

Indications for TEE Before Cardioversion for Atrial Fibrillation: Implications for Appropriateness Criteria

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Indications for TEE Before Cardioversion for Atrial Fibrillation: Implications for Appropriateness Criteria

The purpose of this study was to evaluate appropriateness of transesophageal echocardiography (TEE) before direct current cardioversion (DCC), investigate indications for TEE, and analyze if indications are predictive of outcome. According to American College of Cardiology Foundation/American Society of Echocardiography 2011 Appropriateness Criteria, TEE is appropriate in the evaluation of patients with atrial fibrillation (AF) to facilitate clinical decision making with regards to anticoagulation and/or DCC. However, it is unclear in which instances physicians utilize TEE. We reviewed 671 TEE studies in 604 AF patients (age 66 ± 13 years, 67% male) in which TEE was performed before DCC for left atrial thrombus (LAT)/sludge. Studies were divided by the main indication for TEE into the following 8 categories: 1) congestive heart failure (CHF)/hemodynamic compromise; 2) symptomatic; 3) new onset AF; 4) hospitalized and symptomatic; 5) high stroke risk; 6) subtherapeutic anticoagulation; 7) miscellaneous; and 8) inappropriate for TEE. The main indications for TEE before DCC were symptomatic (26.4%) and CHF/hemodynamic compromise (26.1%). We deemed 2.7% of the studies as inappropriate. LAT/sludge was found in 8.2% of studies. Incidence of LAT/sludge differed significantly between indications ($p = 0.0021$) and the highest incidences occurred in the high stroke risk (17.6%) and hospitalized and symptomatic (14.1%) categories. No LAT/sludge was found in the miscellaneous or inappropriate groups. Stroke occurred in 2.5% ($n = 15$) of all patients and in all groups except for miscellaneous and inappropriate ($p = 0.3$). TEE is appropriately used prior to DCC for patients with the main indications of symptomatic and CHF/hemodynamic compromise. In a minority of studies, TEE utilization was inappropriate. Incidence of LAT/sludge differed between indications.

Direct current cardioversion (DCC) is an important treatment method for atrial fibrillation (AF); however, there is a significant risk of stroke and other systemic thromboembolism after DCC. To decrease this risk, patients have conventionally been anticoagulated to achieve an international normalized ratio (INR) of 2 to 3 for 3 weeks before DCC. More recently, transesophageal echocardiography (TEE) before DCC has been shown to be as effective as conventional anticoagulation in preventing stroke while also expediting DCC (1). TEE-guided cardioversion may be a better option than conventional therapy in certain patients, such as those who are highly symptomatic, hemodynamically compromised, newly diagnosed with AF, or have a high risk of stroke.

By 1998, TEE-guided DCC was performed in 12.1% of cases, and 38% of the practices surveyed were using TEE for 5% of DCC cases (2). Since that time, TEE-guided cardioversion has become increasingly popular, and costs of diagnostic imaging in general have increased rapidly, prompting the development of appropriateness criteria (3). The American College of Cardiology Foundation/American Society of Echocardiography (ACCF/ASE) 2011 Appropriateness Criteria address TEE-guided cardioversion similarly as follows: appropriate, "evaluation to facilitate clinical decision making with regards to anticoagulation, cardioversion, and/or radiofrequency ablation"; and inappropriate, "evaluation when a decision has been made to anticoagulate and not to perform cardioversion" (4).

Little is known about the clinical settings in which physicians are using TEE-guided DCC or if TEE-guided DCC is being overused in situations in which conventional therapy would be preferred. Therefore, our objectives were: 1) to investigate if TEE-guided DCC is being used appropriately; 2) to evaluate indications for which patients are receiving TEE; and 3) as a secondary endpoint, to analyze the risk of thrombus and systemic thromboembolism on the basis of the indication for TEE.

