

## Current Practice Patterns for Adult Perioperative Transesophageal Echocardiography in the United States

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TRANSESOPHAGEAL echocardiography (TEE) was first introduced to the operating room in 1980 when M-mode measurements of left ventricular diameter were used to monitor changes in myocardial function.<sup>1</sup> The subsequent development, in the mid 1980s, of transesophageal transducers capable of real-time, two-dimensional imaging and color Doppler flow mapping resulted in a powerful new tool for the determination of cardiac structure and function.<sup>2,3</sup> Although these new TEE capabilities were initially limited to research centers, their applicability to the perioperative care of patients with complicated cardiovascular disease quickly became apparent.<sup>3-7</sup> In a 1992 survey, Poterack<sup>8</sup> found that TEE was being employed perioperatively in many of the academic anesthesiology programs in the United States.

Since 1990, the use of perioperative TEE has spread beyond academic medical centers to the everyday care of cardiac surgical patients.<sup>9-11</sup> Accordingly, today, many anesthesiologists have undertaken advanced training in the performance and interpretation of echocardiographic studies. Growing interest in this subject prompted the formulation of practice guidelines for perioperative TEE in 1996 by a joint task force of the American Society of Anesthesiologists and the Society of Cardiovascular Anesthesiologists (ASA/SCA).<sup>12</sup> The recently defined standards for a comprehensive intraoperative TEE examination also included substantial contributions from the anesthesiology community.<sup>13</sup>

Despite these developments, there are no reports that describe the extent to which TEE has been incorporated into the daily perioperative care of patients across the spectrum of anesthesia practice environments existent in the United States. Similarly, no recent data are avail-

able regarding the credentialing standards that anesthesiologists have adopted or the training pathways they have chosen. We initiated the current study to determine the frequency with which TEE is currently employed in the perioperative care of surgical patients, to characterize the involvement of anesthesiologists in the provision of this service, and to describe the practice patterns of anesthesiologists who use TEE.

### Materials and Methods

In April 2000, a survey was distributed to the membership of the SCA. The mailing list used was purchased from the SCA's management company with the Society's permission. All individuals with an active, full membership and a mailing address located in the United States or Puerto Rico were included. The SCA membership was selected for this survey with the expectation that this population would include representation from most centers with a cardiac surgical program.

The survey consisted of 24 multiple-choice or fill-in-the-blank questions regarding the member's demographic characteristics, institutional practices, and details of his or her own involvement with TEE (Appendix). A stamped, self-addressed return envelope and a cover letter discussing the rationale and objectives of the study accompanied the questionnaire. Members of SCA were asked to respond to the survey, regardless of whether or not they personally employed TEE in their practice of anesthesia.

Sequential numbering of the return envelopes provided a mechanism for determining which members had responded to the survey. The individual survey questionnaires contained no identifying information, and after separation from the return envelope each member's responses were anonymous. After 8 weeks, an identical survey was mailed to individuals from whom no response to the first survey had been received.

Twenty weeks after the first surveys were mailed, 10% of the remaining nonresponders were selected at random. Each of these individuals was sent a brief letter asking them whether they currently practiced anesthesia, and if so, if they personally employed TEE. The responses to these questions were used as a measure of the sampling bias of the survey.

### Statistical Analysis

The results for individual survey questions are reported as a percentage followed by the actual number of

This article is accompanied by an Editorial View. Please see:  
Thys DM: Echocardiographic and anesthesiology successes and challenges. ANESTHESIOLOGY 2001; 95:1313-4.

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Received from Temple University School of Medicine, Philadelphia, Pennsylvania. Submitted for publication April 16, 2001. Accepted for publication July 27, 2001. Support was provided solely from institutional and/or departmental sources. Presented in part at the 23rd annual meeting of the Society of Cardiovascular Anesthesiologists, Vancouver, British Columbia, Canada, May 5-9, 2001.

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**Table 1. Use of Intraoperative Transesophageal Echocardiography at the Respondent's Institution According to Surgical Procedure**

	Never % (N)	Occasionally % (N)	Most Times % (N)	Always % (N)
Valve surgery	1 (18)	9 (158)	30 (514)	60 (1,032)
CABG	11 (180)	48 (820)	22 (382)	19 (325)
Noncardiac	34 (586)	65 (1,133)	1 (9)	0 (2)

CABG = coronary artery bypass graft.

positive responses in parentheses. Parametric data are reported as the mean  $\pm$  SD. Frequency data were compared using a chi-square or Fisher exact test (for small frequencies). The predictive value of specific demographic characteristics for the use of TEE was determined by calculating an odds ratio (with 95% confidence limits) for each. A multiple logistic regression analysis was then performed to evaluate the independent contribution of each of these variables to the use of TEE.

