A Prospective Comparison of Cardiac Imaging Using Intracardiac Echocardiography with TransEsophageal Echocardiography in Patients with Atrial Fibrillation: The Intra-Cardiac Echocardiography Guided Cardioversion Helps Interventional Procedures (ICE-CHIP) Study

Running title: Saksena et al.; The ICE CHIP study

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Abstract:

Background - The Intracardiac Echocardiography guided Cardioversion Helps Interventional Procedures study evaluated the concordance of intracardiac echocardiography (ICE) as compared to transesophageal echocardiography (TEE) in patients with atrial fibrillation.

Methods and Results - Patients with atrial fibrillation undergoing right heart catheterization underwent left atrium (LA) and inter-atrial septal (IAS) imaging by TEE and ICE. A blinded comparison of the two modalities was performed at a core laboratory. 95 patients, mean age 58±12 years completed the study. The LA was profiled in all patients with both techniques and concordance for image quality was 96%. LA appendage(LAA) imaging was achieved in 85% with ICE and 96% with TEE. There was no difference in the presence of spontaneous echo contrast between ICE and TEE during LA imaging but there was a trend toward greater incidence in the LAA with TEE (p=0.109). Intracardiac thrombus was uncommonly seen (TEE-6.9%, ICE-5.2%). The concordance for the presence or absence of thrombus was 97% in the LA and 92% in the LAA but the latter was more frequently detected with TEE. IAS imaging with ICE was achieved in 91% with ICE and 97% with TEE (p=0.177). Concordance for patent foramen ovale and atrial septal aneurysms was 100% and 96% respectively. A negative ICE examination was associated with absence of dense echo contrast or thrombus on TEE in 86%.

Conclusions - We conclude that this study provides validation for the use of ICE for LA and IAS imaging. ICE imaging was less sensitive compared to TEE for LAA thrombus identification.

Clinical Trial Registration - www.clinicaltrials.gov #NCT00281073

Key words: ablation, echocardiography, imaging, arrhythmia, thrombus
Introduction

Direct current cardioversion of atrial fibrillation has been employed to reestablish sinus rhythm in patients with atrial fibrillation (AF). The presence of either intra-atrial thrombi or their precursors with their propensity for systemic embolism is major concern for patients with atrial fibrillation (AF) undergoing cardioversion. Inability to clinically identify these patients at risk has prompted short-term anticoagulation with warfarin prior to attempting cardioversion in all patients. Trans-esophageal echocardiography (TEE) has been demonstrated to be a sensitive tool to detect septal defects, left atrial thrombi and spontaneous echo contrast. 1, 2, 3 Recently, left atrial imaging with TEE has been utilized to identify patients at low risk for thromboembolism after cardioversion. 4 TEE is currently widely regarded as one method of imaging that can identify AF patients who are candidates for immediate cardioversion. 5, 6 Immediate cardioversion after TEE in these low risk patients has not been associated with a higher risk of embolic events than cardioversion after anticoagulation. 6 The recognition of systemic thromboembolism as a significant potential complication of cardioversion or ablation during interventional electrophysiology procedures in patients with AF has stimulated interest in the clinical evaluation of catheter based intracardiac echocardiography (ICE). Initial experience with intracardiac phased–array imaging has demonstrated the efficacy and feasibility of this technology for intracardiac application and its capability in high resolution imaging of endocardial structures and its effectiveness in visualizing left atrial thrombi during ablative procedures has been demonstrated in observational studies. 7-12 ICE has been used to diagnose the frequency of dense spontaneous echo contrast (SEC) which could identify an increased risk of LA thrombus. 12
However, a comparative study of these two imaging techniques is currently unavailable. We undertook a prospective multicenter trial (the ICE-CHIP trial), which was designed to compare cardiac imaging of the left atrium (LA), left atrial appendage (LAA) and interatrial septum with these two techniques in patients with atrial fibrillation undergoing invasive cardiac procedures. The purpose of this study was to objectively assess ICE and TEE imaging of these structures in a multicenter trial.

