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Neurological Outcomes After OPCAB: How Much Better Is It?

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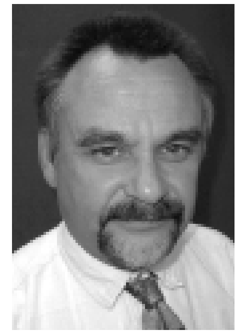

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Recently, Ricci et al. reported their experiences with 269 octogenarians who underwent coronary artery bypass grafting (CABG) with use of either cardiopulmonary bypass (CPB) or beating heart surgery (BHS) techniques [Ricci 2000]. They reported a significantly lower incidence of stroke (0% – 0 of 97) in the BHS group compared with an incidence of 9.3% (16 of 172) in the conventional CABG group. As acknowledged by the authors, however, there are limitations to this data as presented. Importantly, these include the non-randomized nature of the CPB and BHS cohorts, the fact of two entirely different surgical teams managing the two groups, and the trend for a higher graft-to-patient ratio in CPB versus the BHS groups (3.3 vs. 1.8, respectively). Of these, the confounds associated with non-randomization and referral to different surgical groups for either conventional CABG or BHS, (i.e., doing what they do best), can be rationalized as at least ensuring that problems associated with the "learning curve" are less likely to play a significant role. The trend for differing graft-to-patient ratios between groups, however, may well be an important confound as discussed below. Additionally, the trend for a higher risk adjusted perioperative mortality rate in the BHS group compared to the CABG group, (e.g., 2.4% vs. 1.8%, respectively) is concerning. Despite these limitations, however, the most compelling data is the striking difference in stroke rate between these two elderly populations. What may account for this?

Age Associated Stroke Risk

Despite various improvements in oxygenator design, pump circuitry and the like, use of CPB for coronary revascularization continues to be associated with an intractable and unacceptably high stroke rate in high-risk groups. From a database of over 3200 patients, Gardner et al. reported a 7% stroke rate for septuagenarians operated in 1983 [Gardner 1985], while Tuman and colleagues reported a 9% stroke rate in a similar population operated on nearly a decade later [Tuman 1992]. Interestingly, Tuman et al. demonstrated convincingly that as far as cardiovascular risks, these are not age-associated. Thus the elderly high-risk patient may well survive with minimal increased risk of myocardial infarction (MI) or low cardiac output, but may well suffer a stroke. Exactly as Ricci et al. have recently reported [Ricci 2000]. Seemingly nothing has changed in the past two decades – yet nothing could be farther from the truth.

Aortic Atherosclerosis

During the intervening decades remarkable advances in intraoperative monitoring and diagnostics have enabled one of the most important mechanisms of perioperative stroke to be clearly identified – ascending aortic atherosclerosis. In a series of 221 postmortem examinations of cardiac surgical patients, Blauth et al. demonstrated that there was a direct correlation between increasing age, severe aortic atherosclerosis and presence of cerebral, renal and gut atheroemboli [Blauth 1992]. At the same time it has been repeatedly demonstrated that palpation of the aorta is grossly inadequate to detect significant atherosclerosis at sites of aortic instrumentation [Davila-Roman 1994], particularly soft "cheesy" plaque (Figure 1,) of the type that is most likely to embolize. While not commented upon in their paper, it is unlikely that any significant number of patients in either of the groups reported by Ricci et al. underwent epiaortic scanning prior to aortic instrumentation [Ricci 2000]. In fact, at the recent American Association of Thoracic Surgeons (AATS) meeting in Toronto (May 2000), an informal poll of the audience suggested that an overwhelming majority of car-

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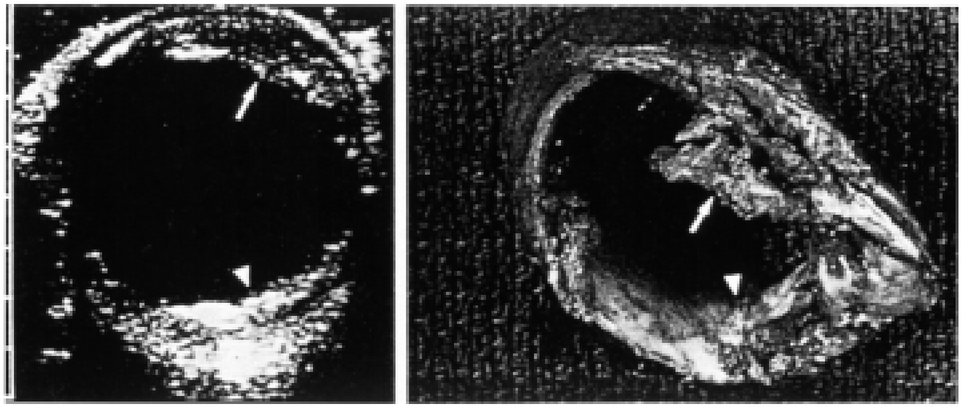

Figure 1. Image on the left is taken from an epiaortic ultrasound scan of the ascending aorta. The long white arrow indicates fraible plaque while the short arrow points to calcific atherosclerosis. An anatomical section from the same section of the ascending aorta after its excision and replacement by a graft. (Reprinted with permission: Davila-Roman VG, et al. Stroke 25:2010-6,1994.)

diac surgeons still do not employ any form of epiaortic scanning for CABG cases. Thus significant aortic atherosclerosis continues to remain undetected, hence the incidence of stroke in these high risk groups undergoing multiple coronary revascularization continues to remain at almost one in ten patients.