## Results

Fifty-six percent (1,859) of the 3,394 eligible SCA members returned completed questionnaires. An additional 1.3% (44) of the surveys were returned as undeliverable, and 0.2% (8) of individuals reported that they did not currently practice anesthesia.

Sixty-seven percent of respondents (1,219) reported that they were in private practice at the time of the survey, 32% (593) worked in academic settings, and 3% (47) declined to characterize their practice. Forty-two percent (786) had completed a fellowship in cardiothoracic anesthesia, and an additional 3% (58) noted other fellowship training, most often in critical care medicine or pediatric anesthesia. Forty-seven percent (875) spent less than 25% of their clinical practice providing anesthesia for cardiac surgery; 15% (279) spent greater than 75% of their time in this area.

Ninety-four percent (1,739) of responding SCA members practiced in an institution where TEE was used intraoperatively. The use of TEE by surgical procedure is illustrated in table 1. Fifty-two percent (905) of respondents noted that an anesthesiologist usually performed the intraoperative TEE examinations at their institution, 18% (320) reported that this was usually performed by a cardiologist, and 29% (508) stated that it could be performed by a physician of either specialty. Seventy-two percent (1,259) of SCA members who worked in an institution where TEE was used intraoperatively reported that they personally employed TEE during their anesthetic care.

By chi-square testing, a significant relationship was found to exist between each of the four demographic characteristics examined and the likelihood that an anesthesiologist would employ TEE (table 2). However,

**Table 2. Use of Transesophageal Echocardiography versus Demographic Characteristics**

	Use TEE % (N)	Do Not Use TEE % (N)	Odds Ratio (95% CI)	P
Practice setting				
Private	70 (779)	30 (335)		
Academic	77 (443)	23 (136)	1.40 (1.11, 1.77)	0.004
Anesthesia training level				
Residency	67 (632)	33 (305)		
Cardiac fellowship	80 (590)	20 (149)	1.46 (1.20, 1.77)	< 0.001
Anesthesia training completed				
< 1985	67 (352)	33 (176)		
1985-1989	75 (214)	25 (72)		
1990-1994	73 (364)	27 (132)		
1995-1999	78 (236)	22 (65)	1.20 (1.08, 1.32)	0.002
Proportion of practice cardiac				
< 25%	56 (428)	44 (332)		
25-50%	77 (353)	23 (104)		
50-75%	94 (214)	6 (14)		
> 75%	91 (253)	9 (26)	2.34 (2.05, 2.69)	< 0.001

TEE = transesophageal echocardiography; CI = confidence interval.

after multiple logistic regression analysis, only the year in which an individual completed his or her anesthesia training (odds ratio [OR] = 1.24; 95% confidence interval [CI]: 1.12-1.38) and the proportion of their practice dedicated to the care of cardiac surgical patients (OR = 2.38; 95% CI: 2.05-2.75) were found to be independent predictors of TEE use.

The SCA members who used TEE reported an average length of experience of  $5.9 \pm 3.5$  yr and performed  $3.9 \pm 3.5$  studies per week. Locations in which respondents reported providing TEE examinations included the cardiac operating rooms (96% [1,214]), noncardiac operating rooms (48% [602]), and intensive care unit (24% [300]). Only 3% (43) reported using TEE in other locations such as the emergency room, the cardiac catheterization suite, or outpatient clinics.

A majority of anesthesiologists (66%) reported that a cardiologist assisted with the TEE interpretation only upon request (51% [637]) or not at all (15% [188]). A smaller proportion stated that a cardiologist was usually involved during specific surgical procedures (26% [330]) (e.g., valve surgery, atrial or ventricular septal defect repair) or was always consulted before any therapeutic intervention (8% [101]). When a question arose regarding the echocardiographic findings, 74% (926) of the respondents who used TEE noted that a cardiologist was immediately available for consultation, 40% (501) could call on another anesthesiologist echocardiographer, and 15% (183) had no access to a second opinion.