Methods

The ICE CHIP trial design and methods have been previously reported. This is a prospective open label multi-center investigation designed to compare two distinct imaging modalities (TEE and ICE). The study hypothesis was that ICE is comparable to TEE in visualization of left atrial pathology or atrial septal defects. The overall design was a paired comparison of ICE with TEE in patients with AF undergoing cardiac catheterization or electrophysiologic studies that could predispose patients to stroke. Figure 1 is a flow diagram that outlines the major domains imaged by the two imaging procedures and their elements. A blinded comparison of the two imaging modalities was performed by an independent core echo laboratory. The study protocol was approved by the individual center institutional review committees for all participating centers.

Patient Selection

Patients with spontaneous AF with or without underlying heart disease undergoing an invasive catheterization procedure involving right heart catheterization were screened. Men or women aged 18 years or older who gave an informed consent for participation in the study were enrolled. They had undergone a trans-thoracic echocardiogram within the prior 14 days showing absence of intracardiac thrombi. Each patient was imaged by TEE immediately prior to or within
48 hours of the ICE procedure. Study exclusion criteria have been previously reported and included patients in whom placement of an ICE catheter in the right atrium for adequate atrial visualization was technically not feasible.

Imaging technology and study procedures

The TEE examination was performed according to standard practice guidelines. All approved TEE systems were permitted in the study including biplane and multi-plane TEE systems. The TEE procedure was performed with 0 to 180 degree field of view at different levels. Images were stored on coded media without patient or institutional identifiers, and were submitted in random order for review to the core lab. The ICE technology used in the current study was the ViewMate® System from EP MED Systems, West Berlin, NJ (USA). This system employs a 64-element parallel drive phased array transducer with the transducer being located at the tip of the probe and the base connected to an isolation box. It is introduced into the body mounted on deflectable VIEW FLEX® catheter. This is a 9 French deflectable tip intravascular catheter. The 2D imaging frequencies range from 4.5 to 8.5 MHz with 0.5 MHz increments and pulse wave frequencies vary from 5 to 7.5 MHz. It has an auto optimized zoom function and is capable of providing high-resolution detailed two dimensional ultrasound images with tissue penetration of 11 cm with shallowest image depth available being 1 cm from the lens. The images are visualized on the VIEW MATE platform.

Imaging by ICE was done during the diagnostic or therapeutic invasive catheterization procedure. The phased array ultrasound imaging catheter was introduced through an 11 F haemostatic sheath and positioned under fluoroscopic guidance in the right atrium. After catheter coupling to the Viewmate imaging platform, imaging frequency was optimized by the operator.
using adjunctive gain, depth and focal length controls to define anatomic structures and minimize noise. Imaging was performed at different levels in the right atrium if needed. Imaging targets included the coronary sinus orifice, fossa ovalis, IAS, tricuspid valve, LA, LAA, orifice of all pulmonary veins, mitral valve, papillary muscles, aortic and pulmonary valve leaflets, and adjoining LV and RV myocardium. Intracardiac physiology in the region of appendage, mitral valve, and IAS was examined with color flow and spectral Doppler.

In the study, TEE and ICE were used to assess the presence of any SEC or thrombus in the LA and LAA, as well as the presence of a patent foramen ovale (PFO) or interatrial septal defect (ASD). SEC was defined as slow-moving, continuous echoes, indicating a low flow state, while a clot was a well-defined mass, which could be immobile or show varying degrees of mobility. The diagnosis of clot would be more definitive if it is associated with poor wall motion in the region of the clot and/or SEC. TEE and ICE were also used to evaluate the presence of mobile or fixed atherosclerotic plaques throughout the length of the aorta, especially the ascending aorta and the aortic arch.

