

# Use of Intraoperative Epiaortic Ultrasonography To Delineate Aortic Atheroma\*

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**Objective:** A cerebrovascular accident (CVA) is a devastating complication of coronary artery bypass grafting (CABG) and a major cause for morbidity and mortality. Aortic manipulation, cannulation, and clamping during CABG may lead to release of atheromatous material from the ascending aorta, which may cause a CVA. This study assessed the hypothesis that the use of intraoperative epiaortic ultrasonography (EAUS) would supplement imaging information with that derived from manual aortic palpation and influence the surgical decision-making approach accordingly.

**Methods:** After undergoing a mid-sternotomy for CABG, 105 patients underwent EAUS with an 8-MHz transducer ordinarily used for conventional transthoracic echocardiography. The surgical strategy was decided on at three stages: preoperatively, after manual aortic palpation, and following EAUS.

**Results:** The preoperative strategy had assigned 105 patients to the “touched aorta” group that was planned for either on-pump or off-pump CABG (OPCAB) with proximal anastomosis to the aorta. Pathologic lesions of the atheromatous ascending aorta were evident in 40 patients (38%), with the lesions detected in 22 patients (21%) by both palpation and EAUS, and in 18 patients (17%) by EAUS alone. The planned surgical strategy was changed in 29 patients (28%): 25 patients (24%) were converted from on-pump CABG to OPCAB, and the EAUS influenced the choice of the aortic cannulation, cross-clamping, and proximal anastomosis site in 4 patients (4%). Among the changes in surgical decision making, changes in 11 patients (10%) were based on lesion detection by both manual palpation and EAUS; in 18 patients (17%), changes resulted from pathologic evidence provided by EAUS alone.

**Conclusions:** This study showed EAUS to be more sensitive in detecting atherosclerotic lesions than manual intraoperative palpation of the ascending aorta. This investigation contributes new data on the effect of EAUS on intraoperative surgical approach in the era of OPCAB. The use of EAUS has emerged as an important tool in intraoperative decision making, and we recommend its use routinely in CABG procedures. (*CHEST* 2005; 127:60–65)

**Key words:** cerebrovascular accident; coronary artery bypass; epiaortic ultrasound

**Abbreviations:** CABG = coronary artery bypass grafting; CVA = cerebrovascular accident; EAUS = epiaortic ultrasonography; OPCAB = off-pump coronary artery bypass; PVD = peripheral vascular disease; TEE = transesophageal echocardiography

Adverse neurologic sequelae following coronary artery bypass grafting (CABG) are relatively common and are associated with substantial increases in mortality, length of hospitalization, and the need for intermediate or long-term care facilities.<sup>1</sup>

Adverse cerebral outcomes have been reported to occur in 6.1% of these patients. Preoperative risk factors to develop ischemic stroke after CABG include age, preexisting cerebrovascular disease, and atherosclerosis of the ascending aorta.<sup>2</sup>

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rotic disease of the ascending aorta was shown to be a possible source of cerebral emboli.<sup>3</sup> Roach et al<sup>1</sup> identified proximal aortic atherosclerosis detected intraoperatively by the surgeon as the strongest independent predictor for a type I (focal injury, or stupor or coma at discharge) cerebral outcome.

Neuroprotection is becoming an increasingly important consideration in the adoption of new methods and the equipment used in cardiac surgery.<sup>4</sup> Recent developments of off-pump coronary artery bypass (OPCAB) and total arterial revascularization without clamping the aorta were shown by several investigators<sup>5,6</sup> to offer new opportunities of neuroprotection. We hypothesized that intraoperative epiaortic ultrasonography (EAUS) would supplement visual information to that derived from manual aortic palpation and, consequently, influence and refine the selection of the appropriate surgical strategy.

## MATERIALS AND METHODS

Between April 2001 and May 2002, 105 patients who underwent CABG at the Tel Aviv Sourasky Medical Center were recruited for this investigation. All patients were screened intraoperatively with EAUS using an 8-MHz transducer, generally used for conventional transthoracic echocardiography. The surgical strategy was determined prospectively at three stages: preoperatively, following manual aortic palpation, and after EAUS had been performed and the results interpreted.