The personal practice patterns of respondents relating to TEE are outlined in table 3. A diversity of practices was reported with regard to documentation and billing. When a cardiologist was involved with interpretation of the TEE examination "never" or "only upon request," 53% of anesthesiologists provided a formal written note and 71% archived the examination "most times" or "always." When a cardiologist was involved "always" or

**Table 3. Personal Practice Patterns for Transesophageal Echocardiography**

	Never % (N)	Occasionally % (N)	Most Times % (N)	Always % (N)	When Billable or Diagnostic % (N)
Provide a formal written report	37 (469)	13 (169)	11 (141)	31 (387)	7 (92)
Record and archive the examination	17 (213)	18 (228)	20 (250)	42 (532)	3 (36)
Issue a bill	35 (442)	13 (158)	21 (270)	22 (279)	8 (95)
A second anesthesiologist is present	55 (690)	30 (372)	9 (116)	4 (53)	2 (24)

“during specific procedures,” only 22% of responding anesthesiologists provided a formal written note and 44% archived the examination. Although many respondents noted that a certified registered nurse anesthetist or resident was often in attendance, few reported the presence of a second fully trained anesthesiologist routinely during a TEE examination. Only a small number of anesthesiologists distinguished certain examinations as “diagnostic” or “billable” and specifically modified their practices in response.

Of the anesthesiologists using TEE, roughly 70% had undergone training after completion of their residency or fellowship. Most described their training as “self-taught” (22% [283]), “by others on the job” (27% [341]), and/or consisting of “short courses” (35% [446]). A minority of individuals had obtained experience with TEE during residency (12% [150]) or fellowship (17% [215]). A small but notable proportion (9% [114]) had undertaken formal training during clinical practice, defined as “a finite period of time without clinical responsibilities during which instruction is received from an ‘expert.’” Overall, there was a strong trend in more recent years toward formal training as a component of an anesthesia residency or fellowship (table 4).

At the time of the survey, 17% (214) of individuals using TEE reported having passed the National Board of Echocardiography’s Examination in Perioperative TEE (formerly the SCA Exam) and 2% (24) had passed the Examination of Special Competence in Adult Echocardi-

ography (formerly the ASEeXAM). A further 37% (461) and 11% (140), respectively, intended to take these examinations.

Most anesthesiologists reported that no specific credentialing was required by either their hospital or department to use TEE (table 5). The written approval of a specific individual or review board was the most common standard when one applied. Only a small number of individuals worked in institutions where the examinations of the National Board of Echocardiography were considered during credentialing.

It was hypothesized that SCA members who personally employed TEE would be more likely to answer the questionnaire. To estimate this sampling bias, the proportion of practicing SCA members who responded to each stage of the survey (first mailing, second mailing, random follow-up letter) was determined. The percentage of individuals who used TEE in each of these groups was then compared. The overall response rate during each stage was 40% (1,357/3,394), 25% (502/2,037), and 41% (61/149), respectively. The proportion of practicing anesthesiologists who reported that they personally used TEE was 72% in the first mailing (982/1,357), 55% in the second mailing (277/502), and 80% from the random follow-up letter (45/56). Five (8%) of the randomly selected SCA members who returned the follow-up letter reported that they were not currently practicing anesthesiologists.

**Table 4. Reported Methods of Transesophageal Echocardiography Training According to the Year in Which the Respondent’s Anesthesia Training Was Completed**

	Before 1985 (Total = 302) % (N)	1985–1989 (Total = 264) % (N)	1990–1994 (Total = 364) % (N)	1995–1999 (Total = 236) % (N)	P
Self taught	30 (91)	23 (62)	21 (78)	12 (28)	< 0.0001
By others “on the job”	34 (103)	31 (81)	25 (91)	19 (46)	0.001
Short course(s)	51 (154)	42 (110)	31 (113)	16 (37)	< 0.0001
Formal, during residency	1 (2)	4 (10)	20 (74)	23 (55)	< 0.0001
Formal, during fellowship	1 (3)	6 (15)	21 (76)	43 (102)	< 0.0001
Formal, during practice	11 (33)	13 (33)	8 (28)	5 (11)	0.01

**Table 5. Credentials Required by the Respondent's Institution for the Use of Transesophageal Echocardiography (TEE) by an Anesthesiologist**

	% (N)
No standardized documentation	51 (636)
Approval of a designated expert individual or review board	28 (347)
Specific course of internal training or examination	16 (200)
External course or series of courses	20 (246)
Formal TEE training during residency or fellowship	13 (166)
NBE Examination in Perioperative TEE ("SCA exam")	4 (51)
NBE Examination of Special Competency in Adult Echocardiography ("ASEeXAM")	2 (19)
Other	1 (15)

