Strategies and Devices to Minimize Stroke in Adult Cardiac Surgery

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Stroke after cardiac surgery is a devastating complication with a frequency of 1%-3% and a potential mortality risk of >20%. The approaches that one should consider to minimize the risk of stroke associated with cardiac surgery involve preoperative, intraoperative, and postoperative interventions, which are described in detail.

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PREOPERATIVE

Stroke is a truly devastating complication of all forms of cardiac surgery and occurs with an incidence of 1%-2% for coronary revascularization to nearly 3% for valvular replacement.[1] Patients at an increased risk for stroke include those with cerebrovascular or peripheral vascular disease, diabetes, renal failure, hypertension, and recent myocardial infarctions. Stroke is associated with a mortality risk of up to 22%.[2,3]

There has been guidance published for evaluation and treatment of patients who have carotid artery disease and require cardiac operative procedures. The American Heart Association and the European Society of Cardiology/European Association of Cardiothoracic Surgery have produced published guidelines for the investigation and management of carotid disease in patients undergoing cardiac surgery.[4-6] These published guidelines have recommended a therapeutic algorithm as described in the Figure.

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An additional concern, which should be addressed before surgery, is the incidental finding of significant aortic calcification noted on a preoperative chest x-ray. When this is seen, there should be a computed tomography of the chest performed with the goal of diagnosing a porcelain aorta, defined as dense circumferential calcification in the wall of the ascending aorta. In these circumstances, conventional cross-clamping of the ascending aorta cannot be safely performed, and alternative measures must be considered at the time of surgery, for example, circulatory arrest if valve surgery is required or beating-heart off-pump coronary bypass if revascularization is indicated.

Transcatheter, non–open-heart surgical techniques, may be recommended for those patients who are at high to inordinate risk for surgery. Patients requiring a mitral repair for severe mitral regurgitation may benefit from a MitraClip procedure.[7] Patients with severe aortic stenosis may be recommended for catheter-based aortic valve replacement. This approach, although fully accepted and used frequently, has been associated with a 2%-6% risk of a cerebrovascular insult.[8]

INTRAOPERATIVE

A surgeon should assess for aortic atheroma before attempting ascending aortic cannulation. It has become a standard of care for the surgeon to undertake visualization of the ascending aorta before cannulation using epiaortic ultrasound scanning.[4] Transesophageal echocardiography (TEE) is also now frequently used for this purpose, but there is normally a blind spot for TEE when scanning the ascending aorta. This may be offset by the use of new

