) were performed

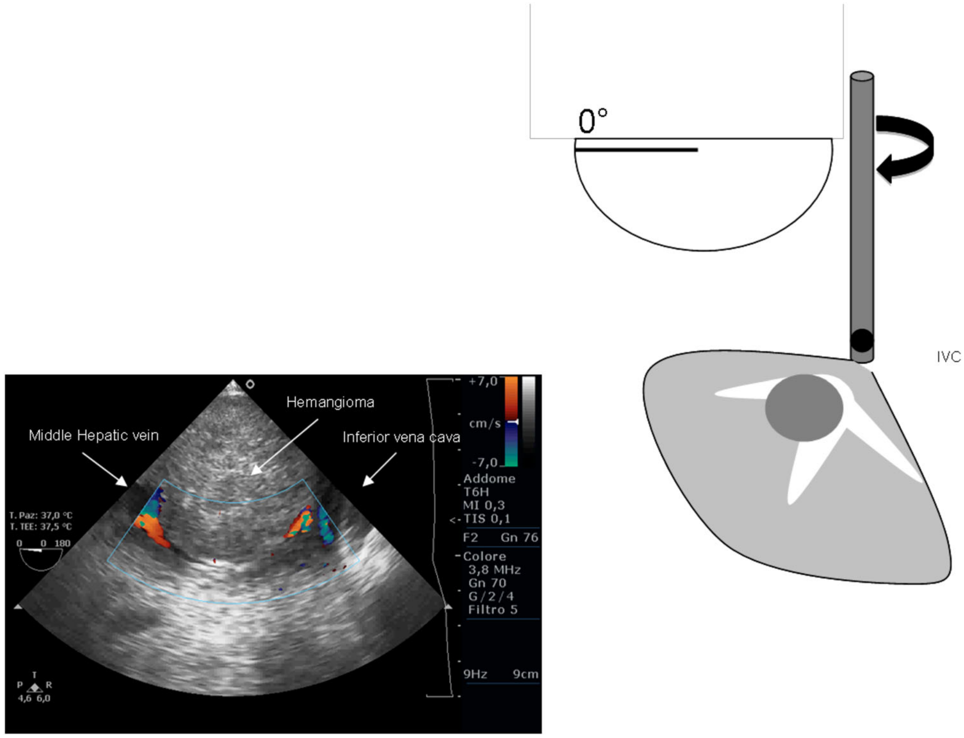

Fig. 2 Transesophageal echocardiography view at 0° and schematic representation, before surgery, of the inferior vena cava (*IVC*) stenosis and the confluence of the right hepatic veins

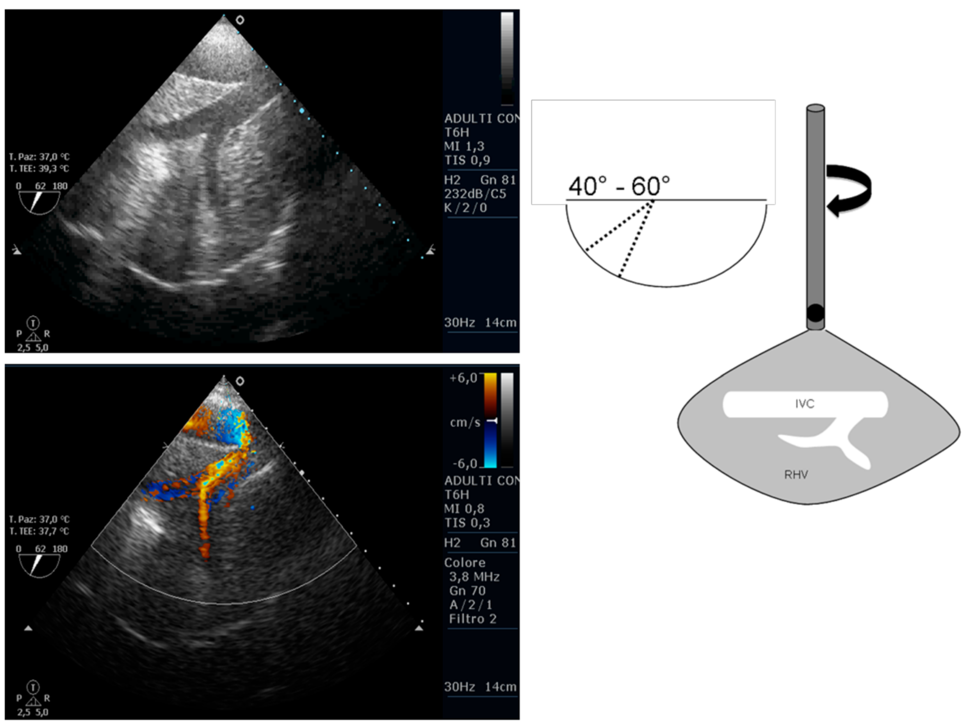

Fig. 3 Schematic representation, after surgery of inferior vena cava (*IVC*) and right hepatic vein (*RHV*) with transesophageal echocardiography view at 62°. Color Doppler demonstrated the restoration of blood flow

using a combination of the Nexfin monitor model 2 (BMEYE B.V. Amsterdam, Netherlands) and TEE, using a Philips SONOS 5500 Ultrasound system (Bothell, WA USA) and transesophageal probe. TEE was started at the edge of the transesophageal-trans-gastric view at 0° to obtain a good image of the right atrium. The probe was further turned to the right and to identify the orifice of the IVC Fig. 2. The right hepatic vein (RHV) was identified by modifying the phasic array signal emitted from the transducer to 40°–60° (Fig. 3).