### *Patient Selection and Preoperative Surgical Decision-Making Protocol*

The study was conducted during 1 operative day every week through the 13-month period, and thus the study cohort represents a random 20% of our patient population. The study population includes patients undergoing CABG without any additional concomitant procedures. Off-pump patients without planned proximal anastomosis to the aorta (*ie*, “no touch aorta”) and patients scheduled for repeat CABG procedures were excluded. Therefore, the patients in this study represent the preoperatively intended “touched aorta” approach for whom a change in surgical strategy would be considered. In addition to the planned surgical strategy, the following risk factors for ascending aortic atherosclerosis were documented prospectively: sex, age, peripheral vascular disease (PVD) and left main disease, hypertension, diabetes mellitus, smoking habits, obesity, hyperlipidemia, and previous neurologic events.

The initial (preoperative) surgical plan was based on the surgeon’s clinical judgment and findings on medical history, coronary angiography, ventriculography, and chest radiograph examination. The second planning stage was conducted after manual palpation of the ascending aorta. The final decision of which surgical approach to be used was now made by the senior surgeon, after intraoperative EAUS, by weighing the combined findings of EAUS, manual palpation, and all the pertinent information gathered earlier. The decision was multifactorial, mainly based on the size of the atheroma, the degree of the intraluminal parts, the morphology of the atheroma, the location in the ascending aorta, and all other clinical variables of the patient. Significant atheroma in the mid portion of ascending aorta that was graded moderate or severe (intimal thickening > 3 mm) was required to consider surgical decision change.<sup>7</sup>

### *EAUS Methodology*

EAUS was performed using an echo system (Hewlett Packard 5500; Hewlett Packard; Seattle, WA). An 8-MHz handheld transducer (Hewlett Packard) was placed inside a sterile glove filled with gel, and inserted through a sterile sheath. For the anterior aortic wall view, a spacer comprised of a second glove filled with saline solution was used. The interpretation of the EAUS findings was carried out during the operation by the surgeon. The surgical decision in the three stages was documented in real-time in the operating room by the echocardiography technician.

### *Follow-up*

Patients were followed up during hospitalization and up to 1 year thereafter. The follow-up during the hospital stay included the following: duration of ventilation in the cardiac surgery ICU, length of stay in the cardiac surgery ICU, and the occurrence of a cerebrovascular accident (CVA) or any other neurologic event, arrhythmias, and any other postoperative complications. The second step took place after the patient had been discharged from hospital, and this follow-up was conducted up to 1 year postoperatively by means of a telephone questionnaire. The main focus of this follow-up was to evaluate the patient’s cognitive state, presence of confusion, memory deficits, language difficulties, and neurologic deficits.

### *Statistical Analysis*

Statistical analysis was performed using the  $\chi^2$  test or Fisher exact test for small numbers in order to discover any relationship between categorical variables;  $p < 0.05$  was considered statistically significant.

## RESULTS

### *Preoperative Characteristics and the Correlation to Atheromatous Findings on the Ascending Aorta*

The study population was comprised of 105 patients (72 men and 33 women; average age,  $69.3 \pm 10.1$  years [mean  $\pm$  SD]; 60 patients were > 70 years old). The distribution of selected risk factors for the entire cohort is displayed in Table 1. There was a statistically significant correlation only between findings of pathology in the ascending aorta as detected by EAUS and the presence of PVD ( $p = 0.036$ ) and age > 70 years ( $p = 0.021$ ).

### *Changes in Surgical Strategy and Comparison of Manual Palpation to EAUS*

An atheromatotic ascending aorta was found in 40 patients (38%), in 22 patients (21%) by both palpation and EAUS, and in 18 patients (17%) by EAUS alone. Figure 1 is an example of a lesion by EAUS that was not detected by palpation. The sensitivity of manual palpation compared to EAUS was found to be 55%.