**Study Endpoints, Definitions and Analysis**

The study endpoints included:

1. Assessment of the presence of thrombus or SEC in the LA or LAA
2. Assessment of the IAS for the presence of a PFO, ASD and/or septal aneurysm

The primary endpoints for imaging concordance were to compare rates of detection of thrombus, dense SEC, ASD and PFO’s in patients in whom the IAS and LA (including appendages) could be fully imaged. Secondary outcome measures were analyzed to characterize the ICE imaging modality but were not used in the efficacy evaluation of ICE.
Definitions:

Complete imaging: Visualization of the entire structure with clear definition and adequate image quality

Incomplete imaging: Failure to visualize the entire structure, absence of clear definition or adequate image quality

SEC was defined as slow-moving, continuous echoes, indicating a low flow state, swirling slowly within the structure cavity. When present, the gain was systematically decreased to exclude noise artifacts caused by excessive gain.

Dense SEC: Continuous contrast fills the entire cavity of the structure and does not clear with cardiac cycle

Mild SEC: Intermittent contrast is seen, often in only part of the structure

Thrombus: Thrombus was defined as a dense well-circumscribed mass, which could be immobile or show varying degrees of mobility, acoustically distinct from the underlying endocardium or trabeculations

Definite Thrombus: Thrombus is visualized in two or more views of the structure

Probable Thrombus: Thrombus was visualized in one view of the structure

Septal Imaging: Assess the whole extent of the atrial septum for any IASD or a patent foramen ovale (PFO) using color Doppler, as well as saline contrast studies with maneuvers such as the Valsalva maneuver, to transiently raise the right atrial pressure.

Analysis:

ICE & TEE images were evaluated at a core laboratory (see appendix) by 2 independent observers (SS, NN or TL). Inter-observer differences were resolved by a third observer. They were displayed in random order without clinical information on the patient and analyzed by
means of the evaluation software provided by the manufacturer and analysts were blinded to site and individual patient to minimize interpretation bias. Imaging quality control was done by external echocardiographer consultant.

Statistical analysis was conducted by independent statistical group (MLC) with SAS Version 9.1. Concordance between the techniques was calculated as the number of subjects with identical findings on ICE and TEE, divided by the number of subjects with readings on both ICE and TEE. Thus, while unpaired data were available, concordance analyses required both imaging techniques with adequate quality images. Proportions were compared using Fisher’s exact test. Confidence intervals for sensitivity, specificity, positive predictive value and negative predictive value were calculated using the exact binomial test.

Results

Patient Population

Ninety five patients were enrolled in the study, 80 male and 15 female, with a mean age of 58 ±12 years. AF was greater than 6 months duration in 91%, 3-6 months duration in 3%, and less than 3 months duration in 1% of patients. The indication for cardiac catheterization included a diagnostic electrophysiologic study in 31%, right atrial ablation procedure in 7%, and a left atrial ablation procedure in 85%.

Technical Image Quality Assessment

Images of sufficient quality, as judged by the core lab, for each of the three anatomic structures were included in the final analysis. Table 1 shows the study imaging procedure completion for LA & LAA imaging between the two techniques for the entire study population. The LA was
profiled in all patients with both techniques. The study imaging for the LA was rated as complete in 94% of patients with ICE and 100% of patients with TEE. The percentage concordance for complete imaging of the LA was 96%. (Table 1) The LAA could not be profiled in 3% of patients with ICE. For the LAA, complete imaging was achieved in 85% of patients with ICE and 96% with TEE. The percentage concordance for complete imaging for the LAA was 83% between the two techniques. (Table 1) Figure 2 is an example of visualization of both LA and LAA by both ICE and TEE in the same patient. Note the ability of both techniques in complete studies to visualize these structures. The omitted study elements included peak flow velocity in the left atrial appendage in 74% with TEE and 95% with ICE. Color flow Doppler at the IAS was absent in 29% of patients with TEE and in 53% of patients with ICE.

**Procedural complications**

In this trial, there were no adverse events or complications reported for ICE or TEE. This included local complications including local or retroperitoneal bleeding, vascular damage and hematoma formation as well as damage to cardiac structures, perforation or embolization.

