



Review article

Does epiaortic ultrasound screening reduce perioperative stroke in patients undergoing coronary surgery? A topical review

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ABSTRACT

Although the occurrence of stroke in patients undergoing coronary artery bypass grafting (CABG) is decreasing, it remains an important concern. Therefore, it is important to identify and adopt strategies that can decrease the incidence of stroke in these patients. One of the strategies that have demonstrated the potential to decrease the rate of post-CABG stroke is an assessment of aorta for atherosclerosis before surgery and changing the surgical plan accordingly to minimize the stroke risk. This assessment can be done through palpation of the aorta, transesophageal echocardiography (TEE), and epiaortic ultrasound scanning (EAS). EAS has shown superiority over both palpation and TEE for intraoperative evaluation of aorta. However, despite the evidence demonstrating reduced stroke rates with the EAS-guided approach, EAS is not yet the standard of care procedure in patients undergoing CABG. Therefore, we have reviewed the literature for evidence that supports the routine use of EAS in patients undergoing coronary surgery and have presented solutions to overcome the barriers to its routine use.

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1. Introduction

Atherosclerosis of the ascending aorta is recognized as a significant risk factor for perioperative [1–3] and postoperative [4] systemic embolization, stroke and major adverse cardiac and cerebrovascular events (MACCE) [5–7] in patients undergoing coronary artery bypass grafting (CABG) surgery. Because significant aortic atherosclerosis is present in more than 50% of patients undergoing CABG [8], it is imperative to identify and adequately evaluate aortic pathology to prevent dislodging of the atheroma and help devise and implement an appropriate surgical strategy.

Aortic palpation and manipulation are often employed before cannulation, but this technique has limited sensitivity [9] and is associated with a greater risk of atheroma dislodgement [8,9]. Among the other techniques available is Transesophageal Echocardiography (TEE) but with this technique, the ascending aorta and proximal arch may not be fully visualized due to signal drop-off from the right bronchus. Epiaortic ultrasonographic screening

(EAS) is the preferred, easy, safe and effective modality [10] offering greater accuracy in the assessment of ascending aortic pathology than both TEE and manual palpation [11,12].

Although several surgical centers are now utilizing intraoperative epiaortic ultrasound screening to identify patients at an increased risk for stroke, it is still not a standard procedure for patients undergoing CABG, despite various studies depicting its effectiveness [13–15]. Consequently, there is considerable disparity between the rates of adverse neurologic outcomes among institutions. Therefore, in this review, we aim to highlight the benefits of epiaortic ultrasound screening in terms of superior imaging sensitivity and subsequent influence on modifications of surgical strategy, its cost-effectiveness and ensuring favorable cardiac and extra-cardiac outcomes and propose how this technique can be easily adopted as a routine practice in all patients undergoing CABG.

2. Aortic atherosclerosis and risk of cerebral atheroembolism in patients undergoing coronary surgery

While mortality rates for isolated CABG have declined over time [16], neurologic adverse events remain a paramount concern [17]. It is known that ascending aortic, and arch atherosclerosis is a

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prominent source of cerebral embolic material and hence a common underlying cause of early stroke after CABG [4,6,18].

Hangler et al. [15] showed that when the ascending aorta was evaluated by EAS intraoperatively, the moderate atherosclerotic disease was detected in 47.5% of patients undergoing CABG while 9.6% had severe disease. A number of studies have established the correlation between significant ascending aortic atherosclerosis and perioperative stroke [11,15,19] and also that the degree of atherosclerotic burden relates to the rate of cerebral embolization during cardiac surgery [13,20–21].

Because manipulation of the ascending aorta is not only routine but necessary in patients undergoing cardiac surgery, procedures like cross-clamping and the sandblasting effect of cannula flow present great risk of dislodgement and embolization of the plaque [8]. Direct manipulation of the aorta is hence considered the predominant cause of embolic brain injury [22]. Therefore, correct assessment of the plaque without manipulation, with a no-touch screening technique like EAS and corresponding surgical plan alteration would offer the greatest prospects of changing outcomes.

3. Superiority of EAS over other imaging techniques in aortic atherosclerosis identification

Some investigations have proven the superior sensitivity of EAS over both TEE and surgical palpation for accurate assessment of ascending aortic atherosclerosis [7,9,11,12,23]. While TEE is a useful modality to scan the aortic arch, visualization of the distal ascending aorta may be interrupted by the blind spot created by the interposition of the right mainstem bronchus between the esophagus and aorta [9] making it unsatisfactory for comprehensive evaluation. This poses a problem because the distal ascending aorta is a frequent site for aortic cannulation and clamping during surgery. Suvarna et al. [23] demonstrated the sensitivity of TEE to be as low as 31% in comparison to EAS and reported six false positive proximal aortic atherosclerosis cases with TEE that were negative with EAS.

