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

Wayne Soong, MD, MSCI, FCCP,* Saadia S. Sherwani, MD, MHCM,* Michael L. Ault, MD, FCCP, FCCM,* Andrew M. Baudo, MD,* Joshua C. Herborn, MD,* and Andre M. De Wolf, MD*

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.2–5 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 classified 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
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. 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% (4,831) 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).

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

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<td><strong>Percent of LT anesthesiologists who also practice cardiac anesthesiology</strong></td>
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* Abbreviation: LT, liver transplantation.

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<th>Table 2. Transesophageal Echocardiography Use</th>
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<td><strong>By Center</strong></td>
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<td><strong>(2011 Adult LT)</strong></td>
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<td>Routine</td>
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<td>Special circumstances or rescue situations</td>
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* Abbreviation: LT, liver transplantation.
Salient obstacles were inadequate anesthesiologist training and a sense that TEE is not necessary during LT.

Differences in study format between this and the two previously published surveys addressing this topic preclude exact historic comparison, but there appears to be a recent increase in TEE use during LT. Schumann’s 2003 study evaluated the broader question of LT anesthesia resource utilization, asking department chairs or LT anesthesiology directors to characterize their respective group’s practices. Of the 49 responding programs performing adult LT, 14.3% used TEE routinely.12 Five years later, Wax et al examined TEE use at high-volume US centers, surveying known contacts at each practice performing more than 50 cases per year. At the 30 responding centers, 13% of practitioners used TEE routinely, with 72% reserving it for rescue or special circumstances.13 Although the 2003 study presented results by center and the 2008 study presented results by anesthesiologists, the current percentages remained consistent whether examined by center, case volume, or number of practitioners. Despite differences in response rate and practice demography among these three studies spanning 10 years, the now 38% routine use rate among the 79 responding institutions likely reflects a truly substantial temporal increase in TEE use, though the exact amount of growth cannot be quantified. Without longitudinal data, the impetus for this growth cannot be characterized fully, but potential causal factors include increased equipment availability, changes in LT anesthesiologist demography (cardiac, critical care, or LT fellowship training; TEE exposure during residency; or a generational shift in practice composition), progressive adoption of technology, and the recent publication of societal recommendations.

In 2010 the EAE updated its recommendations to include LT as an indication for intraoperative TEE.3 Per practice guidelines also published that year, expert consultants to the ASA and SCA agreed with this recommendation.7 Both European and American societies cited a low overall complication rate but mentioned esophageal disease as a potential contraindication.2,3 In the largest such series in LT recipients, 287 patients with documented esophageal varices underwent LT with intraoperative TEE monitoring, but perioperative variceal hemorrhage occurred in only one patient. The authors concluded that TEE was relatively safe even in this setting.11 Correspondingly, respondents to the survey did not consider TEE to be contraindicated in LT patients.

Inadequate anesthesiologist training often is cited as a limitation to more frequent intraoperative TEE use.5,12,13 Despite this rationale similarly emerging in the data, the majority of LT anesthesiologists (69.9%) actually are proficient in TEE. Most lack NBE certification, however, with 54.8% of TEE-proficient LT anesthesiologists qualified based solely on practice experience. Before 2010, formal training and certification in this skill largely was limited to cardiologists and cardiac anesthesiologists. It is, therefore, possible that a large part of this 54.8% is composed of more senior members in each practice, because only 11% of all LT anesthesiologists were reported to be NBE certified in 2008.13 This Advanced PTEeXAM certification rate has since grown to 21.6%, with an additional 4.4% qualifying as testamurs. In 2010 the NBE instituted the Basic PTEeXAM in order to broaden verification of training in TEE for uncomplicated, nondiagnostic, intraoperative monitoring. This relatively novel pathway adds another 5.7% to the pool of LT anesthesiologists now adept in TEE. Advanced certification has become almost prohibitive outside of cardiothoracic anesthesiology fellowship graduates, but Basic Certification remains attainable by many anesthesiology residency graduates. The conceptual knowledge needed to pass the written examination, combined with the minimum requirement of performing 50 TEE examinations, implies a level of echocardiography skill that may prove sufficient for LT anesthesia. As recognition of the Basic PTEeXAM becomes more established, the number of general and LT anesthesiologists pursuing some form of NBE certification likely will continue to grow.

Because cardiac anesthesiology has become nearly synonymous with TEE proficiency, the results of this study, as expected, indicated that institutions employing at least one cardiac anesthesiologist on the LT team are significantly more
likely to use TEE routinely. These cardiac practitioners currently comprise 28.4% of the LT anesthesiologists represented. Although a recent study specifically sought to characterize anesthesiology practice structures at US academic LT centers, it did not address this LT-cardiac anesthesiology overlap.17

Despite the association between institutional LT volume and practice structure,17 these data reveal no such correlation with clinical practice. Modeling the cutoff between high- and low-volume centers after Wax et al’s survey, the authors found no association between LT volume and TEE use. However, the 2008 study only surveyed institutions performing more than 50 cases annually, so no analysis was made based on LT volume.13 Schumann’s 2003 survey divided centers into small (<30 cases annually), moderate (31-60), and large volume (>60), finding TEE use to be significantly more common in small-volume (25%) than in moderate-volume (0%) programs, with 21.1% of large-volume programs reporting routine use.12 Given this bimodal distribution, it is difficult to reconcile the result as other than type I error. That author also suggested academic affiliation as being of possible influence on TEE usage,12 but these results indicate no difference in the practice patterns of academic, affiliate, and private groups.