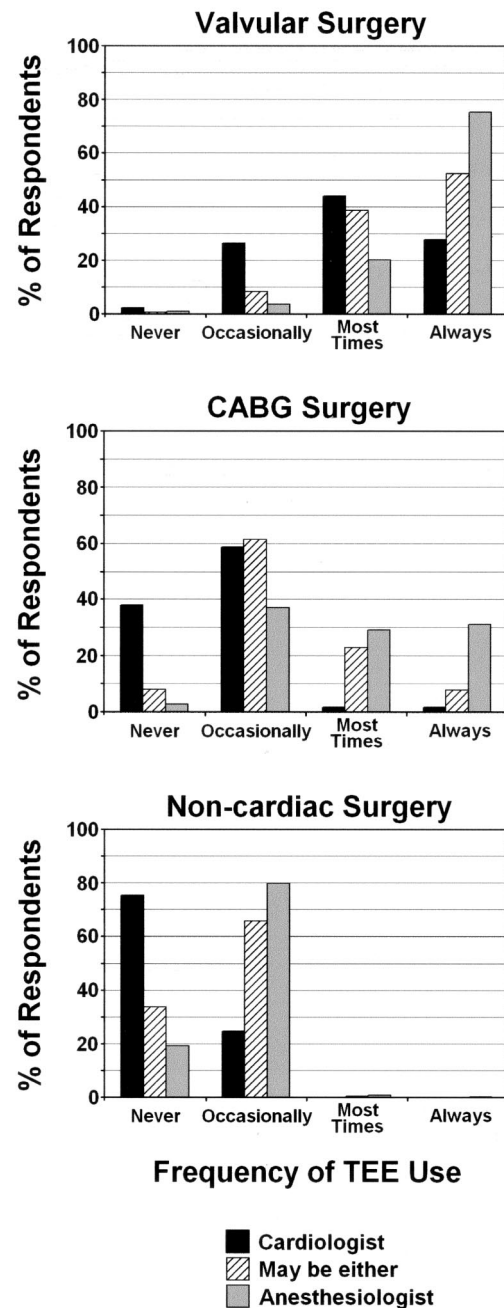
NBE = National Board of Echocardiography; SCA = Society of Cardiovascular Anesthesiologists; ASEeXAM = American Society of Echocardiography Examination.

## Discussion

A TEE examination during the perioperative period may be used for either the initial diagnosis of cardiovascular disease or to monitor a previously documented disease state that is relevant to the concurrent anesthetic or surgical care. According to the ASA/SCA Practice Guidelines, such an examination can frequently lead to improved patient outcomes under certain circumstances.<sup>12</sup> Our data show that cardiac anesthesiologists have embraced this concept and, indeed, use TEE frequently whether they are in academic or private practice (tables 1 and 2).

The current study demonstrated that perioperative TEE is currently widely available in the United States, insofar as the vast majority of respondents to our survey reported the use of TEE in the operating rooms at their institutions. As would be predicted, TEE was a routine component of valvular surgery more frequently than of coronary artery bypass grafting (90% *vs.* 41%). However, only 11% of anesthesiologists indicated that TEE was never used during coronary revascularization in their hospital. Many respondents noted that TEE was also used "occasionally" during noncardiac surgery (table 1). This availability of TEE for use outside the cardiac operating rooms is noteworthy because intraoperative hemodynamic disturbances unresponsive to therapy represent an important indication for TEE.<sup>12</sup>

More than 80% of the respondents to our survey practiced in an institution where anesthesiologists carried some or all of the responsibility for the performance of intraoperative TEE. Most performed the examinations themselves, but if a second opinion was needed, a cardiologist was the specialist most commonly available for consultation. Of particular note, TEE was more likely to be employed during any given surgical procedure when an anesthesiologist was available to provide this service (fig. 1). This might be expected given the significant disruption to other responsibilities for a cardiologist when he or she is required to make frequent trips to the



**Fig. 1.** The frequency of intraoperative transesophageal echocardiography (TEE) use as reported by the members of the Society of Cardiovascular Anesthesiologists. Responses were categorized according to the profession of the individual usually responsible for performing the intraoperative TEE examinations at each respondent's institution. The use of TEE was significantly more common for valvular surgery ( $P < 0.0001$ ), coronary artery bypass grafting (CABG;  $P < 0.0001$ ), and non-cardiac surgery ( $P < 0.0001$ ) when an anesthesiologist was identified as the usual echocardiographer. Data are represented as percentage of respondents and were analyzed using a chi-square or Fisher exact test.

operating room. However, this study did not specifically examine the reasons for this difference in use.