On the other hand, intraoperative palpation of the aorta greatly underestimates the severity and frequency of atherosclerosis and cannot precisely assess the nature of the embolic risk [10,12]. Moreover, palpation is associated with an increased risk of dislodgement and embolization of plaques [22].

Yamaguchi et al. [24] reported that computerized tomography (CT) scanning only identified the most severe aortic pathology while mild and moderate go undiagnosed. The frequency of preoperative atherosclerosis detection was approximately 12% with CT scans while EAS detected moderate or severe aortic pathology in 22.6% of the same group of patients.

Intraoperative assessment with EAS is therefore more sensitive for localizing disease in the aortic arch, middle and distal parts of ascending aorta (cannulation and cross-clamping sites) and offers the advantages of better resolution, less artifact and no blind spot in comparison to TEE [8], making it the gold standard technique for diagnosis and characterization of atheroma.

4. The influence of EAS on surgical plan modifications

Without altering the surgical strategy in accordance with EAS findings, detection in itself would not be of much clinical value. Modifications in surgical approach may include EAS-guided modification of the cannulation or cross-clamping site [20] or avoidance of clamping altogether. Table 1 summarizes findings from different studies depicting the EAS-guided changes in surgical plan and the subsequent outcomes.

Daniel et al. [25] reported in a recent study that while the use of epiaortic screening doubled from 45% in 2002 to 90% in 2009, aor-

tic clamping became less frequent (98% in 2002 to 73% in 2009). Other modifications like aortic no-touch techniques, conversion to off-pump surgery, conversion to ventricular fibrillatory arrest with no cross-clamp application, and circulatory arrest with aortic debridement or aortic replacement procedures have also been utilized [26]. However, the published rates of such modifications range from 4 to 31% [8].

Dajaini et al. [27] reported that compared to the control group, surgical management was modified more often in the EAS group (29% of patients in the EAS group vs. 12% of patients in the non-EAS group, $P = .025$). Moreover, seven patients from the control group later crossed over to the EAS group, and three of them had surgical plan modifications. Changes in surgical strategy included conversion to off-pump surgery, ventricular fibrillatory arrest with no cross-clamp application, and distal aortic arch cannulation in an area free of atheroma [27].

Bolotin et al. [28] demonstrated that EAS influenced a change in the surgical procedure in 28% of 105 patients undergoing isolated CABG. Hammon et al. [19] also showed that this change in surgical approach might result in an improved postoperative cognitive outcome. Furthermore, Lyons et al. [29] found that among 4278 patients in whom grading was available, EAS detected low-risk atheroma (grade 1–2) in 86% patients and a high-risk atheroma (grade 3–5) in 14% patients. These findings influenced surgical plan modifications in 12% of cases compared to only 4.6% (162 out of 3535) surgical strategy alterations in patients undergoing isolated CABG in the study by Rosenberger et al. [26]. The changes in the surgical plan in both studies included conversion to off-pump CABG surgery, changing a two clamp technique to a single or no clamp technique and altering cannulation/clamp/proximal placement sites.

5. The role of EAS in reducing adverse neurological outcomes in patients undergoing coronary surgery

Several studies have reported a reduction in the occurrence of stroke in patients who underwent surgical technique modifications based on the results of epiaortic scanning [15,26,29,30]. A comprehensive review by Whitley et al. [8] also reinforces that the routine use of epiaortic ultrasound screening in cardiac surgery patients may improve postoperative outcomes.

In a study of 909 CABG patients Yamaguchi et al. [24] suggested that due to the possible preventive effect of EAS and subsequent surgical modifications employed, aortic clamping or cardiopulmonary bypass of the diseased aorta was not associated with postoperative neurological events. Rosenberger et al. [26] also described that in the isolated CABG patient population managed with EAS there was a lower incidence of stroke (1.4% vs. 1.6%, $p < .05$) along with reduced transient ischemic attack (TIA) associated neurologic complications (0.35% vs. 0.4%, $p < .05$). Lyons et al. [29] reported an evident reduction in the incidence of mortality and major adverse cardiac and cerebrovascular events (MACCE) in patients who underwent EAS-guided surgical plan modifications. This was most apparent in groups where an aortic clamp was used, thus suggesting that perioperative EAS may minimize morbidity and mortality with techniques where clamping is necessary. Zingone et al. [30] also found that the total stroke rate, as well as early stroke rate, decreased in an isolated CABG cohort following the use of epiaortic imaging, thus strengthening the link between intraoperative maneuvers and outcomes.

6. Cost-effectiveness of EAS

To add to the advantages that tilt the balance in favor of the routine use of EAS in patients undergoing CABG is the fact that this

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