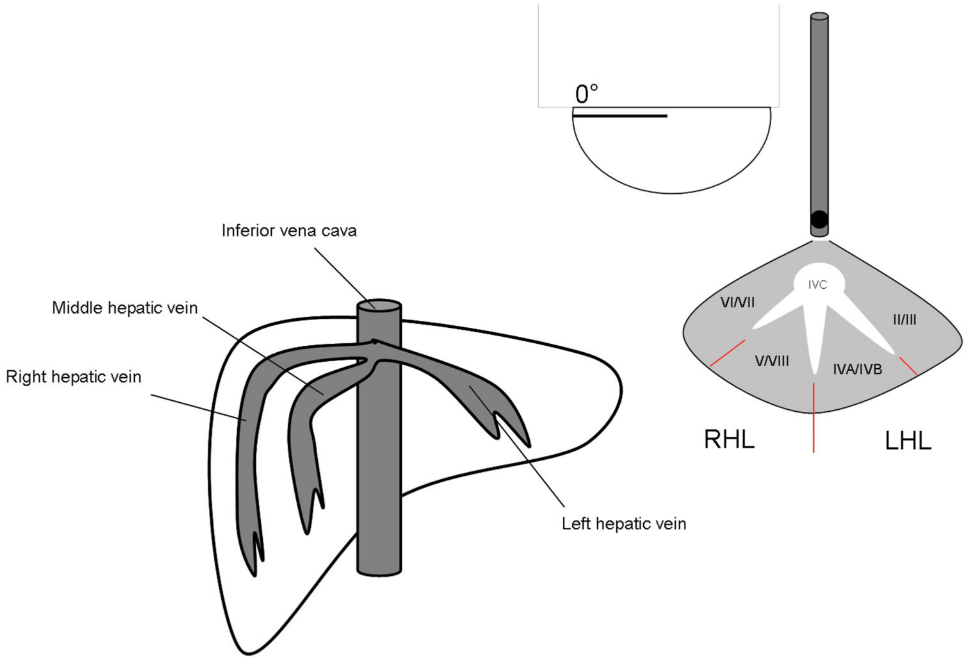

Fig. 4 Topographic representation: the left hepatic vein separates the lateral left lobe (segments *II*, *III*), from the medial left lobe (segment *IVA* and *IVB*). The middle hepatic vein separates the right and left lobes, the median left lobe and the median right lobe (segments *V* and *VIII*). The right hepatic vein separates the medium right lobe from the lateral right lobe (segments *VI* and *VII*)

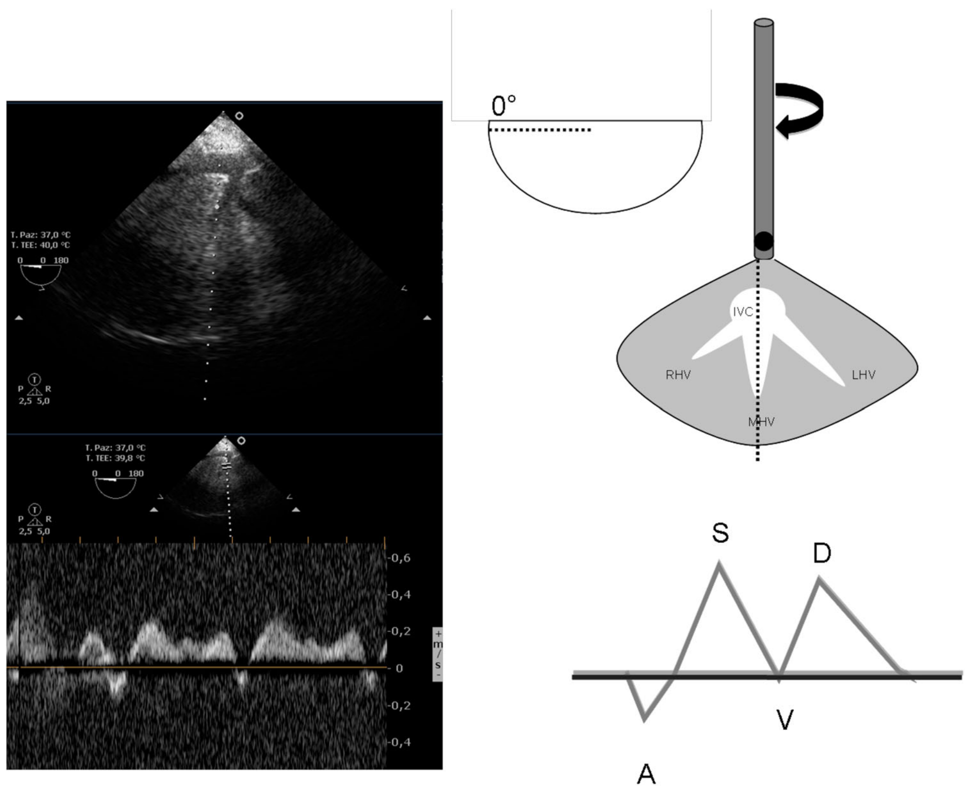

Fig. 5 Normal triphasic hepatic Doppler waveform. The four waveforms constituting the normal spectral Doppler waveform are indicated: the *A* wave lies below the baseline (retrograde component); the *S* and *D* waves peak above the baseline and are caused by anterograde blood flow toward the heart; and the *V* wave, a transitional wave, may peak just below or above the baseline