Practice patterns for the documentation and reporting of TEE examinations varied significantly. Anesthesiolo-

gist echocardiographers have been called on to improve perioperative communication between specialists by archiving a complete echocardiographic examination (as a VHS recording or in digital format) and documenting the findings in the patient's chart whenever a TEE probe is placed.<sup>14</sup> The current study found that when an anesthesiologist was primarily responsible for TEE interpretation, he or she was more likely to document and archive the data in each case. Nonetheless, fewer than half of the respondents recorded each TEE examination that they performed and less than one third provided a written report on every occasion. This reveals a substantial departure from the principle that the "ability to communicate the results of a TEE examination to the patient and to other healthcare professionals and to summarize these results cogently in the medical record" are basic components of perioperative TEE.<sup>12</sup>

As might be expected of any "new" technology, training experiences varied widely and processes for credentialing were not universal. Only half of survey respondents who used TEE reported that their hospital or department required formal credentialing to perform this procedure. Moreover, those individuals reported a wide variety of criteria used to assess an anesthesiologist's qualifications in echocardiography (table 5). This was an expected result given the diversity of backgrounds presently existent among anesthesiologist echocardiographers. In contrast, the infrequent use of available objective external examinations for credentialing was somewhat surprising. This finding may reflect the relatively recent introduction of these examinations and the limited number of individuals who have had an opportunity to complete them. Given the substantial number of anesthesiologists who reported an intention to write these examinations, and the increasing interest of the Joint Commission on Accreditation of Healthcare Organizations in credentialing for procedures, the importance of such standardized examinations may increase in the future.

Our study design differed significantly from that employed by Poterack,<sup>8</sup> who examined "TEE use in anesthesiology training programs in the United States." To obtain his data, Poterack directed a questionnaire to the program director at each of the 155 active training institutions. Accordingly, his study's results were based on a limited number of individuals' impressions and reflected practices exclusively at academic centers. No documentation was made of whether or not the anesthesiologists contacted had any direct involvement with cardiac anesthesia or intraoperative TEE. These differences with our study notwithstanding, it is interesting to compare two of the observations from this earlier study with our present results. Poterack<sup>8</sup> reported that, in 1992, only 42% of anesthesiologists who used TEE in the operating room routinely recorded their findings in the patient's medical record. This is essentially identical to the proportion identified 8 years later in our survey. With regard

to credentialing, Poterack found that 69% of program directors believed that a formal system of certification should exist for anesthesiologists to use TEE. However, only 32% worked in an institution where such a system was in place. In our survey, approximately half of respondents practiced anesthesia in an institution with a defined credentialing process for TEE. These comparisons suggest that anesthesiologists have not evolved quickly with regard to their practice standards for TEE despite urgings from the relevant professional societies.

Several steps were taken to ensure the accuracy of our results. The survey questionnaire was pretested for clarity on a small group of cardiac anesthesiologists. We also reviewed each question for face validity before distribution. Because most questions were objective and required only multiple-choice answers, it seemed likely that the degree of error introduced during communication of the survey recipients' intent would be minimal. The information collected regarding the frequencies of certain practices was intentionally limited in detail. This aspect of the study design represented a compromise between obtaining clinically relevant answers and capturing the maximum number of survey respondents.

To assess the possibility of a selection bias among respondents, we evaluated the proportion of responding anesthesiologists during each stage of the survey who reported using TEE.<sup>15</sup> If these anesthesiologists who used TEE were, in fact, more likely to return the survey, they would have been expected to represent a smaller proportion of responders during each subsequent mailing. In contrast, the percentages of respondents who used TEE were not dissimilar throughout the sampling, suggesting that any selection bias with regard to TEE use was minimal. However, under this study design we were not able to assess for a selection bias with regard to other characteristics, such as the method of the respondent's TEE training or the successful completion of an external examination.

The practice patterns outlined above are those currently reported by active members of the SCA. It is possible that different patterns of use for perioperative TEE would be found if alternate groups of physicians were studied. However, the members of the SCA were specifically chosen for this survey because of their daily involvement with the operating room and their interest in echocardiography. We thought that, of any subset of physicians, they would be able to characterize the use of TEE in the perioperative period most accurately.