**Study Endpoints**

*Spontaneous Echo Contrast (Table 2 and Figure 3)*

Table 2 shows the presence of any SEC in the LA or the LAA with the two techniques. There was no significant difference in the presence of any SEC between ICE and TEE during LA imaging. (Figure 3) The incidence of any SEC in the LAA detected with TEE as compared to ICE was not significantly different (Figure 3, p=0.109). Percentage concordance for the presence of SEC was 65% for the two techniques in the LA and 60% for the two techniques in the LAA. Dense SEC was seen in the LA in 12.5% of ICE studies and 17.8% of TEE studies but
limited paired data were recorded. Figure 2 shows SEC detected with both techniques in the same patient. Note that substantial and dense SEC is observed with both techniques in the LA. In the LAA, dense SEC was less common with ICE (ICE-5.3% vs. TEE-16.7%). Figure 2 also shows the imaging of the LAA for SEC with the two techniques. Note that the LAA is visualized with both techniques and the presence of SEC in both the LA and the LAA is clearly seen. Note the similarity in density and extent of the finding.

**Intracardiac Thrombus (Table3)**

As seen in table 3, intracardiac thrombus was uncommonly seen with both techniques (TEE-6.9%, ICE-5.2%). Figure 4 shows the incidence of intracardiac thrombus with ICE and TEE in the LA and LAA. The percentage concordance for the presence or absence of thrombus was 97% in the LA and 92% in the LAA. Note that probable thrombus in the LA was detected more frequently by ICE and not by TEE. However, thrombus of the LAA was more frequently detected or reported with TEE versus ICE. All patients with LA or LAA thrombus on TEE demonstrated moderate or dense SEC in the LA or LAA on ICE imaging. Figure 5 shows the presence of a medial left atrial thrombus identified with ICE that was not seen on TEE.

**Inter-Atrial Septal Imaging**

In unpaired analyses, an atrial septal aneurysm was detected by TEE in 4 of 45 (9%) patients with TEE and in 5 of 34 (15%) patients with ICE. A PFO was detected in 2 of 42 patients with TEE but neither of these two patients had a complete ICE study for PFO detection. In paired analyses, there was no ASD identified by either technique. The percentage concordance in paired
analysis for the presence of a PFO was 100%. The percentage concordance in paired analysis for the presence of atrial septal aneurysm was 96%.

Concordance of ICE for TEE Findings in the Left Atrium or Appendage (Table 4)

Both techniques showed a fully negative examination in 32% and a positive examination in 12%. A negative ICE examination (defined as absence of any SEC or thrombus on ICE) was associated with absence of dense SEC or thrombus on TEE in 86%; however the association of a positive ICE study (defined as presence of any SEC or thrombus on ICE) with dense spontaneous echo contrast or thrombus on TEE was only 42%.

Discussion

This report details the findings of a prospective, multicenter comparative study with these two techniques using blinded observers to compare the findings of ICE and TEE. Furthermore, detailed comparative evaluation of these two methods in different intracardiac structures has been reported. To our knowledge, this is the first comparative ICE & TEE imaging trial using a core lab that has been reported.

The main findings of this trial include:

1. Both techniques can be performed with a high degree of safety in virtually all patients with atrial fibrillation.
2. LAA and septal imaging is achieved with both methods in the vast majority of patients.
3. SEC detection in the LA and LAA is accomplished with substantial concordance by both techniques.
4. ICE & TEE did not show concordance for LA and LAA thrombus detection

5. ICE & TEE are highly concordant for IAS visualization

6. A completely negative ICE study is associated with TEE findings showing absence of dense spontaneous echo contrast or thrombus.

7. An abnormal ICE study does not frequently reflect similar TEE findings and absence of LAA thrombus on this study do not reflect absence of thrombus on TEE.

The findings of this trial validate the safety of the ICE technique as applied in electrophysiologic and catheterization procedures. Importantly, imaging ability and quality for LA imaging was high with both methods but LAA imaging was more limited with ICE as used in this study. For the IAS imaging, these two methods were both useful. However, absence of color flow Doppler imaging of the septum and peak left atrial appendage flow velocity in a proportion of patients limited some paired analyses of the two techniques. Detailed Doppler imaging was less frequently used than expected by the operators in this study. This could be possibly related to the potential for further prolongation of extended duration interventional electrophysiologic procedures.