Methods

Patients. We retrospectively analyzed 671 TEE-guided DCCs (604 unique patients; 67% male) performed from January 2007 to December 2008. The study was approved by the local insti-

tutional review board. Clinical data, such as age, sex, components of the CHADS₂ score, and incidence of future thromboembolic events, were collected from patient medical charts. A CHADS₂ score ranging from 0 to 6 was calculated for each patient at the time of TEE, as follows: congestive heart failure (CHF), 1 point; hypertension, 1 point; age >75 years, 1 point; diabetes mellitus, 1 point; and history of stroke, transient ischemic attack, or systemic thromboembolism, 2 points.

TEE and transthoracic echocardiography. TEE study reports were reviewed for left ventricular ejection fraction (LVEF) (if a transthoracic echocardiography was not done within 24 h of the TEE); presence of left atrial thrombus (LAT); sludge; and/or spontaneous echo contrast. Thrombus was defined as a circumscribed and uniformly echodense intracavitary mass distinct from the underlying left atrium or the left atrium appendage endocardium and pectinate muscle that is present in >1 imaging plane (5). Sludge was defined as a dynamic gelatinous, precipitous echodensity, without a discrete mass, and present throughout the cardiac cycle. Spontaneous echo contrast was defined as dynamic smoke-like echoes with characteristic swirling motion with an optimal gain setting during the cardiac cycle. When available, transthoracic echocardiography reports were reviewed for the left atrial area.

Indications and definitions. Patient charts were reviewed for indications for TEE. These indications were categorized as being “appropriate,” “inappropriate,” or “unable to be classified” by applying the ACCF/AHA 2011 Appropriateness Criteria (4). Studies were labeled “unable to be classified” due to insufficient documentation and were excluded from further analysis.

Studies were further sorted according to the main indication for use of TEE into 7 appropriate categories and 4 inappropriate categories that are defined here as well as listed in Table 1 (6).

Table 1. Appropriate and Inappropriate Indications for TEE-Guided DCC

| |
|--|
| Appropriate indications |
| CHF/hemodynamic compromise |
| Symptomatic |
| Hospitalized and symptomatic |
| New-onset AF |
| High stroke risk |
| Subtherapeutic anticoagulation |
| Miscellaneous |
| Inappropriate indications (not indicated) |
| Stable with therapeutic anticoagulation >3 weeks |
| AF <48 h |
| Permanent AF |
| Hospitalized but asymptomatic |

Adapted from Asher et al. (6).
 AF = atrial fibrillation; CHF = congestive heart failure; DCC = direct current cardioversion; TEE = transesophageal echocardiography.

Appropriate:

1. “CHF/hemodynamic compromise” included patients with current CHF exacerbation or hemodynamic instability. This indication did not include patients with a history of CHF that was currently well compensated.
2. “Symptomatic” included patients who were having significant symptoms of AF, including palpitations, chest pain, dyspnea, fatigue, lightheadedness, or syncope (7). This indication did not include patients who were already hospitalized or patients who were diagnosed for the first time with AF.
3. “Hospitalized and symptomatic” included patients who were hospitalized for a reason other than AF and who developed symptomatic AF during admission.
4. “New-onset” AF included patients who were diagnosed for the first time with AF and who were in AF for >48 h.
5. “High stroke risk” included patients with a history of stroke, transient ischemic attack, previous LAT, hypertrophic obstructive cardiomyopathy, or rheumatic fever (7).
6. “Subtherapeutic anticoagulation” included patients who were under-

going conventional anticoagulation but had a documented INR <2 at any point in the last 3 weeks and who did not already have one of the indications defined here.

7. “Miscellaneous” included patients who received TEE for a reason unrelated to AF that is found elsewhere in the appropriateness criteria, such as evaluation of valve function or endocarditis. The timing of the TEE coincidentally happened to help expedite DCC.

Inappropriate:

1. “Stable with therapeutic anticoagulation >3 weeks” included patients who were hemodynamically stable and who were therapeutically anticoagulated for at least 3 weeks. These patients completed the conventional method of risk reduction for thromboembolism and did not need TEE (7).
2. “AF <48 h” included patients with no history of AF and who were in AF for <48 h. It was believed that there was not enough time for a thrombus to form and therefore TEE was not useful (7,8).
3. “Permanent AF” included patients in whom sinus rhythm was unable to be sustained after cardioversion or in whom the physician and patient decided to accept AF (7). These patients were not indicated for TEE or DCC.
4. “Hospitalized but asymptomatic” included patients who were hospitalized and in AF but were not having symptoms, CHF exacerbation, or hemodynamic compromise. These patients were able to be managed with 3 weeks of anticoagulation.

