United States Practice Patterns in the Use of Transesophageal Echocardiography During Adult Liver Transplantation

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Objective: **To characterize contemporary practice patterns in the use of transesophageal echocardiography during adult liver transplantation and to identify factors preventing more frequent use.**

Design: **Online questionnaire.**

Setting: **Liver transplantation centers in the United States performing 12 or more adult liver transplants in 2011.**

Participants: **One representative from each qualifying center: The transplant anesthesiology director, a transplant anesthesiologist personally known to the authors, or the department of anesthesiology chair.**

Interventions: **Three e-mail attempts were made to solicit participation in the study between June and August 2012.**

Measurements and Main Results: **Of the 97 institutions identified, an anesthesiologist from each of 79 (81.4%) centers completed the questionnaire; 38.0% of centers reported routine use and 57.0% for special circumstances or rescue situations, yielding an overall use rate of 94.9%. This distribution was consistent regardless of operative volume, practice size, or academic affiliation. The sole factor predictive of routine transesophageal echocardiography use was an overlap between an institution's cardiac and transplant anesthesiology teams. In practices not routinely employing the technology, the most compelling reason was a sense that it was not necessary. Although 69.9% of transplant anesthesiologists reportedly were proficient in echocardiography, inadequate anesthesiologist training was also a strongly cited hindrance.**

Conclusions: **Transesophageal echocardiography during adult liver transplantation in the United States has become widely prevalent, with notable growth in its use as a routine diagnostic and monitoring modality. Almost all institutions now use the technology at least occasionally, with the participation of cardiac anesthesiologists being predictive of a center's routine use.**

KEY WORDS: transesophageal echocardiography, liver transplantation, intraoperative monitoring, clinical practice patterns, questionnaires

TRANSESOPHAGEAL ECHOCARDIOGRAPHY (TEE) is a well-established monitoring and diagnostic imaging tool for cardiac surgery, and it is used increasingly during noncardiac surgery to facilitate management of hemodynamic instability. Since its conception in 1976, TEE progressively has advanced in both technology and utility.[1] It is now considered indispensable in cardiac surgery, guiding operative and anesthetic management.[2,3] Liver transplantation (LT) also presents a rational setting for TEE use, because patients undergoing the procedure have substantial comorbidities and the operation results in dramatic changes in global hemodynamics.[4,5]

As early as 1996, clinical findings supported the intraoperative use of TEE in LT. In a review of 100 cases, TEE influenced care decisions in 64 patients: 11 interventions qualified as major, 48 minor, and 10 limited.[6] In addition to its utility as a routine cardiovascular monitor, TEE has been reported to be of value in revealing various unique pathologic conditions, such as intracardiac thrombosis, ventricular outflow tract obstruction, and pericardial tamponade.[6–9]

Per practice guidelines published in 2010 by the American Society of Anesthesiologists (ASA) and the Society of Cardiovascular Anesthesiologists (SCA), expert consultants recommend that TEE be used during LT.[2] Contemporaneously, the European Association of Echocardiography (EAE) also updated its recommendations to include this indication.[3] Although TEE has proven to be relatively safe in LT, a potential deterrent remains the concern for injury to esophageal varices.[2,6,10,11] Another major hindrance to its use is anesthesiologist experience, because formal training and certification in perioperative TEE largely have been limited to cardiologists and cardiac anesthesiologists.[12,13]

Despite the suggested benefit, a 2008 survey of high-volume LT centers in the United States (US) reported that only 13% of transplant anesthesiologists routinely use TEE, whereas the majority (72%) reserves it for special situations and rescue settings.[13] Five years before, a survey of all US LT centers reported a similarly low 14.3% routine use rate.[12]

In the context of the 2010 EAE recommendations,[3] ASA/SCA practice guidelines,[2] and National Board of Echocardiography (NBE) initiation of certification in basic perioperative TEE,[14] the goal of the study was to assess the current prevalence of intraoperative TEE use by adult LT anesthesiologists in the United States. Furthermore, the authors aimed to identify potential obstacles to its more widespread use. Given the absence of clinical outcomes trials, as well as the inherent difficulties in conducting such experiments, accurate characterization of general practice norms, in conjunction with published practice guidelines, may translate into a de facto standard of care.[15]

METHODS

According to data from the Organ Procurement and Transplantation Network (OPTN), 116 transplant centers performed a total of 5,805 adult LTs in 2011.[16] The authors estimated 12 cases per annum (average 1 case per month) to be the minimum experience necessary to have established, generalizable group practices amenable to measurement by survey; so the 17 centers performing fewer than 12 such

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Table 1. Respondent Characteristics

Response rate	81.4% (79/97)
Practice type	
Academic	81.0% (64/79)
Academic affiliate	7.6% (6/79)
Private practice	11.4% (9/79)
LT cases per center	50 (13-180)*
LT anesthesiologists per center	6 (4-34)*
Percent of LT anesthesiologists who also practice cardiac anesthesiology	15.5 (0-100)*

Abbreviation: LT, liver transplantation.
* Data are presented as median and range.

operations that year were excluded. One additional hospital has since closed.