One hundred five patients were scheduled to undergo either on-pump CABG or OPCAB with

**Table 1—Prevalence of Preoperative Risk Factors in the Patient Cohort and in the Subgroup With Positive Findings on EAUS**

| Risk Factors                         | Patients With Negative Ascending Aorta Findings (n = 65), % | Patients With Positive Ascending Aorta Findings (n = 40), % | p Value* |
|--------------------------------------|---|---|----------|
| Hypertension                         | 72.3  | 77.5  | 0.554    |
| Dyslipidemia                         | 56.9  | 50.0  | 0.489    |
| Diabetes mellitus                    | 47.7  | 52.5  | 0.632    |
| Smoking                              | 33.9  | 45.0  | 0.253    |
| Left main arterial occlusive disease | 27.7  | 27.5  | 0.982    |
| Status post-CVA                      | 10.8  | 20.0  | 0.189    |
| PVD                                  | 23.1  | 42.5  | 0.036    |
| Age > 70 yr                          | 52.3  | 75.0  | 0.021    |
| Male gender                          | 70.8  | 65.0  | 0.535    |
| Obesity                              | 18.5  | 20.0  | 0.845    |
| Status post myocardial infarction    | 46.2  | 57.5  | 0.259    |
| Arrhythmias                          | 7.7   | 10.0  | 0.469    |

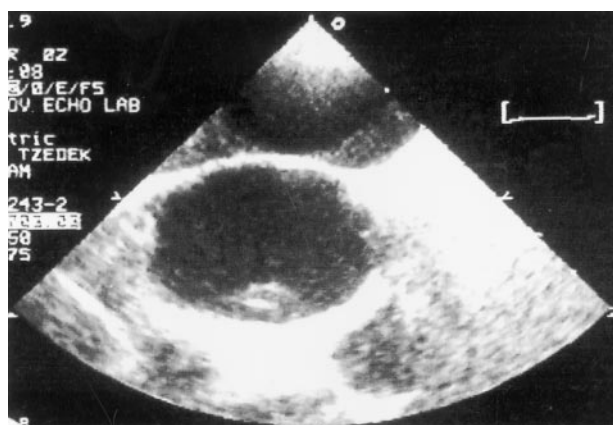
\*Fisher exact test or  $\chi^2$  test as appropriate.

proximal saphenous vein graft connected to the aorta. There were 29 changes in surgical planning (24%) due to significant atheromatous findings in the ascending aorta: 25 patients (24%) were converted from on-pump CABG to OPCAB (without proximal anastomosis to the aorta) and 4 changes (4%) were changes of cannulation, cross-clamping, or the saphenous vein graft proximal anastomosis site (Fig 2). Of the 29 patients with surgical decision changes due to significant atheromatous findings in the ascending aorta, both manual palpation and EAUS detected the lesions in 11 patients (38%), while alterations were made as a result of findings picked up only by EAUS in 18 patients (62%) [Fig 2].

#### Patient Outcome

There were no intraoperative deaths among the study participants. Two patients (2%) died within 9

days and 10 days postoperatively, respectively. Five patients (4%) had a CVA: one patient died (one of the two deaths mentioned earlier), two patients had some neurologic sequelae, and the other two patients had complete resolution at the first-year postoperative follow-up. Two of these five patients had an atheroma in the aorta, but were operated on with the use of the heart-lung machine according to the senior surgeon's decision. In the aortas of the other three patients, no evidence of pathology was found. However, one of the three patients had bilateral carotid stenosis (60 to 70%) with a preoperative decision not to perform carotid endarterectomy; in a second patient in that group, the CVA occurred several days postoperatively following intermittent atrial fibrillation. All other CVAs occurred immediately postoperatively. There were no CVAs in any patients with a pathologic aorta who were converted to off-pump total arterial coronary artery grafting.



**FIGURE 1.** An EAUS examination revealing an intraluminal ascending aortic atheroma (12 mm × 6 mm) at the posterior wall in the planned area for cross-clamping. This lesion was not detected by previous manual palpation and led to conversion from cardiopulmonary bypass surgery to the OPCAB approach.

#### DISCUSSION

Of the entire study cohort, intraoperative findings of atheromatous disease in the ascending aorta led to 29 changes (28%) in surgical strategy. EAUS was found to be more sensitive than manual palpation, with 62% of these surgical planning changes due to findings missed by manual palpation but detected by EAUS.