Often, patients had >1 indication for TEE. To determine the main indication, categories were ranked as follows: 1) CHF/hemodynamic compromise; 2) hospitalized and symptomatic; 3) new onset; 4) symptomatic; 5) subtherapeutic anticoagulation; 6) miscel-

Table 2. Patient Clinical and Echocardiographic Characteristics and Outcomes

| | All Studies (N = 659) | CHF/Hemodynamic Compromise | Symptoms | New-Onset AF | Hospitalized and Symptomatic | High Stroke Risk | Inadequate Anticoagulation | Misc. | Not Indicated | p Value |
|---------------------------|--------------------------|-------------------------------|------------|-----------------|---------------------------------|---------------------|-------------------------------|-----------|------------------|----------|
| Male | 67.7 (446) | 68.0 (117) | 67.8 (118) | 70.9 (56) | 62.0 (44) | 66.2 (45) | 75.0 (42) | 52.4 (11) | 77.8 (14) | 0.4152 |
| Age (yrs) | 66 ± 13 | 66 ± 30 | 65 ± 29 | 65 ± 22 | 67 ± 21 | 67 ± 20 | 66 ± 19 | 69 ± 12 | 77 ± 11 | 0.85 |
| CHADS ₂ score | | | | | | | | | | |
| 0 | 11.8 | 5.8 | 17.2 | 15.2 | 7.0 | 4.4 | 17.9 | 28.6 | 11.1 | <0.0001* |
| 1 | 24.6 | 14.5 | 25.3 | 39.2 | 28.2 | 16.2 | 32.1 | 42.9 | 22.2 | |
| 2 | 31.4 | 33.7 | 33.3 | 25.3 | 22.5 | 35.3 | 30.3 | 47.6 | 22.2 | |
| 3 | 21.1 | 31.4 | 17.2 | 10.1 | 22.5 | 23.5 | 8.9 | 23.8 | 27.8 | |
| 4 | 9.1 | 10.5 | 6.3 | 7.6 | 14.1 | 10.3 | 3.6 | 23.8 | 5.6 | |
| 5 | 3.5 | 4.1 | 4.0 | 2.5 | 4.2 | 5.9 | 0 | 0 | 0 | |
| 6 | 0.2 | 0 | 0 | 0 | 1.4 | 0 | 0 | 0 | 0 | |
| CHF | 53.7 (354) | 82.6 (142) | 41.4 (72) | 32.9 (26) | 54.9 (39) | 52.9 (36) | 44.6 (25) | 42.9 (9) | 38.9 (7) | <0.0001* |
| Hypertension | 67.7 (446) | 69.2 (119) | 63.8 (111) | 70.1 (56) | 71.8 (51) | 77.9 (53) | 66.1 (37) | 52.4 (11) | 55.6 (10) | 0.2275 |
| Age >75 yrs | 28.4 (187) | 33.1 (57) | 22.4 (39) | 26.6 (21) | 33.8 (24) | 27.9 (19) | 21.4 (13) | 42.6 (9) | 33.3 (6) | <0.0001* |
| Diabetes mellitus | 26.9 (117) | 34.9 (60) | 27.6 (48) | 25.3 (20) | 26.8 (19) | 22.1 (15) | 8.9 (5) | 33.3 (7) | 28 (5) | 0.0287* |
| Previous stroke | 12.7 (84) | 11.0 (19) | 9.8 (17) | 6.3 (5) | 21.1 (15) | 32.4 (22) | 8.9 (5) | 4.8 (1) | 11.1 (2) | <0.0001* |
| Valvular disease | 17.0 (112) | 11.0 (19) | 9.8 (17) | 6.3 (5) | 21.1 (15) | 32.4 (22) | 8.9 (5) | 4.8 (1) | 11.1 (2) | 0.99 |
| TTE/TEE findings | | | | | | | | | | |
| LVEF | 43.5 ± 14.6 | 35 ± 16.3 | 48 ± 11.5 | 49 ± 11.2 | 45 ± 14.3 | 45 ± 14.6 | 47 ± 12.3 | 46 ± 12.4 | 46 ± 12.4 | 0.0001* |
| Spontaneous echo contrast | 44 (290) | 47.1 (81) | 39.1 (68) | 27.9 (22) | 32.4 (23) | 57.4 (39) | 48.2 (27) | 76.2 (16) | 77.8 (14) | 0.0048* |
| Prevalence of LAT/sludge | 8.19 (54) | 10.5 (18) | 3.4 (6) | 5.1 (4) | 14.1 (10) | 17.6 (12) | 7.1 (4) | 0 (0) | 0 (0) | 0.0021* |

