Mechanical thrombectomy for acute stroke complicating cardiac interventions

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Abstract:

INTRODUCTION: Acute ischemic stroke (AIS) complicating cardiac interventions (CI) is well described. The use of mechanical thrombectomy (MT) for treatment of emergent large vessel occlusion (ELVO) in this setting, however, is not widely reported.

METHODS: Cases of patients undergoing MT for AIS with ELVO at a single institution were reviewed. Cases preceded by recent CI were investigated retrospectively. Data was collected for patient demographics, type of cardiac intervention, stroke characteristics, neurovascular intervention, and patient outcomes.

RESULTS: Between 2008 and 2017, registry analysis identified nine patients treated with MT for AIS complicating recent CI. Patients were more commonly male with a mean age of 67 years. A large majority had a known cardiac arrhythmia. Coronary artery bypass graft surgery (CABG) was the most identified CI, followed by valve repair, and cardiac ablations. Mean presenting NIHSS was 18. Most presented with hemiplegia. Seven cases were found to have MCA occlusions. Stent-retrievers were used in 6 cases with excellent recanalization in five MCA cases (TICI 2c or 3) and in two basilar cases. Despite immediate improvements in NIHSS scores in most cases, functional outcomes were poor in 7 cases (mRS of 4-6). Three cases were complicated by hemorrhage and three cases ended in mortality.

CONCLUSION: AIS with ELVO following recent CI is associated with high rates of mortality and poor functional outcomes despite MT. Further work is needed to understand the key drivers to poor outcomes in this ELVO subgroup.

Keywords: Coronary artery bypass graft surgery, emergent large vessels occlusions, mechanical thrombectomy, stroke

Introduction

Acute ischemic stroke (AIS) complicating cardiac interventions (CI) is well described. Predisposing factors include aortic surgery, prior stroke history, advanced age, poor left ventricle function, and female gender.[1] In patients undergoing CIs complicated by stroke, high levels of mortality have been reported.[1,2] Management of these patients is further complicated by the recent use of heparinization, surgery, and other factors that preclude the use of intravenous thrombolitics. Recently, modern techniques in performing mechanical thrombectomy (MT) have dramatically changed the management of ischemic strokes presenting with emergent large vessel occlusion (ELVO).[3] The specific use of MT for treatment of ELVO in the setting of recent CI has not been widely reported, particularly in the stent-retriever era. Here we report our experience with MT in patients suffering AIS following CIs.
Methods

Institutional review board approval with a waiver for individual consent was obtained. Patients undergoing MT for AIS with ELVO at a single center between 2008 and 2017 were reviewed. Cases preceded by recent cardiac surgery or transcatheter cardiac procedures were investigated retrospectively. AIS occurred either intraoperatively or during the postoperative hospitalization period of the CI. Cases of AIS complicating CI without ELVO were not reviewed. Data was collected for patient demographics, type of CI, stroke characteristics, neurovascular intervention, and patient outcomes. A literature search was performed on PubMed and MEDLINE regarding the treatment of AIS complicating CI. Search terms included combinations of “thrombectomy” and “acute stroke,” “large-vessel occlusion,” “CI,” “cardiac surgery,” “valve replacement.” Statistical analysis was performed in GraphPad Prism (La Jolla, California).

Results

Between 2008 and 2017, registry analysis identified nine patients treated with MT for AIS complicating recent CI. Patients were largely male (n = 7) with a mean age of 67 years. A large majority had a known cardiac arrhythmia (n = 6). None of the patients had a history of prior stroke. All nine patients were fully competent in their activities of daily living before their CI with modified Rankin Scale (mRS) scores of 0. Hypertension, diabetes, and peripheral vascular disease were commonly identified comorbidities [Table 1]. CABG was the most identified CI (n = 4), followed by valve repair (n = 2), and cardiac ablations (n = 2). One-third of patients were on aspirin and a large majority received heparinization during their CI [Table 1].

Mean presenting NIHSS was 18, and in 6 of 9 cases presented with moderate to severe (NIHSS 16–20) or severe (NIHSS 21–42) symptoms at onset [Table 2]. Most patients presented with hemiplegia (n = 8). One patient who underwent cardiac pacemaker placement did receive intravenous thrombolitics after developing AIS and before undergoing MT. Catheter angiography demonstrated MCA occlusions in seven cases with most of these cases revealing occlusions within the M1 or M2 segments. The remaining two cases demonstrated occlusions of the basilar circulation. In all cases, last seen normal to puncture time was below 7 h with most cases (n = 7) achieving puncture below 4 h from last seen normal time.

In six cases, stent-retrievers were used and in all six of these cases, excellent recanalization was achieved. Thrombus aspiration was used either alone, with stent-retrievers, or with a self-expanding stent in five cases. A self-expanding stent was used in a single case [Table 3]. Overall rates of excellent recanalization were high (n = 7) with TICI 2b/c or 3 achieved in five MCA occlusion cases and successful recanalization of the basilar artery TICI 2b or 3 achieved in the two cases of vertebrobasilar occlusion. The two cases