After Institutional Review Board approval, in June 2012 an initial e-mail was sent to each of the remaining 98 centers. One representative —the transplant anesthesiology director, a transplant anesthesiologist personally known to the authors, or the department of anesthesiology chair—was solicited at each center to participate in an online questionnaire regarding his or her group's practice. Nonresponders were sent an electronic reminder in July 2012. A final e-mail request was sent in August 2012 to any remaining nonresponders' chair of anesthesiology. Data collection terminated in September 2012.

The questionnaire (reproduced in Appendix 1) addressed practice demography, use of intraoperative TEE, and anesthesiologist training in echocardiography. For groups not routinely using TEE, 5-point Likert items then were presented to further assess obstacles to its use. In order to avoid confounding responses from centers performing both pediatric and adult LT, the survey cover page and each applicable question specified interest in institutional *adult* LT practices. The questionnaire was hosted online using SurveyMonkey software (SurveyMonkey.com LLC, Palo Alto, CA).

Use of intraoperative TEE in high- and low-volume centers was compared using Fisher's exact test, with the cutoff of 50 cases per year modeled after the 2008 survey.[13] Analyses of the effect of practice demography on TEE use were likewise made using Fisher's exact test. Descriptive statistics were used to characterize the remainder of variables. Data were analyzed using Stata 10.1 software (2009 release, StataCorp LP, College Station, TX).

RESULTS

Of the 97 LT centers surveyed (one respondent representing an anesthesiology group covering two OPTN-listed institutions was treated as a single practice entity for the purposes of statistical analysis), 79 (81.4%) institutions completed the questionnaire, representing 83.2% (4831) of 2011 US transplants (Table 1). Response rate was highest in academic (88.9%) and affiliate (85.7%) programs; 50% of private practices participated.

Thirty (38%) centers reported routine use of TEE, 45 (57%) for special circumstances or rescue situations, and 4 (5.1%) not at all. These rates were consistent when examined by multipliers of case volume or number of LT anesthesiologists at each center (Table 2). There was no significant difference in TEE use between high- (n = 39) and low-volume (n = 40) centers (p = 0.570), with the cutoff of 50 cases per year also coinciding with the median caseload among respondents. Likewise, there was no difference in use among academic, affiliate, or private practices (p = 0.963).

Table 3. Transesophageal Echocardiography Proficiency

	LT Anesthesiologists
Proficient	69.9% (418/598)
Advanced PTEeXAM Certified	21.6% (129/598)
Advanced PTEeXAM Testamur	4.3% (26/598)
Basic PTEeXAM Certified	3.7% (22/598)
Basic PTEeXAM Testamur	2% (12/598)
By practice experience	38.3% (229/598)
Not proficient	30.1% (180/598)

Abbreviation: LT, liver transplantation.

Practices with at least one member of the LT team concomitantly on the cardiac anesthesiology team were significantly more likely to report routine use of TEE in LT (p = 0.036). Of the 30 groups who routinely used TEE, 23 (76.7%) had overlap between LT and cardiac practitioners. The remaining 49 groups were divided evenly between those with or without LT-cardiac commonality. Among the 598 (full-time equivalent) LT anesthesiologists represented in this study, 170 (28.4%) also practiced cardiac anesthesiology; 418 (69.9%) were reported to be proficient in TEE, whether by practice experience or NBE verification (Table 3).

For programs not routinely using TEE, attitudes regarding potential contributing factors are characterized in Figure 1. Because only four programs reported never using TEE, those responses were pooled with those from centers using TEE only for special circumstances or rescue situations. The variable most strongly influencing the decision not to routinely use TEE was a sense that the technology was not necessary, followed closely by anesthesiologist training. The other surveyed factors did not prove consequential.

DISCUSSION

The results demonstrated widespread use of TEE during LT in US centers. Of survey respondents, 38% reported routine use and 57% for special circumstances or rescue situations, with an overall utilization rate of 94.9%. This distribution remained consistent regardless of institutional case volume or academic affiliation. The sole demographic factor predictive of routine use was overlap between a practice's LT and cardiac anesthesiology teams. In groups not routinely using TEE, the two

Table 2. Transesophageal Echocardiography Use

	By Center	By Volume (2011 Adult LT)	By Practice Size (Full-Time Equivalents)
Routine	38.0% (30/79)	39.5% (1,910/4,831)	36.8% (220/598)
Special circumstances or rescue situations	57.0% (45/79)	55.2% (2,667/4,831)	56.2% (336/598)
Not at all	5.1% (4/79)	5.3% (254/4,831)	7.0% (42/598)

Abbreviation: LT, liver transplantation.