Spontaneous echo contrast and thrombus detection

The incidence of SEC and thrombus identification is probably related to the refractory and recurrent AF in this population undergoing electrophysiologic evaluation for therapy. This trial shows that any SEC detection by both techniques in the AF population was quite high, while dense SEC was less common and seen equally often in the LA by both methods but less often by ICE in the LAA. These findings compare with prior reports with TEE, which have shown a 20% incidence of dense SEC in the SPAF 2 analysis. 4
Furthermore, while LAA thrombus detection was uncommon by both techniques, but it was clearly more frequent with TEE. Three of these five patients however, had SEC on the ICE image that was dense in two and moderate in one patient. Two patients did not have this finding and would not have been suspected to be at risk by ICE. These data would also imply that additional views to detect LAA thrombi beyond a single right atrial image are warranted. Alternative locations such as different right atrial views, the coronary sinus and right ventricular outflow tract or pulmonary artery are being evaluated. However, one LA thrombus believed to be present on ICE imaging by all three observers was not detected on all views by TEE.

There is currently no “gold” standard for imaging the LA & LAA. Computed tomography, magnetic resonance imaging, intraoperative measurements and autopsy studies have all been used for comparative evaluation. \(^1\)\(^2\)\(^3\) TEE imaging of thrombi has been validated in one study with intraoperative findings at mitral valve replacement in patients with valvular heart disease with a positive predictive accuracy of 86%. \(^1\) Similar data in patients with atrial fibrillation is not available. In the ACUTE study, 14% of patients undergoing TEE demonstrated LA or LAA thrombus. \(^5\)\(^6\) Comparison of planar and segmented computed tomographic and TEE imaging shows definite variability in LAA imaging between methods. \(^15\) The increased incidence of probable thrombus in the left atrium with ICE merits critical comment as well. These patients should have significant spontaneous contrast as well. Three dimensional echocardiography or TEE and computed tomography may provide more information in the future if this is accurate or not. In addition, differentiation from trabeculation or ridges in the appendage is often difficult with TEE in some patients and ICE offers an important opportunity for confirmation as an imaging alternative during an electrophysiologic or catheterization procedure.
The clinical implications of our findings merit brief discussion. ICE imaging is most suitable for usage when a concomitant diagnostic or therapeutic catheterization procedure is planned. It is not a routine replacement for diagnostic TEE in the clinical setting. A negative ICE examination, defined as absence of both any SEC and thrombus in the left atrium or left atrial appendage, can predict absence of findings in a TEE examination that define low risk patients for cardioversion with a level of negative predictive accuracy seen in the initial TEE validation studies mentioned above. Furthermore, presence of dense SEC on an ICE image from the right atrium at electrophysiologic study should give pause before LA catheterization or ablation procedures.

This study highlighted some other clinical issues as well.

1. There is operator dependence to all echocardiographic imaging and ICE imaging is no exception. The experienced operators in this study did not obtain multiple ICE views of the LAA from the right atrium in many patients, reflecting the need for standardization of technique and more operator experience and effort.

2. Furthermore, detailed ICE imaging of the LAA from additional right atrial locations, the coronary sinus, right ventricular outflow tract or pulmonary artery to visualize multiple lobes of the LAA or a TEE study should be considered before proceeding with an interventional procedure. (16,17)

3. ICE imaging may have future potential advantages in prolonged interventional catheterization or electrophysiologic procedures with respect to patient tolerance and limiting need for general anesthesia e.g. septal closure or AF ablation procedures, when imaging is needed over a longer period than in a diagnostic TEE study.
Inter-atrial septal imaging

This study validates the high quality of ICE imaging of the IAS which is comparable to TEE. Concordance between the two techniques is high (90%), and detection of atrial septal aneurysm or PFO by the two techniques was consistent. However, the markedly lower use of color flow Doppler with the ICE method reflected the limited operator usage of this modality, which has been highly validated for PFO detection in autopsy specimen correlations. Atrial septal aneurysms may also have important implications for interventional procedures as trans-septal puncture sites may be impacted by septal aneurysms.