Values are % (n), mean ± SD, or %. *Indicates statistically significant values.
LVEF = left ventricular ejection fraction; Misc. = miscellaneous; TTE = transthoracic echocardiography; other abbreviations as in Table 1.

laneous; and 7) high stroke risk (ranked first if patient had history of LAT).

Thromboembolic events. Incidence of thromboembolic events, including stroke, transient ischemic attack, or any other systemic embolization as a secondary endpoint, was determined by retrospective chart review.

Statistical analysis. Continuous variables were summarized as mean ± SD. Categorical and ordinal variables were reported as frequencies and percentages. Patient characteristics, TEE characteristics, and outcome variables were compared across indications using linear and logistics regression models as appropriate. CHADS₂ scores were compared across categories by using the Kruskal-Wallis test. A p value <0.05 was considered statistically significant. Statistical analysis was performed using Stata version 11 (StataCorp LP, College Station, Texas).

Results

Patient characteristics. Patient characteristics are shown in Table 2. The mean patient age was 66 ± 13 years, and 67.7% of patients were male. The mean CHADS₂ score was 2.01 ± 1.27. LVEF was measured in 80.9% of studies (n = 533), and mean LVEF was 43.5 ± 14.6%. There were no significant differences across indications relating to sex, hypertension, valvular disease, or left atrium area. However, there were significant differences between indications regarding CHADS₂ scores, age, CHF, diabetes mellitus, history of stroke, and LVEF.

Appropriateness and indications. Of the 671 studies performed before DCC, 639 (95.2%) were appropriate, 18 (2.7%) were inappropriate, and 12 (1.8%) were unable to be classified due to insufficient documentation.

The categories of symptomatic (26.4%; n = 174) and CHF/hemodynamic compromise (26.1%; n = 174) comprised the main indications for TEE before DCC. All 4 inappropriate

