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Review Article

A Comprehensive Review of Transesophageal Echocardiography During Orthotopic Liver Transplantation



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Orthotopic liver transplantation (OLT) is characterized by significant hemodynamic disturbances and anesthetic challenges. Intraoperative transesophageal echocardiography (TEE) can be used to guide management during these procedures. This review examines the role of echocardiography during OLT, presents common TEE findings during each phase of OLT, and discusses the benefits demonstrated with TEE use and the safety of TEE in this patient population. Finally, the authors propose an algorithm for the safe use of TEE during OLT.

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Key Words: transesophageal echocardiography; echocardiography; orthotopic liver transplantation; intracardiac thrombus; transesophageal echocardiography certification; transplantation anesthesiology; transesophageal echocardiography monitoring; intraprocedural transesophageal echocardiography guidance

PATIENTS PRESENTING FOR orthotopic liver transplantation (OLT) can be difficult to manage due to preoperative medical comorbidities, significant intraoperative hemodynamic shifts, and periodic unexpected findings such as intracardiac thrombi or pulmonary emboli.^{1–3} Transesophageal echocardiography (TEE) allows for real-time, continuous, intraoperative monitoring of cardiac structures and function and is recommended during high-risk surgical procedures.⁴ According to the American Society of Echocardiography (ASE)/Society of Cardiovascular Anesthesiologists (SCA) Practice Guidelines for Transesophageal Echocardiography, TEE may be a beneficial adjunct in noncardiac surgical procedures during which there may be severe hemodynamic compromise or when unexplained life-threatening circulatory instability persists despite corrective therapy.⁵ The American

Association for the Study of Liver Diseases states that TEE should be used for all OLT procedures to assess intracardiac chamber sizes, ventricular hypertrophy, systolic function, diastolic function, valvular function, and left ventricle outflow tract obstruction (LVOTO).⁶ As such, many anesthesiologists have advocated for the routine use of TEE in all liver transplantation surgeries.⁷ In this study, the authors review the current literature regarding the utility, safety, and logistics of TEE during OLT and highlight the evidence gaps pertaining to 3-dimensional (3D) TEE, diastolic evaluation, and the role of transthoracic echocardiography (TTE) during liver transplantation.

Methods

Published English language studies, practice guidelines, and review articles from 2000 to 2017 were collected using PubMed, Google Scholar, the Harvard Medical School Countway Library, and the Massachusetts General Hospital

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Treadwell Library. Key words used in the search included “intraoperative TEE,” “orthotopic liver transplantation,” “safety of TEE,” “anesthetic complications during OLT,” “TEE findings during OLT,” and “transthoracic echocardiography use during OLT.”

A review of this literature was performed with the goal of determining the following:

- Value of TEE during liver transplantation
- Prevalence of TEE use during liver transplantation
- Level of training held by individuals performing TEE during liver transplantation
- Safety of TEE during liver transplantation
- TEE findings specific to liver transplantation
- Limitations of TEE during liver transplantation
- Role of transthoracic echocardiography during liver transplantation
- Future of TEE in liver transplantation

Utility of TEE

Each phase (pre-anhepatic, anhepatic, and neohepatic) in a liver transplantation is associated with specific anesthetic management challenges that may benefit from the use of TEE.⁸ In 2010 the American Society of Anesthesiologists (ASA) and the SCA published survey results regarding TEE use during OLT. More than half (53.7%) of expert consultants and 46% of ASA members agreed that TEE should be used routinely for monitoring during OLT.⁷ In addition, the ASA, SCA, ASE, and European Association of Echocardiography all individually have recommended the use of TEE monitoring during OLT.⁹ The use of intraoperative TEE monitoring during OLT has been shown to improve volume status monitoring and patient resuscitation, both which are crucial to patient survival during OLT.¹⁰ A single-center series of 100 OLT cases performed with intraoperative TEE monitoring reported that the majority of patients (64%) required a management change due to findings on TEE.¹¹ A separate single-center case series published in 2015 reported that 88% of patients demonstrated at least 1 abnormal intraoperative TEE finding.¹² Shillcut et al. reported that the 10 most common findings during all phases of OLT included microemboli, right ventricular dysfunction, thromboemboli, left-to-right flow through the patent foramen ovale, biventricular dysfunction, hyperdynamic ventricle, hypovolemia, mildly reduced left ventricular function, left-to-right flow through the patent foramen ovale, and left ventricular dysfunction.¹² Given the available literature and societal guidelines, it would be practical to consider the use of TEE for all liver transplantations. At the very least, the availability of TEE for use in emergency situations such as unrelenting hypotension, unexplained hypoxia, or malignant arrhythmias is crucial.

Prevalence of Use of TEE during OLT and Training

Recent surveys of liver transplantation centers have reported the frequency of TEE use during liver transplantation as between 87% and 94%.^{13,14} Wax et al. surveyed 40 high-

volume liver transplantation centers regarding intraoperative TEE use, and 13% of respondents reported TEE use in most or all liver transplantations; these results were similar to those in a survey published 5 years prior that indicated routine TEE use in 14.3% of all liver transplantations.^{13,14} The comprehensiveness of the echocardiographic examination performed during transplantation was variable. A limited examination was performed by 73% of anesthesiologists, whereas 27% of anesthesiologists performed a comprehensive examination as defined by the ASE and SCA guidelines.¹³ The different degrees of examination completeness in this study may reflect the level of TEE training. Only 12% of responding anesthesiologists were certified as diplomats of the National Board of Echocardiography (NBE) and had gained TEE competency through practicing cardiac anesthesia or completing a cardiac fellowship. The majority (89%) had gained competency through self-directed learning or continuing medical education courses.

The most recent survey to date reported the findings of 79 high-volume liver transplantation centers, performing at least 50 OLT cases a year, which represents 83% of all OLTs performed in the United States.¹⁵ The overall intraoperative TEE usage rate was 94.9% during liver transplantation. Specifically, 38% of respondents reported using TEE routinely in all OLTs and 57% used TEE for “special circumstances” or under “rescue conditions.” In the survey, 25.9% of anesthesiologists performing TEE either were diplomats of the NBE in advanced perioperative TEE or had achieved testamur status in advanced perioperative TEE, whereas 5.7% either were diplomats or had achieved testamur status of basic TEE as outlined by the NBE.¹⁵ Of the 598 responding anesthesiologists, 28.4% regularly practiced cardiac anesthesia. There was no difference in utilization rates between high- and low-volume centers and no statistical difference among academic, affiliate, or private practice institutional usage.¹⁵ The belief that TEE was “not necessary” and lack of training in TEE were the most commonly cited reasons by programs that did not use TEE on a routine basis. Per the surveys discussed, there is no uniformity across institutions with regard to the required certification level needed to perform TEE for liver transplantation.

Safety Considerations of TEE During Liver Transplantation

Kallmeyer et al. performed a retrospective review of complications associated with TEE in 7,200 cardiac surgical patients.¹⁶ The overall complication rate was reported to be between 0.02% and 1%.¹⁶ Daniel et al. reviewed more than 10,000 TEE examinations and confirmed similar results.¹⁷ The reported frequency of TEE during liver transplantation is increasing despite the debate on safety in the presence of esophageal varices, upper gastrointestinal (UGI) hemorrhage, coagulopathy, and thrombocytopenia.¹⁸ Esophageal varices are considered a relative contraindication to TEE placement, yet 73% of patients awaiting OLT have varices.¹⁹ Esophageal injury and rupture of esophageal varices are among the highest

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