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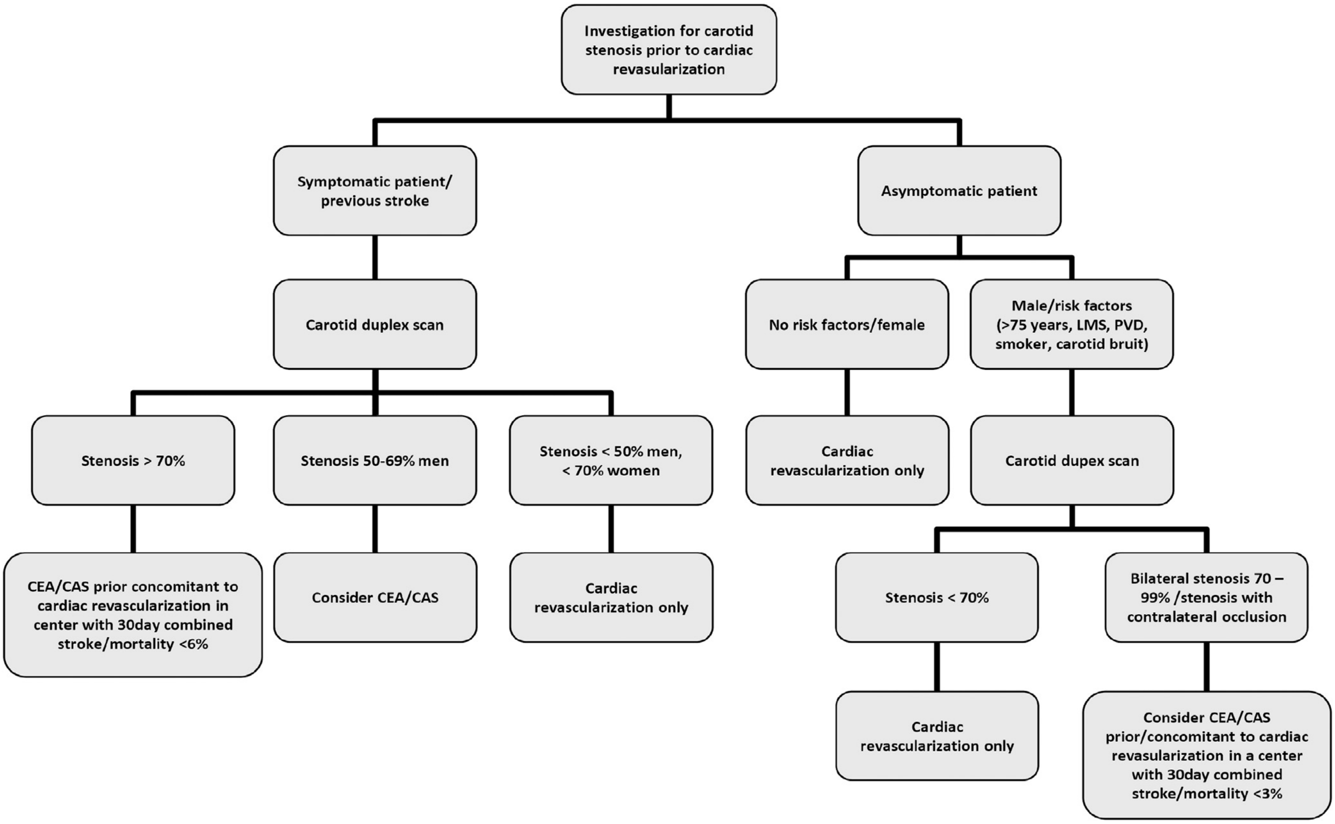

Figure. A therapeutic algorithm for how to address issues of potential carotid atherosclerosis for stroke prevention associated with coronary revascularization. (Reproduced with permission from Abah and Large.[1])

technology in the form of an A-View approach, but the published data require additional studies, and the complexity of the approach may deter its wide use.[9]

Assuming that any atherosclerotic density is noted in the ascending aorta, the surgeon should appropriately modify cannulation based on the presence of aortic atheroma. The most obvious approach to the presence of aortic atheroma is simply to avoid cannulation altogether, which then necessitates an off-pump coronary artery bypass graft (CABG). This has the published potential of reducing stroke in a population that is at a highly increased risk.[10] For patients who are unable to undergo off-pump surgery, for example, a patient requiring valvular repair or replacement, there are specifically designed aortic cannulae to reduce fluid velocity and the accompanying sandblasting effects.[11] Additionally, one could use axillary or femoral arterial inflow in the presence of a severely diseased ascending aorta.[12] If the surgeon can identify a portion of the aorta free of atherosclerosis when using epiaortic ultrasound, safe aortic cannulation can be accomplished if appropriate cannulae are used. Beating-heart, on-pump bypass can be performed if a "no-touch" technique for the aorta (to be discussed subsequently) is used.

One of the issues to be considered in any cardiopulmonary bypass (CPB) procedure is temperature management during bypass. Hypothermia is seen as protective for cerebral function during bypass, with an associated decrease in cerebral metabolism and thereby oxygen use of approximately 6%-7% with each degree centigrade decline in temperature.[13] There are many factors that are associated with hypothermia that are potentially neuroprotective. In an ischemic brain, hypothermia blocks glutamate release,[14] reduces calcium influx,[15] allows improved recovery of protein synthesis,[16] decreases membrane-bound protein kinase C activity,[17] slows onset of depolarization,[18] reduces generation of reactive oxygen species,[19] and suppresses nitric oxide synthase activity.[20] Given these generally accepted findings, one would wonder why hypothermia is not universally accepted as a routine approach for bypass. The explanation rests with the knowledge that a normothermic or mildly hypothermic heart functions better after bypass, with significantly less stunning and associated coagulopathy than when moderate or severe hypothermia is used.

It has also been well documented that a consequence of inadvertent cerebral hyperthermia is