Economic Implications

This study was not designed to provide an economic comparison of the two techniques. However, ICE catheters are disposable items costing $700-1000 and while reuse has been performed, are not labeled for this purpose. TEE probes cost approximately $35,000 but can be reused and may last several years. The mainframe platform for ICE costs $20,000-50,000 while it may cost $125,000 for TEE. Additional costs include need for an echocardiographer during TEE procedures in the catheterization laboratory and an anesthesiologist if prolonged (>30 minutes) therapeutic interventions are planned with TEE. Diagnostic use of ICE to replace TEE is clearly unlikely due to the invasive nature of the ICE procedure and brief sedation needed for TEE.

Study limitations
This study was performed with one proprietary phased array system and this may not be extrapolated to other types of ICE systems e.g using rotational transducers. There was no significant difference in study image quality between the two techniques when complete studies were obtained. However, the omission of study image elements was more likely to be more extensive with ICE when studies were not complete. The relatively lesser usage of Doppler imaging for the LAA and IAS in these procedures and population emphasizes operator diligence to ensure a complete evaluation. There are potential risks of ICE based on the need for invasive procedures, which may not have been observed in the course of this study. These include the need for large vascular sheath placement, arteriovenous fistulae, perivascular bleeding, thrombosis and embolism.

Conclusions

This prospective comparative multicenter study provides evidence based validation of the use of ICE for imaging of the LA and interatrial septum. LAA imaging with ICE usage solely from the right atrium in this study can be inadequate to identify thrombus. Improvement in this imaging modality requires more detailed views of the LAA using either more intensive operator effort to obtain multiple views of the complete LAA, or placement of the ICE probe at different locations e.g. pulmonary artery, right ventricular outflow tract or coronary sinus, to obtain these images. Unless these approaches are utilized, TEE remains more sensitive and preferred modality for this purpose.

While therapeutic applications using the ICE technique for guidance are already in vogue for catheter ablation to perform transseptal puncture or monitor ablation, pulmonary vein physiology
or cardiac perforation, as well as in septal device deployment, our data should provide a quantitative estimation of the imaging strengths and limitations of this technique vis a vis transesophageal echocardiography. Further development of ICE will require standardization of echocardiographic technique, imaging views, parameter measurements, use of Doppler methodology and color flow imaging as well as operator experience in obtaining complete and high quality studies.

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**Conflict of Interest Disclosures:** Dr. Saksena is a consultant and investigator for Medtronic, St. Jude, and Sanofi-Aventis. Dr. Saksena and the other investigators were supported as research investigators for EP Med Systems during the period of this study. Dr. Nagarakanti, Dr. Simon, Ms. Viggiano, Ms. Lokhandwala and Dr. Chandler have no conflict of interest.

**References:**


Table 1: Study Image Quality and Concordance Between ICE and TEE
(Abbreviations as in text)

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<th>Imaging Modality</th>
<th>LA ICE</th>
<th>TEE</th>
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<tr>
<td>Complete</td>
<td>94%</td>
<td>100%</td>
<td>96%</td>
</tr>
<tr>
<td>Incomplete</td>
<td>6%</td>
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<td>0%</td>
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<tr>
<td>Not profiled</td>
<td>0%</td>
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<tr>
<td>Percent concordance</td>
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<td></td>
<td>96%</td>
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<th>Imaging Modality</th>
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<tr>
<td>Complete</td>
<td>85%</td>
<td>96%</td>
<td>82%</td>
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<tr>
<td>Incomplete</td>
<td>12%</td>
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<td>0%</td>
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<td>0%</td>
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<tr>
<td>Percent concordance</td>
<td></td>
<td></td>
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Table 2: Incidence and Concordance of Spontaneous Echo Contrast Seen with ICE and TEE.
(Abbreviations as in text)