Stroke in OPCAB vs. CABG

While eliminating CPB may permit smaller incisions and provide more physiologic conditions, it is not clear from the literature that this always leads to improved neurologic outcomes [Murkin 2000]. In a large clinical series, Iaco et al. published a comparison of 472 off-pump coronary artery bypass (OPCAB) patients who received one to three grafts compared to 290 conventional CABG patients [Iaco 1999]. They reported that mortality rates and incidences of cerebrovascular accident (CVA) while numerically lower were not significantly different for OPCAB versus CABG (1.9% vs. 3.8%, and 0.4% vs. 1.7%, respectively) for both crude and risk-adjusted scores, with significantly fewer anastomoses per patient performed in the OPCAB compared to the CABG group (2.3 vs. 3.1). Arom et al. compared a series of 350 OPCAB patients to 3171 conventional CABG patients [Arom 2000]. Predicted risk was significantly higher for OPCAB compared with CABG (4.3% vs. 2.6%), and significantly fewer distal anastomoses were performed in OPCAB compared with the CABG group (2.1 vs. 3.2). While numerically lower, there was no significant difference in incidence of permanent stroke (1.4% vs. 2.0%) or transient ischemic attack (0.3% vs. 0.9%) between OPCAB and CABG groups. It appears as though performance of multiple grafts in BHS may not be associated with a significantly lower risk of stroke compared with conventional CABG.

Partial Aortic Clamping

Today most BHS procedures are done as multi-vessel OPCAB procedures, which employ the use of a partial aortic clamp to perform proximal anastomoses. Yet the literature has repeatedly demonstrated that clamp application and removal is the greatest source of embolic activity during surgery and that the number of cerebral emboli is closely linked to subsequent adverse neurologic outcomes. In a series of studies by Barbut et al. [Barbut 1997], over 58% of the emboli generated in cardiac surgery occur during clamp manipulation of the ascending aorta (see Movie 1,). Aldea et al. demonstrated that release of partial aortic clamp was associated with the greatest number of emboli [Aldea 1997]. While their data was obtained during CPB for CABG, a similar mechanism is likely operative during BHS, particularly since the partial aortic clamp is usually applied during maintenance of systemic mean arterial pressure (MAP). Until some method of avoiding or managing emboli is incorporated into beating heart procedures, it appears less likely that there will be significant improvements in overt neurological complications associated with multi-vessel revascularization.

Epiaortic Scanning

Unlike transesophageal echo, where overlying carinal and lung air shadows mask a significant portion of the ascending aorta, the use of epiaortic scanning provides accurate images of the ascending aortic wall and lumen and allows for optimization of cannulation and clamp sites (see Movie 2,). As shown in Figure 2 ( ), in a recent study of 102 patients in whom epiaortic scanning was performed directly after conventional aortic assessment by surgical palpation, in 23.5% of these patients, aortic scanning resulted in a change in the surgical approach for aortic instrumentation by prompting relocation of the clamp or cannulation sites (see Movie 2,) [Murkin 2000]. This was also associated with a significantly lower incidence of cerebral emboli associated with cannulation and release of aortic cross clamp and partial clamp. It is clear then that for patients in whom any form of ascending aortic manipulation and instrumentation will be undertaken, routine employment of epiaortic scanning to detect and thus avoid atherosclerotic plaque at sites of

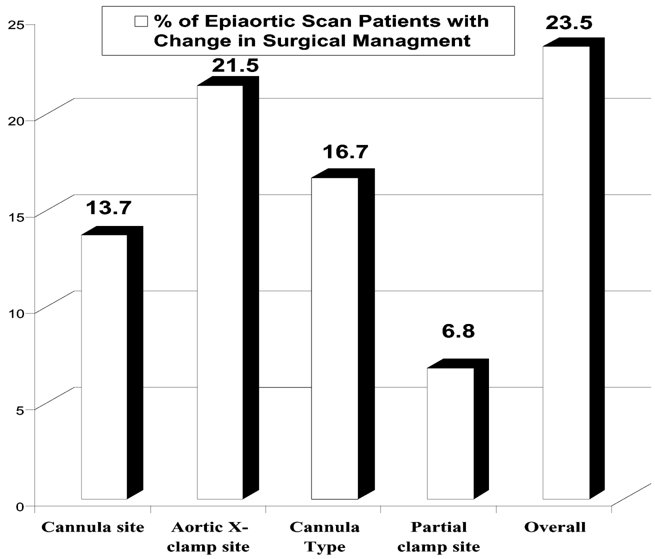

Figure 2. The percentage incidence of change in surgical management based on epiaortic ultrasound scanning prior to aortic instrumentation in 105 patients undergoing coronary artery revascularization. Aortic X-clamp refers to aortic cross-clamp. (From Murkin JM, et al, Ann Thorac Surg, in press 2000.)