#### Limitations of Aortic Palpation and Transesophageal Echocardiography

Manual intraoperative palpation can detect approximately one half of the cases of atherosclerotic disease of the ascending aorta and may, therefore, lead to incorrect surgical decisions.<sup>8,9</sup> Transesophageal echocardiography (TEE) was found by others<sup>10,11</sup> to be better

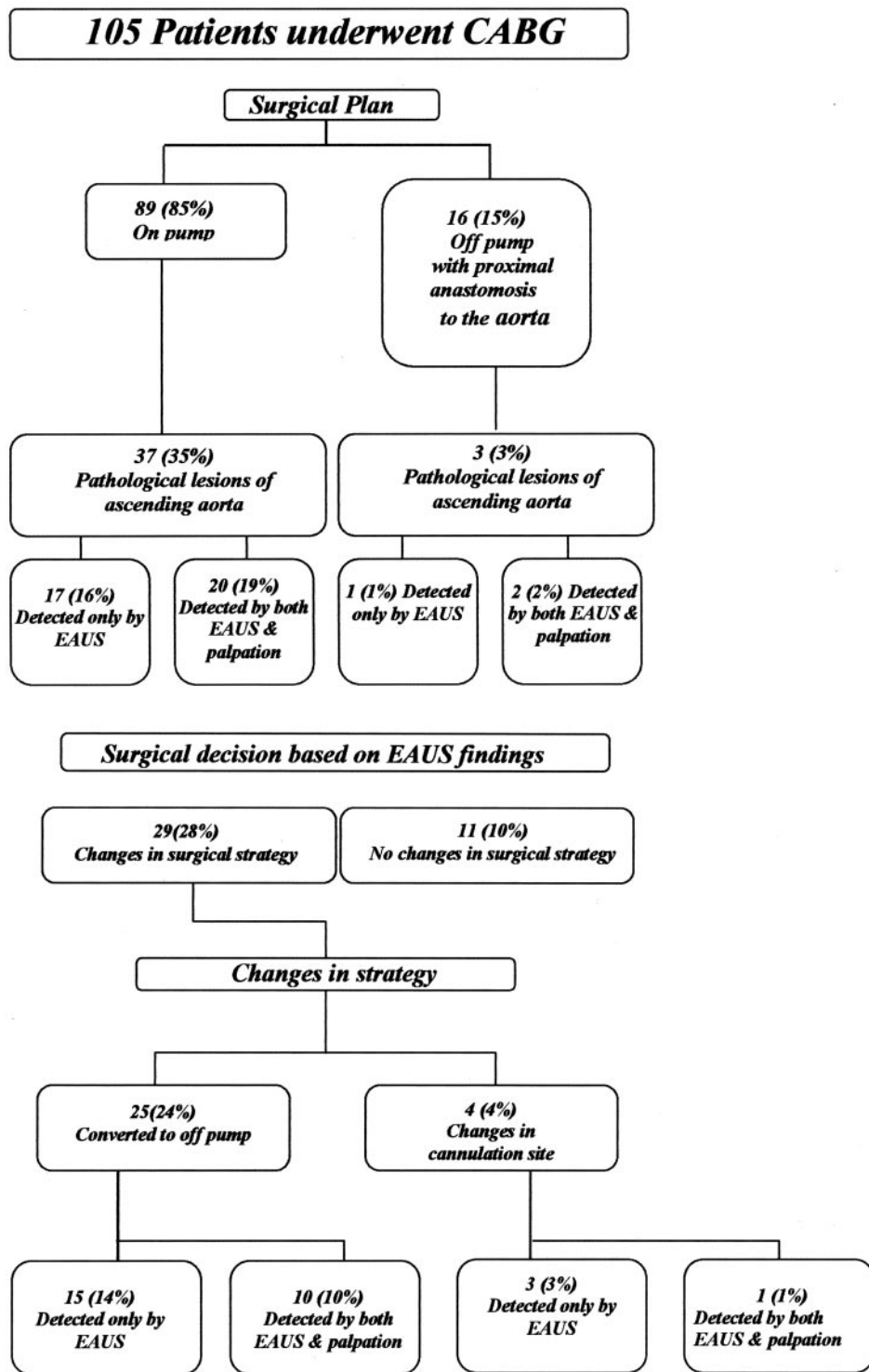


FIGURE 2. A flow chart displaying the management of the study patients as influenced by the implementation of EAUS.

than manual aortic palpation but less sensitive than EAUS, especially in the mid and distal ascending aorta. In our study, the sensitivity of manual palpation in comparison to the EAUS was found to be 55%. Intra-

operative EAUS has been reported to be a rapid, reliable, and accurate method of detecting atherosclerotic disease in the ascending aorta.<sup>7</sup> Royse et al<sup>12</sup> used EAUS as a “gold standard” for comparing manual

palpation with TEE, and found the positive predictive value of TEE to be 39%; Ozatik et al<sup>13</sup> reported EAUS sensitivity to be 96.8%. In our current study, EAUS was found to be highly accurate: no case of pathologic ascending aorta detected by other methods (manual palpation or radiographs) failed detection by EAUS.