Transesophageal echocardiography was helpful in assessing hemodynamic changes in response to hepatic cross-clamp: increase in mean arterial pressure and increase in vascular resistance; decrease in pulmonary arterial pressure and cardiac index. In addition, in case of ischemia/reperfusion syndrome TEE could be useful to the patient management of hypotension and bradycardia. TEE allows detection of inferior vena cava stenosis and the two right and middle hepatic vein, as well as its restoration after surgery and, last but not least, the control and interruption of hepatic vein if air embolism is observed. The patient provided informed consent for the procedure and for data publication. No early or late TEE complications were reported.

Discussion

The main reason why liver resection is considered major surgery is because of anticipated blood loss and hemodynamic disturbances caused by manipulating some of the major venous vessels and blood return to the heart. Jarnaging and colleagues [5] studied 1,803 consecutive patients undergoing hepatic resection and analyzed factors associated with morbidity and mortality and the trends in operative and perioperative variables over the period of study. The number of hepatic segments resected and operative blood loss were the only predictors of perioperative morbidity and mortality, with fewer segments and less blood loss correlated with less perioperative morbidity. In another study, Melandez and colleagues [6] identified the following aspects as morbidity risk factors: ASA grading, patient age, size of resection, preoperative cholangitis, elevated creatinine and bilirubin levels, and preexisting cirrhosis; especially when associated with high operative blood loss. The ASA/SCA practice guidelines (category II) indicate TEE for perioperative use in patients with increased risk of hemodynamic disturbances. Indeed, TEE has been recommended as a pre-emptive monitoring tool to avoid life-threatening disturbances and to optimize organ perfusion [4]. Although direct evidence supporting these indications is lacking, expert opinions agree that TEE is clearly beneficial for diagnosing hemodynamic problems and for suggesting the most appropriate therapy [2]. Currently, the American Association for the Study of Liver Diseases (AASLD) recommends routine TEE for all liver transplant candidates for the assessment of chamber sizes, hypertrophy, systolic and diastolic function, valvular function, and left ventricle outflow tract obstruction [7].

Guidelines for the use of perioperative TEE have been specifically written for skilled examiners, and the present case highlights how the use of TEE for imaging liver anatomy and the hepatic vessels is extremely complex.

The liver can be divided longitudinally (i.e. the craniocaudal plane) along its three hepatic veins (left, middle, and right). The left hepatic vein separates the lateral left lobe (segments II, III) from the medial left lobe (segment IVA and IVB). The middle hepatic vein separates the right and left lobes of the liver, and more precisely, the median left lobe and the median right lobe (segments V and VIII). The right hepatic vein separates the medium right lobe from the lateral right lobe (segments VI and VII) Fig. 4. The left and middle hepatic veins join to form a single vein before entering the IVC in 60–86 % of people [8, 9]. Using TEE, Kirkeby-Garstad et al. reported good liver anatomy visualization and an acceptable-quality image of the IVC and the RHV in 95 and 87 % of cases, respectively [10]. Meierhenrich et al. [11], on the other hand, studied 34 patients scheduled for abdominal surgery and using multiplane TEE, they successfully identified the three main hepatic veins in all patients. Indeed, a number of studies support the proposition that TEE can provide good visualizations of both the IVC and RHV [12–14].

Doppler ultrasound tracing forms a fundamental component of a complete TEE examination of the liver, and spectral Doppler tracing from the hepatic veins can provide important information about cardiac and hepatic pathology [10]. A typical Doppler trace consists of three phases and four peaks: A, S, V, and D; where the S and D waveforms indicate blood flow in the anterograde direction toward the heart Fig. 5. In hepatic and cardiac disease, the S and D waveforms may be absent, as recently described in depth by Scheinfeld and colleagues [15].

In the present case study, through the use of color Doppler TEE, stenosis of the inferior vena cava and the two RHV and MHV was clearly evident (Fig. 2), as was their restoration after surgery (Fig. 3). Thus, TEE should be encouraged in patients undergoing liver resection, not only for hemodynamic monitoring, but for its ability to provide information about the anatomy of the liver, its vessels, and inferior vena cava patency.

Conflict of interest Luigi Vetrugno, Livia Pompei, Ester Zearo, Giorgio Della Rocca declare that they have no conflict of interest.

Informed consent The procedures were followed in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration. The patient provided written informed consent to the inclusion of information in this article that could potentially lead to their identification.

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