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<th>Imaging Modality</th>
<th>LA ICE</th>
<th>TEE</th>
<th>Both</th>
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<tbody>
<tr>
<td>Incidence of any SEC</td>
<td>50% (40/80)</td>
<td>56% (41/73)</td>
<td>35% (24/69)</td>
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<tr>
<td>Dense SEC</td>
<td>13% (10/80)</td>
<td>18% (13/73)</td>
<td>6% (4/69)</td>
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<tr>
<td>Percent concordance</td>
<td></td>
<td></td>
<td>65%</td>
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<table>
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<th>Imaging Modality</th>
<th>LAA ICE</th>
<th>TEE</th>
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<tr>
<td>Incidence of any SEC</td>
<td>24% (18/76)</td>
<td>36% (26/72)</td>
<td>8% (5/64)</td>
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<tr>
<td>Dense SEC</td>
<td>5% (4/76)</td>
<td>17% (12/72)</td>
<td>0% (0/64)</td>
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<tr>
<td>Percent concordance</td>
<td></td>
<td></td>
<td>60%</td>
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Table 3: Summary of Thrombi seen on ICE and TEE in LA and LAA (Abbreviations as in text)

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<tr>
<th>Image Technique</th>
<th>LA ICE</th>
<th>LA TEE</th>
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<th>LAA TEE</th>
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<td>Definite Clot</td>
<td>0</td>
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<td>1</td>
<td>3</td>
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<tr>
<td>Probable Clot</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
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Table 4:

- Sensitivity of ICE for TEE findings: 69% (41.3-89.0%)
- Specificity of ICE for TEE findings: 67% (51.1-80.0%)
- Predictive value of Negative * ICE exam for TEE findings of absence of dense spontaneous echo contrast or thrombus in LA or LAA: 86% (69.7 – 95.2%)
- Predictive value of * Positive ICE exam for dense spontaneous echo contrast or thrombus on TEE: 42% (23.4-63.1%)

*defined as absence (negative) or presence (positive) of any Echo Contrast and Thrombus in ICE
Figure Legends:

Figure 1 - Study flow diagram showing images obtained by ICE and TEE during the ICE CHIP study

TEE= Transesophageal Echocardiography; ICE=Intracardiac Echocardiography

Figure 2 - Spontaneous Echo Contrast as visualized in the LA by ICE and TEE imaging techniques in the same patient

TEE= Transesophageal Echocardiography; ICE=Intracardiac Echocardiography

Figure 3 - Incidence and Concordance of Spontaneous Echo contrast in LA and LAA using ICE and TEE

TEE= Transesophageal Echocardiography; ICE=Intracardiac Echocardiography; LA=Left Atrium; LAA=Left Atrial Appendage

Figure 4 - Spontaneous Echo Contrast as visualized in the LAA by both ICE and TEE imaging techniques.

TEE= Transesophageal Echocardiography; ICE=Intracardiac Echocardiography

Figure 5 - Incidence of Intracardiac thrombi in the LA and LAA by ICE and TEE imaging techniques.

TEE= Transesophageal Echocardiography; ICE=Intracardiac Echocardiography; LA=Left Atrium; LAA=Left Atrial Appendage

Figure 6 - LA thrombus seen in the medial aspect of the left atrium with ICE imaging was not visualized on TEE imaging

TEE= Transesophageal Echocardiography; ICE=Intracardiac Echocardiography
Spontaneous AF
Invasive Right Heart Catheterization Procedure

- TEE
  - Left Atrium
  - Left Atrial Appendage
  - Septum

- ICE
  - Left Atrium
  - Left Atrial Appendage
  - Septum
Presence of "SMOKE"

Percent of patients (%)
Presence of Thrombus

- None
- Probable
- Definite

Bar chart showing the percent of patients for LA ICE, LA TEE, LAA ICE, and LAA TEE with different levels of thrombus presence.