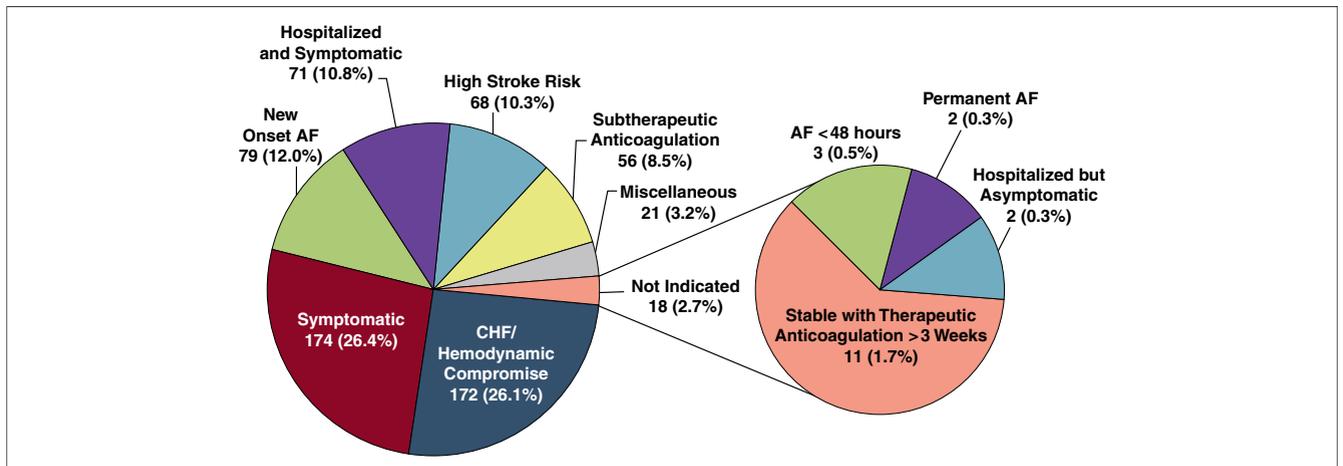


Figure 1. Indications for TEE Before DCC

Proportions of transesophageal echocardiography (TEE) studies performed for different indications are represented. Inappropriate studies were further classified into the categories shown on the right. AF = atrial fibrillation; CHF = congestive heart failure; DCC = direct current cardioversion.

indications together comprised 2.7% (n = 18) of studies: stable with therapeutic anticoagulation >3 weeks, n = 11; AF <48 h, n = 3; permanent AF, n = 2; and hospitalized but symptomatic, n = 2 (Fig. 1).

Thrombus and sludge. LAT/sludge was found in 8.19% (n = 54) of 659 classifiable TEE studies. Incidence of LAT/sludge was significantly different between different indications (p = 0.0021), with the highest incidences being in the high stroke risk (17.65%) and hospitalized and symptomatic (14.08%). The lowest incidences oc-

curred in the indications of new onset (5.06%), miscellaneous (0%), and inappropriate (0%) (Fig. 2). Outside the high stroke risk group, no patients with LAT received DCC, and 1 patient with sludge received DCC.

In the high stroke risk group, there were 12 studies with LAT/sludge (11 with LAT and 1 with sludge). Cardioversion was performed in 3 patients with LAT/sludge, all of whom had a history of LAT, had been receiving therapeutic anticoagulation for >3 weeks, and who were also in CHF or symptomatic from AF. Only 4 patients

in the high-risk group did not have a therapeutic INR at time of TEE, and 8 patients had a subtherapeutic INR in the 3 weeks preceding TEE.

Of the studies with LAT/sludge, 33.3% were found in studies for CHF/hemodynamic compromise, 22.2% in high stroke risk, 18.5% in hospitalized and symptomatic, 11.1% in symptomatic, 7.4% in new onset, and 7.4% in subtherapeutic anticoagulation.

Thromboembolism. After a mean follow-up of 17.9 months, thromboembolism occurred in 2.5% (n = 15) of patients and occurred in all indication groups except miscellaneous and inappropriate, although this was not statistically significant (p = 0.3) (Fig. 3). One thromboembolic event occurred 3 days after DCC, while the remainder occurred 2 to 18 months after DCC. In the high stroke risk group, 4 thromboembolic events occurred, although none was within 3 days of DCC.

Discussion

Despite the ACCF/ASE 2011 Appropriateness Criteria addressing TEE in the setting of AF (4), it is still not clear in which clinical situations TEE is more appropriate. The current concerns are whether we can better identify clinical situations for which TEE is

