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Neurocognitive Function Days, Weeks and Months Post Cardiopulmonary Bypass

Neurocognitive function is a major consideration in adult patients undergoing cardiac surgery. Numerous patient risk factors, as well as pre-operative neurocognitive function, can be used as indicators for risk of post-operative neurocognitive impairments.[1,2,4,5,6,7,8] Post-op delirium (POD) can also indicate poor post-operative neurocognitive function outcomes.[1] The method of assessing neurocognitive function pre-operatively, and post-operatively needs to be considered, as well as what specifically, in cardiac surgery, influences these outcomes.

Stroke, encephalopathy, and neurocognitive disorders are the causes of decline. These can lead to different classifications of outcome.[1,3] A Type I outcome is most likely associated with cardiopulmonary by-pass.[1,3] Type I consists of cerebral death, nonfatal stroke, or a new transient ischemic attack (TIA).[1,3] A Type II outcome would be intellectual decline at discharge, or new onset of seizures.[1,3]

When we asses neurocognitive function we look at visuoconstriction, language, verbal memory, attention, executive function, visual memory, motor speed, and response to stimuli. These parameters can be measured by comparing pre-operative and post-operative test results.[1,2,4,5] The Confusion Assessment Method, the Mini Mental State Exam, and the Trail Making Test, can be used in these instances. MRI and CT scan can also be used to directly examine the brain for injury. It is important to note that some test results prior to discharge from CT ICU may have fault due to pain, medications, and sleep deprivation.[1,2,4,5]

Any patient undergoing cardiopulmonary bypass (CPB), is at increased risk. Stroke risk increases 1-9% on CPB, while there is a 10-80% higher incidence of neurocognitive deficit.[1] Approximately 5-20% of patients retain these deficits 3 to 6 months post-op.[1] Long term decline occurs in 10-30% of patients.[2] Patients of advanced age show the most dramatic changes.[1,2] Prior history of neurological events, aortic and/or carotid disease, low cardiac output, atrial arrhythmias, hypertension, and diabetes also increase the risk of poor outcomes.[1]

Age alone is very important due to the increased risk of stroke. Approximately 50% of cardiac surgery-related strokes occur post-op.[1] Over the last 2 decades, patients greater than 60 years old undergoing cardiac surgical repairs requiring CPB have doubled.[1] Patients under age 60 have less than 1% stroke risk post-op.[1] The population of patients greater than 70 years old, have increased 7-fold resulting in an additional 4-9% risk of stroke or coma post op.[1.]

One study examining adult patients post-operatively, who had a history of stroke pre-operatively, showed that 44% of patients developed a neurological deficit post-op.[8] In the same study 8.5% of patients developed a new deficit, 27% had a re-appearance of an old deficit, and 8.5% showed worsening of an old deficit.[8] Of note, about 5% of patients will have an abnormal MRI pre-op with an absence of known clinical stroke.[4] This 5% is also more likely to have a new post-op deficit.[4]

Early post-op incidence of decline in neurocognitive function occurs in 35-85% of adult patients.[2] Patients who experience strokes in the first 30 days after cardiac surgery have a mortality rate upwards of 20%, compared with 2-4% for patients without stroke.[4] Transfusion of autologous blood in cardiac surgery does not completely eliminate lipid micro-emboli in blood that is eventually returned to the patient. Lipid micro-emboli can lead to an increased risk of post-op delirium, as well as TIA.[4]

POD commonly occurs in 26-52% of adult patients.[1] It is also a major indicator in neurocognitive decline during the post-op recovery period.[1] Age, depression, stroke/TIA, decreased baseline MMSE score, increased baseline serum creatinine, abnormal serum albumin, and neuro imaging findings can correlate to post-op delirium.[1,6] Despite the identification of these risk factors, the pathophysiology of POD remains unclear.[1] It is important to note that patients with Alzheimer's have an increased risk for post-op delirium, but Alzheimer's pathology begins decades prior to observable cognitive defects.[7]

In 2012, Saczynski et al[6] compared adult patients with POD versus adult patients without POD, patients with POD were typically older, female, and had lower baseline education and pre-op scores.[6] The study also measured significant Mini Mental State Exam decline on post-op day 2, but increases on days 3 -5.[6] A slow improvement was documented through the first 6 post-op months, but stabilized by 1 year without return to baseline.[6] Patients without POD had a general lower functional impairment, and returned to cognitive baseline by 1 month post-op. [6]

Arensen et al[6] assessed 1000 post-op adult ICU patients, at two different hospitals. Approximately 15% of patients tested positive for signs of delirium.[6] All patients were more than 65 years old, had post-operative stroke, mechanical ventilation greater than 24hrs, post-operative renal insufficiency, post-operative blood product administration, concomitant CABG-valve surgery, and/or pre-operative benzodiazepine use. [6]

The exposure to the CPB circuit is what is attributed as the reason for neurocognitive outcomes compared to other surgeries performed without use of the heart-lung machine (HLM).[1] One study of adult patients requiring coronary artery bypass grafting compared the outcomes of those exposed to CPB and compared their outcomes to those undergoing cardiac surgical procedures that did not utilize CPB. Patients were only included if they completed both the pre-op and post-op tests. Both groups were similar with respect to age, pre-operative neurologic and intellectual status, anesthetic methods, duration of operation, peri-operative complications, and time spent in the CT ICU. Certain potential risk factors for cerebrovascular disease were more common in the control (non-CPB) than the CPB patients.[1] The authors concluded that cardiac surgery, especially on CPB has a much higher risk of effecting neurocognitive function.[1] 55% of CABG patients had mild deterioration, compared to 31% of the surgical control.[1] 19% of CABG patients showed moderate deterioration, and 4.7% severe deterioration, when compared to the surgical control having 0% deterioration in both the moderate, and severe categories.[1]

Comparing on pump vs. off pump CABG neurocognitive outcome testing compared the effect of CPB as well. It was postulated that off pump surgery would reduce blood loss and blood transfusion, as well as reduce risk of renal dysfunction, atrial fibrillation, stroke, and neurocognitive decline.[2] The trial randomized 142 off pump versus 139 on pump CABG cases in adults.[2] Patients were assessed pre-op, 3 months post-op, and 12 months post-op in the areas of verbal and visual memory, language, visuoconstruction, psychomotor skills, and motor speed.[2] In the first 3 months post-op, 21% of patients in the off-pump category showed a cognitive decrease compared to 29% in the on-pump cohort.[2] At the 1-year mark, 31% of off pump patients had a neurocognitive decline vs. 34% of on pump patients.[2]

Neurocognitive injury in children post-op will manifest itself differently than adults, which suggests a different etiology.[1] Signs of decline or defect in pediatric patients are observed as seizures, movement disorders, or developmental delays.[1]

Neurocognitive decline after cardiac surgery is still a significant factor in a large population of patients. Screening patients properly, and using appropriate testing tools is vital, as some tests like the MMSE have a floor and ceiling effect.[7] Timing of testing can also be a factor in patient response and outcome.[7] Consideration of the patient's cognitive changes from baseline should be conducted approximately 30 days post-op due to pain, medications, anesthesia, and mechanical ventilation.[7] Development of an

intraoperative management bundle assessing all variables of the operation, with all members of the operative team, including neurology, will hopefully improve neurocognitive outcomes in the future.[7]

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