Our survey questionnaire did not collect information regarding the age distribution of respondents' patients. However, only a small proportion of cardiac surgical patients are children, and it is reasonable to assume that the vast majority of the data reported in the current study refer to practices in an adult setting. Given the distinct nature of pediatric surgical patients, the manner in which perioperative TEE is employed during their care is likely to be substantially different. Therefore, the authors believe that

the current results cannot be presumed to reflect such practices and that further study would be required to characterize the use of TEE during pediatric surgery.

This survey demonstrated that intraoperative TEE has, indeed, become a common component of the perioperative care of surgical patients for many anesthesiologists. Operations for valvular disease are usually performed with the aid of echocardiography, and TEE is also often used or available for many coronary revascularization procedures. In the majority of cases, anesthesiologists both perform and interpret these examinations. However, standards for training and credentialing are not yet universal, and overall documentation patterns still fall short of practice guidelines.

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3. Most advanced level of clinical anesthesia training completed: anesthesia residency; cardiac anesthesia fellowship
4. Year that anesthesia training was completed: \_\_\_\_\_
5. Current proportion of your clinical practice involving cardiac surgery: < 25%; 25-50%; 50-75%; > 75%
6. Is TEE ever used intraoperatively at your institution? yes; no (If "no," skip remainder of questionnaire and return in enclosed envelope)
7. At your institution, TEE is used during valvular surgery: never; occasionally; most times; always
8. At your institution, TEE is used during coronary artery bypass grafting surgery: never; occasionally; most times; always
9. At your institution, TEE is used during noncardiac surgery: never; occasionally; most times; always
10. At your institution, intraoperative TEE is usually performed by a(n): anesthesiologist; cardiologist; may be either
11. Do *you* employ TEE for monitoring or diagnostic purposes during patient care? yes; no (If "no", skip remainder of questionnaire and return in enclosed envelope.)
12. Number of years you have been using TEE in your practice of anesthesia: \_\_\_\_\_
13. Average number of patients per week during whose care you employ TEE: \_\_\_\_\_
14. Locations in which you provide TEE examinations (check all that apply): cardiac OR; noncardiac OR; intensive care unit; other \_\_\_\_\_
15. When you perform a TEE examination, you provide a formal written report: never; occasionally; most times; always; only when a bill will be issued for the service
16. When you perform a TEE examination, you record and archive the examination: never; occasionally; most times; always; only when a bill will be issued for the service
17. Considering all occasions during which you employ TEE, you bill for this service: never; occasionally; most times; always; only when it is considered a "diagnostic" examination
18. When you are using TEE, a second anesthesiologist is present to provide anesthetic care: never; occasionally; most times; always; only during "diagnostic" or "billable" studies
19. When you use TEE, a cardiologist is involved with interpretation of the study before any therapeutic interventions are made: never; only when I request their opinion; only during specific procedures (e.g., valve repair/replacement, ASD/VSD repair, etc.); always
20. When you are performing a TEE examination, a second opinion is immediately available when required from an "expert" echocardiographer who is a (check all that apply): cardiologist; anesthesiologist; no second opinion is readily available
21. Of the following, the single best description of your TEE training would be: self-taught; instructed by others "on the job"; short course(s) after completion of anesthesia training; formal training during residency; formal training during fellowship; formal training during practice (i.e., finite period of time without clinical responsibilities during which instruction is received from an "expert")
22. Note if you have passed: NBE Examination in Perioperative TEE ("SCA exam"); ASE Examination of Special Competency in Echocardiography ("ASEeXAM")
23. Note if you have definite plans to take: NBE Examination in Perioperative TEE ("SCA exam"); ASE Examination of Special Competency in Echocardiography ("ASEeXAM")
24. For an anesthesiologist to use TEE, my department/hospital specifically requires (check all that apply): no standardized documentation; the written approval of a designated expert individual or review board; the completion of a specific course of internal training or examination; the completion of an external course or series of courses; the completion of formal TEE training during a cardiac anesthesia residency/fellowship; NBE Examination in Perioperative TEE ("SCA exam"); ASE Examination of Special Competency in Echocardiography ("ASEeXAM"); other \_\_\_\_\_

## Appendix: Survey Questionnaire

The questionnaire was formatted as a single sheet of paper. Questions were listed on both sides. Answers to multiple-choice questions were indicated by individual "check-boxes."

1. US state in which you practice anesthesiology: \_\_\_\_\_ (two-letter abbreviation)
2. Setting in which you practice anesthesiology: private; academic