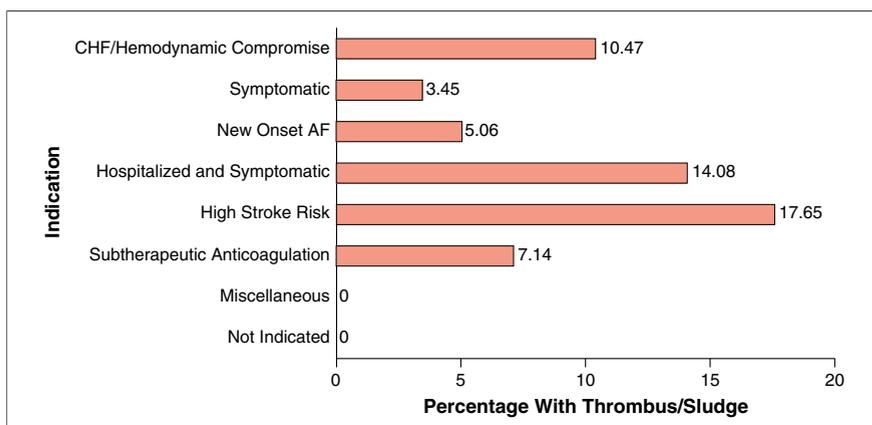
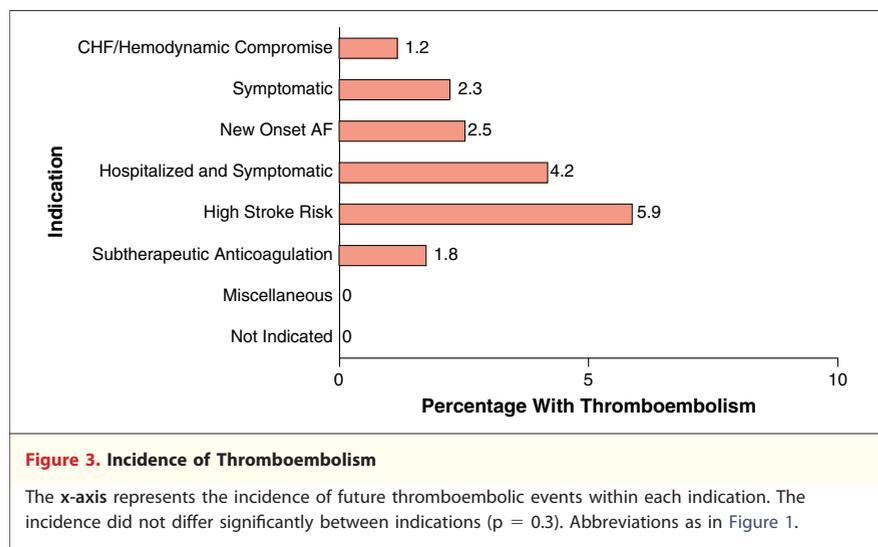


Figure 2. Prevalence of LAT/Sludge

The x-axis represents the percentage of TEE studies within each indication revealing left atrial thrombus (LAT)/sludge. There is a significant difference in prevalence of LAT/sludge between indications (p = 0.0021). Abbreviations as in Figure 1.



best suited and if perhaps TEE is being overutilized. Academic centers with high volumes of DCC (such as our institution) may be prone to overutilization of TEE because these types of centers are more likely to perform a larger proportion of DCCs with TEE guidance (2). Therefore, this study examined the indications for which TEE-guided DCC was being performed.

Our study found that: 1) the vast majority of TEEs performed before DCC are appropriate under the current criteria; 2) the most frequent indications are CHF/hemodynamic compromise and symptomatic, suggesting that TEE is being used to expedite the DCC process; and 3) the prevalence of LAT/sludge differs among indications for TEE.

The fact that approximately one-half of all TEEs were performed for the indications of CHF/hemodynamic compromise and symptoms suggests that TEE is being used to expedite DCC by avoiding prolonged anticoagulation until a therapeutic INR is maintained for 3 consecutive weeks. Although conventional therapy dictates 3 weeks, it often takes longer to achieve this goal, as evidenced by the ACUTE (Assessment of Cardioversion Using Transesophageal Echocardiography) trial, in which patients undergoing con-

ventional therapy waited 30.6 ± 10.6 days for DCC (9). In addition, in an 8-week follow-up of functional status, the ACUTE trial found that TEE-guided DCC was a predictor for improvement in functional status (10). The trial also found that patients with CHF had a greater improvement in functional status than did patients without CHF.

The third most common indication was new-onset AF (12%). TEE-guided cardioversion may be beneficial in these patients because it helps prevent atrial remodeling that may occur while waiting for a therapeutic INR. It is known that prolonged AF results in atrial enlargement in humans (11). The ACUTE study also found that sinus rhythm is more likely to be maintained in patients undergoing TEE-guided DCC than in patients undergoing DCC after conventional anticoagulation (1).