Limitations of this study derived largely from its survey format, but overall the methodology was consistent with published recommendations for critical conduct of survey science.18-20 Rather than survey all US LT anesthesiologists, the authors chose to query a single representative at each group, presuming that this approach would provide a more complete picture of broader practices. Soliciting all practitioners about individual norms, in addition to being impractical without the existence of a membership database, likely would generate a much lower overall response rate and therefore increase the likelihood of nonresponse bias. Walia et al’s recent survey of practice structure suggested that the unique complexity of LT anesthesia demands institutional team subspecialization and collaboration17; such requisite communication should therefore also translate into members of each team being capable of portraying their respective group’s general practice. In order to link responses to OPTN data on institutional volume, questionnaires were not anonymous. This further allowed confirmation of each respondent’s identity as transplant anesthesiology director, anesthesiology department chair, or a contact personally known to one of the authors, additionally validating that the respondent was qualified to comment on the institutional practice patterns of multiple anesthesiologists. Nonetheless, these results depend wholly on each individual accurately characterizing the group. With this lack of anonymity, response bias could have contributed to the high reported TEE use rate, with respondents compelled to portray their respective institutions as “progressive.” Although not as ideal as surveying every US LT anesthesiologist about individual practices, in the context of historic comparison, both 2003 and 2008 surveys also relied on representative reporting.

The span of the questionnaire itself served as both strength and weakness of this study. To achieve the notable 81.4% completion rate, the authors intentionally limited the scope of questions. The relatively short survey thereby also precluded more detailed characterization of institutional attitudes and practices. As is, the Likert results answer only the question of why more LT anesthesiologists do not routinely use TEE, failing to further characterize the decision-making processes of those practitioners who only use it in special circumstances or rescue situations.

The high overall response rate for this study minimizes nonresponse bias, but only 50% of private practices completed the questionnaire. Therefore, the lack of association between academic affiliation and TEE use could be the result of type II error.

Although primarily examining use of a clinical tool, this study is not meant to address the actual clinical utility of TEE, because no outcomes were assessed. As with any intervention, large-scale randomized trials are needed to effectively measure the benefit, risk, and cost effectiveness of TEE in LT. However, in the absence of such outcomes trials, de facto practice norms often dictate standard of care.15 If these data are accurate in indicating that 94.9% of US LT centers use intraoperative TEE to at least some degree, these findings may contribute to establishing TEE availability as the practice standard. Realistically, as with other now commonly used monitoring modalities (pulse oximetry, chest radiography, continuous electronic fetal monitoring, etc.), scientifically sound outcomes trials become ethically precarious once the technology is widely adopted.

CONCLUSION

In this article the authors describe widespread use of TEE during adult liver transplantation in the United States. Importantly, these data indicate a substantial shift toward more routine use of TEE during LT compared with 2003 and 2008 findings.12,13 Almost all institutions now use TEE at least occasionally during surgery, with the presence of cardiac anesthesiologists on the LT team being predictive of a center’s routine use. Although 69.9% of LT anesthesiologists are reported as proficient in TEE, inadequate training remains a significant hindrance to routine TEE use, as does a sense that the modality is not indicated during LT. As more anesthesiologists pursue NBE Basic PTEEexAM certification, TEE, with its minimal morbidity and unique diagnostic capabilities, likely will continue to grow in intraoperative LT application.

APPENDIX 1. QUESTIONNAIRE

Please provide responses as they pertain to your institution’s ADULT liver transplant program.

1. Institution:
2. Your title:
3. Your name:
4. Practice type:
   ○ Academic
   ○ Academic affiliate
   ○ Private practice
   ○ Other (please specify):
TRANSESOPHAGEAL ECHOCARDIOGRAPHY IN LIVER TRANSPLANTATION

5. Approximately how many adult liver transplants are performed at your institution annually?
6. How many anesthesiologists are on your adult liver transplant team?
7. Of these, how many are also on your adult cardiac anesthesia team?
8. How frequently do you use a pulmonary artery (Swan-Ganz) catheter during liver transplantation?
   ○ Routinely
   ○ For special circumstances or rescue situations
   ○ Not at all
   Comments:
9. How frequently do you use intraoperative transesophageal echocardiography (TEE) during liver transplantation?
   ○ Routinely [SKIP QUESTION 12]
   ○ For special circumstances or rescue situations
   ○ Not at all [SKIP TO QUESTION 11]
   Comments:
10. Who performs the intraoperative TEE examination? (Check all that apply)
    ○ Primary anesthesiologist
    ○ Another anesthesiologist
    ○ Consultant cardiologist
    ○ Echocardiography technician
    ○ Other (please specify):
11. How many of your liver transplant anesthesiologists are proficient in TEE? (NBE = National Board of Echocardiography)
    ● NBE Advanced Perioperative TEE Certified:
    ● NBE Advanced Perioperative TEE Trainee:
    ● NBE Basic Perioperative TEE Certified:
    ● NBE Basic Perioperative TEE Trainee:
    ● By practice experience:
12. What prevents your group from routinely utilizing TEE during liver transplantation? [Strongly agree, Slightly agree, Neutral, Slightly disagree, Strongly disagree]
    ● Do not feel it to be necessary
    ● Consider it to be contraindicated in this patient population
    ● Cardiology availability
    ● Anesthesiologist training
    ● Coverage model, OR staffing constraints—solo attending, multiple OR coverage
    ● Equipment limitations— inadequate number or quality of machines or probes
    ● Financial considerations—cost of hardware, billing issues
    ● Other (please specify):

REFERENCES