#### *Prevalence of Atheromatous Disease in the Ascending Aorta and the Relation to Preoperative Risk Factors*

The prevalence of atherosclerotic disease in the ascending aorta was 38% (n = 40) in the current study. This seemingly high percentage is generally comparable to the findings of other authors.<sup>2</sup> Davila-Roman et al<sup>7</sup> reported mild atherosclerosis of the ascending aorta in 33% of their patients, moderate in 19%, and severe in 10%. Our findings of atheroma are reflected by the changes in the patients' surgical planning: 72% of atheromas led to changes in decision making and were usually larger and located in the areas intended for manipulation, while the remaining 27% of atheromas were small and remote and thus did not result in any revisions of surgical planning. Of the selected preoperative risk factors, PVD (p = 0.036) and age > 70 years (p = 0.021) were associated with a pathologic ascending aorta. Ozatik et al<sup>13</sup> reported that age > 70 years, hypertension, and PVD were preoperative risk factors for ascending aortic disease, while other investigators<sup>7</sup> reported that the parameters of age and diabetes correlated with ascending aortic pathologic findings. The relatively high prevalence of ascending aortic findings in our patients without those risk factors, however, leads us and other authors<sup>12</sup> to recommend EAUS in every patient undergoing cardiac surgery.

#### *Changes in Surgical Planning as a Result of Perioperative Findings*

Of the 105 patients included in the study group, 29 changes (28%) were decided on in our study, with the majority of these patients (n = 25) being converted from on-pump CABG to OPCAB. Reports that emerged prior to the recent development of OPCAB surgery described comparable percentages but different types of surgical changes.<sup>14</sup> Ozatik et al<sup>13</sup> reported switching the operative strategy from on-pump CABG to OPCAB in 27% of the modifications. The higher conversion rate to OPCAB in our study is probably the result of the general improvement in OPCAB techniques and the fact that 50% of our CABG procedures are routinely performed without the use of the heart-lung machine. The OPCAB option makes EAUS an even more important tool in contemporary surgical decision making.

#### *Reduction in the Number of Neurologic Complications*

The current study was not designed to look for reduction of stroke rates with the use of EAUS. For that purpose, a much wider study is required. Several authors reported postoperative improvement as a result of surgical modifications based on EAUS findings. Ozatic et al<sup>13</sup> reported a significant reduction in the incidence of stroke (from 2.8 to 0.9%). Other authors<sup>12,14,15</sup> reported improved neurologic outcomes in patients with ascending aortic disease that had been detected by EAUS leading to surgical modification. The latter studies did not include OPCAB as an optional surgical modification. The improvements in OPCAB techniques, together with careful screening of the ascending aorta, may lead to better surgical results

#### *Study Limitations*

This study focused on the intraoperative decision-making process as a result of the availability of supplemental evidence from intraoperative EAUS. The study was not designed to reduce neurologic complications. A larger randomized trial would be needed to address the possible reduction in postoperative stroke as a result of EAUS in the OPCAB era. We used an 8-MHz echocardiography transducer usually used for transthoracic echocardiography. This transducer was not designed for epiaortic imaging, and this led to a suboptimal image. Surgeons using an 8-MHz transducer need to gain experience in order to accurately visualize the ascending aorta. Using transducers that were designed for that purpose should speed up the test, improve the visualization of the ascending aorta, and may improve the overall surgical results.

In conclusion, our findings showed that EAUS is more sensitive for detecting atherosclerotic disease than manual intraoperative palpation of the ascending aorta. The recent developments in cardiac surgery heighten the importance of EAUS as a tool in intraoperative surgical decision making. We recommend the routine use of EAUS in every CABG procedure.

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