Those patients with the indication of high stroke risk may benefit from TEE, especially if they have a history of LAT/sludge, to evaluate for the serial resolution of LAT/sludge. Although we considered it appropriate to use TEE to screen for LAT/sludge in patients with a history of LAT/sludge, not all groups believe this is currently addressed in the ACCF/ASE 2011 Appropriateness Criteria. A University

of Chicago group found that many of the TEEs at their institution were performed to evaluate for resolution of LAT/sludge but felt that this use was not addressed in the current appropriateness criteria (12). Regardless of the criteria, both the University of Chicago and our group agree that this is an appropriate use. In fact, a follow-up TEE to detect residual LAT may be more cost-effective than assuming 4 weeks of anticoagulation is sufficient, although this is highly dependent on the risk of post-cardioversion stroke (13).

Those patients with the indication of subtherapeutic anticoagulation would benefit from TEE because it has been shown that the incidence of LAT/sludge is higher in this group (14). TEE allows these patients to finally receive DCC with the same risk reduction that successful anticoagulation would have provided. The least common indications were miscellaneous and inappropriate. The low incidence of inappropriate findings is reassuring.

The most common inappropriate indication was stable with therapeutic anticoagulation >3 weeks (11 of 18 inappropriate studies), serving as a reminder to check INR history before performing TEE. There were 3 studies performed with the indication of AF <48 h. It is generally accepted that 48 h is not enough time to form LAT/sludge, although LAT/sludge has been reported in patients with AF <48 h (15). There were 2 TEE-guided DCCs performed on patients with permanent AF. Both patient and physician have accepted remaining in AF. Therefore, it is unlikely that DCC should be performed on these patients, much less a TEE-guided approach.

A full one-third (18 of 54) of the studies revealing LAT/sludge were found in the CHF/hemodynamic compromise group. This finding suggests that TEE is especially useful in screening patients with CHF/hemodynamic compromise because it is a group with a significant amount of LAT/sludge that

can be associated with increased thromboembolic risk.

The highest prevalence of LAT/sludge was found in the indications of high stroke risk and hospitalized and symptomatic, suggesting that these 2 groups also benefit from TEE. This finding is not particularly surprising because it shows that sicker patients tend to be at higher risk for LAT/sludge. It is reassuring that none of the studies in the not indicated category revealed LAT/sludge; however, there were only 18 studies.

Study limitations. This study was retrospective and depended on documentation in patient charts. Follow-up may have been incomplete in our referred patient population. Practice at our institution may not reflect the practice at other centers, but we are a high-volume center for TEE-guided DCC and see a variety of patients. Almost all TEEs ordered before DCC at our institution are ordered by a cardiologist, and the decision to pursue TEE-guided DCC or traditional anticoagulation is left to the physician's clinical judgment. The categories used in the study are arbitrary, and there is overlap between the

groups; however, they were based on previous experience with TEE-guided cardioversions (10). Due to the low incidence of thromboembolic events, this study was not sufficiently powered to correlate indications with thromboembolism. A larger study would be needed to determine which indications have an increased risk of post-DCC thromboembolism. Additional studies will be needed to address the role of new anticoagulants in TEE-guided DCC (16).

Clinical implications. Appropriateness criteria are often a combination of evidence and consensus among experts. This study adds evidence to the criteria. Furthermore, it also clarifies the applicability of the criteria by providing better described indications. In addition, it reveals the indications for which physicians are using TEE-guided cardioversion and is a step in further stratifying which patients are more likely to benefit from TEE.

Conclusions

Our study found that TEE is being used appropriately in clinical decision

making before DCC, with the main indications being symptomatic and CHF/hemodynamic compromise. The study also found that one-third of studies with LAT/sludge were found in patients with the indication of CHF/hemodynamic compromise and that the highest prevalence of LAT/sludge was in patients who received TEE for the indication of high stroke risk or hospitalized and symptomatic. Our study did not reveal any LAT/sludge in inappropriate studies; however, there were very few inappropriate studies conducted. Due to the low incidence of future thromboembolic events, a larger study will be needed in the future to correlate indications for TEE-guided DCC to outcomes.

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Key Words: atrial fibrillation ■ cardioversion ■ transesophageal echocardiography.

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