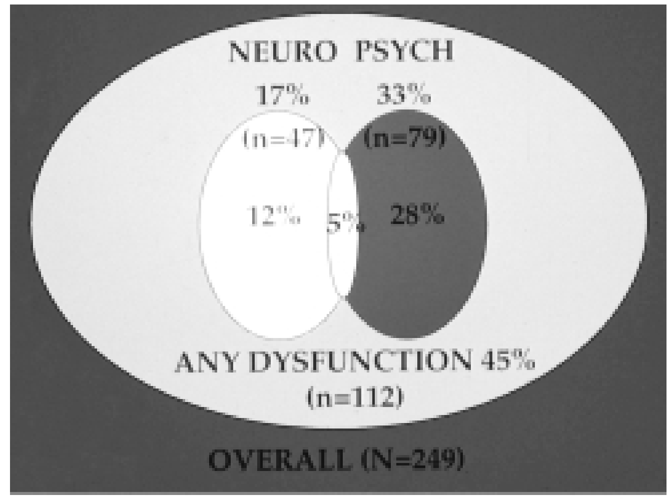

Figure 3. The incidence of central nervous system (CNS) dysfunction in 249 patients 2 months after elective coronary artery revascularization. Neuro refers to patients demonstrating new neurological signs, Psych refers to patients demonstrating cognitive dysfunction, and Any Dysfunction refers to patients experiencing either neurological or cognitive dysfunction. (From Murkin JM, et al. J Thorac Cardiovasc Surg 1995;110:349-62.)

cannulation and clamp placement would seem to be the most direct method of decreasing risk of cerebral embolization and attendant stroke.

Neurocognitive Dysfunction

Stroke is not the only form of adverse central nervous system (CNS) sequelae, however. In a landmark study, Shaw et al. prospectively examined 312 patients undergoing CABG surgery employing both a standardized neurological exam and a battery of cognitive tests administered preoperatively and at intervals of 7 days and 6 months postoperatively [Shaw 1987]. The overall stroke rate was 1.1%. However, 61% of patients manifested new neurological signs including primitive reflexes, scotoma, and areas of hypoesthesia, and fully 79% demonstrated a significant decrement in their cognitive performance at time of hospital discharge, as compared with their preoperative status. Very similar results were reported by Murkin et al. [Murkin 1995]. In a prospective study of 316 CAB patients, in which the overall stroke rate was 2.5%, 85% of patients additionally demonstrated either new neurological signs or cognitive dysfunction at 7 days postoperatively. As shown in Figure 3 (◉), at 2 months postoperatively 45% of patients manifested signs of neurobehavioural dysfunction. To date, there have been no similar large scale studies of patients undergoing beating heart surgery to compare incidences of cognitive dysfunction in this group.

Hemodynamic Changes with Beating Heart Surgery

While many of the potential mechanisms of cerebral injury may be eliminated by avoidance of CPB, that does not mean that cerebral injury does will not occur during beating heart procedures. Increased attention must be paid to the hemodynamic changes and decreases in cerebral perfusion that are seen during OPCAB, especially as greater degrees of myocardial dislocation become necessary for more extensive myocardial revascularization [Malheiros 1999]. Maneuvers such as steep Trendelenburg positioning to access the posterior coronary circulation have been shown to increase jugular venous pressure, potentially compromising cerebral blood flow through outflow obstruction, independent of whether an otherwise acceptable mean arterial pressure is maintained. When associated with significant decreases in cardiac output, whether due to arrhythmias, dislocation of the heart, subclinical ischemia or some combination of these, blood flow to the brain may be significantly compromised.

Summary

In addition to the avoidance of many of the detrimental systemic and central nervous system (CNS) effects associated with CPB [Murkin 1999], the avoidance of aortic cannulation and clamping may represent some of the most important benefits of BHS. As the trend to more extensive coronary revascularization during BHS continues, however, particularly when associated with use of an ascending aortic partial occlusion clamp for proximal anastamoses, it is predicted that the stroke rate following BHS will also rise unless some form of intraoperative aortic scanning is employed, or the ascending aorta is avoided entirely. Seen in this light, the trend for lower graft-to-patient ratio reported in the octogenarian BHS group of Ricci et al., compared to the CABG group (1.8 vs. 3.3 respectively), associated with their highly significant and dramatically lower (0%) stroke rate, may well be causally linked [Ricci 2000]. Accordingly, whether the lower stroke rate reported by Ricci et al. truly reflects avoidance of cardiopulmonary bypass, or rather it is the avoidance of aortic cannulation and clamping, remains to be seen.

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