| Table 1: Demographics and stroke | n  |
|----------------------------------|----|
| Mean age (SD)                    | 67 (8.3) |
| Male                             | 7   |
| HTN                              | 6   |
| DM                               | 4   |
| PVD/CAD                          | 6   |
| Cardiac arrhythmia               |     |
| Atrial fibrillation              | 6   |
| Aflutter                         | 2   |
| No history                       | 3   |
| Prior stroke                     | 0   |
| Unstable angina                  | 1   |
| Preoperative ejection fraction    |     |
| >60                              | 1   |
| 50-60                            | 5   |
| 40-50                            | 2   |
| Unknown                          | 2   |
| Cardiac intervention             |     |
| CABGs                            | 4   |
| Other bypass                     | 1   |
| Valve repairs                    | 2   |
| Catheterizations                 | 1   |
| Ablation                         | 2   |
| Pacemaker                        | 1   |
| Aspirin                          | 3   |
| Clopidogrel                      | 0   |
| Heparin                          | 6   |
| Time from CI to AIS              |     |
| <60 min                          | 2   |
| 1-3 h                            | 1   |
| 3-24 h                           | 1   |
| 1-3 days                         | 0   |
| 3-5 days                         | 5   |
| NIHSS at presentation            |     |
| 0-4 (minor)                      | 0   |
| 5-15 (moderate)                  | 3   |
| 16-20 (moderate to severe)       | 4   |
| 21-42 (severe)                   | 2   |
| Signs and symptoms               |     |
| Aphasia                          | 4   |
| Hemiplegia or hemiparesis        | 8   |
| Somnolent, not waking            | 3   |
| tPA given                        | 1   |
| Occlusion by angiogram           |     |
| M1                               | 4   |
| M2                               | 2   |
| M3                               | 1   |
| Basilar                          | 2   |

SD: Standard deviation, PVD: Peripheral vascular disease, CAD: Coronary artery disease, DM: Diabetes mellitus, HTN: Hypertension, CABG: Coronary artery bypass graft, AIS: Acute ischemic stroke, CI: Cardiac interventions, tPA: Tissue plasminogen activator.
of MCA occlusion achieving poor recanalization (TICI 1 or 2a) were performed before 2011.

Despite immediate improvements in NIHSS scores in most cases \((n = 7)\), functional outcomes were poor \((\text{mRS} \text{ of } 4-6)\) at the time of discharge [Table 2]. Change in NIHSS did not significantly correlate with discharge mRS \((\text{Spearman’s } r \text{ coefficient } = 0.5921; P = 0.09299)\). Three cases were complicated by post-MT intracranial hemorrhage (ICH), two were symptomatic and three mortalities occurred in the immediate post-MT hospitalization period. Two of these three mortalities involved large post-MT symptomatic ICHs associated with midline shift of at least one cm. In both cases of large post-MT ICH, MT was performed during active anticoagulation therapy. In all three cases of mortality, MT failed to improve NIHSS by more than 2 points.

**Case example**

A 69 year-old with renal impairment and chronic insulin-dependent diabetes presented with chest discomfort and shortness of breath. Workup revealed pulmonary edema secondary to a non-ST segment myocardial infarction. The patient eventually underwent quintuple coronary artery bypass graft surgery after cardiac catheterization revealed the severe multi-vessel coronary disease. Following cardiac surgery, the patient was extubated and initially did well with no arrhythmias on telemetry. On the fifth postoperative day, however, the patient collapsed to the floor when attempting to mobilize. Examination revealed unresponsiveness, left-sided hemiplegia, right-sided hemiparesis, and right-sided gaze preference. NIHSS was 25. Atrial fibrillation was noted by telemetry. Emergent diagnostic angiography revealed an occlusive thrombus at the basilar apex extending into the right posterior cerebral artery (PCA). Intravenous thrombolytics were contraindicated due to the recent cardiac surgery. The patient subsequently underwent MT using a stent-retriever deployed between the mid-basilar trunk and right PCA. Posttreatment angiography demonstrated excellent recanalization of the basilar apex and right PCA [Figure 1] 4 h and 52 min after symptom onset.

Post-MT, the patient improved neurologically, was extubated, and had an NIHSS of 9 3 days after the stroke. Post-MT imaging revealed intraventricular hemorrhage within the right temporal horn. This was managed observantly with serial scans, but complicated management of cardiac arrhythmias which were felt to require anticoagulation. After serial imaging indicated stability in the intraventricular hemorrhage, the patient was eventually started on heparin anticoagulation and would later undergo placement of a cardiac pacemaker. Due to persistent paraparesis and severe dysphagia, the patient remained bedridden and would eventually require placement of a percutaneous endoscopic gastrostomy tube. The patient was eventually discharged with ongoing needs of constant nursing care.

**Discussion**

Stroke is a well-known complication of cardiac surgeries and transcatheter cardiac procedures.\(^{1,2,4-7}\) AIS complicating CI is associated with significantly higher rates of mortality.\(^{1,2,5}\) Patients undergoing cardiac surgery, for example, were six times more likely to die if

| Table 2: Stroke intervention and outcomes |
|-----------------------------------------|
| **Last seen normal to puncture time (h)** | **n** |
| <2                                      | 3     |
| 2-3                                     | 1     |
| 3-4                                     | 3     |
| 4-7                                     | 2     |
| **Devices used**                        |       |
| Solitaire                               | 5     |
| Trevo                                   | 1     |
| Penumbra aspiration                     | 5     |
| Enterprise                              | 1     |
| **Stent-retriever used**                | 6     |
| **Intra-arterial thrombolytics used**   | 2     |
| **Groin puncture to revascularization time (min)** |       |
| <60                                     | 4     |
| 60-90                                   | 1     |
| 90-120                                  | 2     |
| >120                                    | 2     |
| **End TICI for MCA occlusions**         |       |
| TICI 1                                  | 1     |
| TICI 2a                                 | 1     |
| TICI 2b/c                               | 3     |
| TICI 3                                  | 2     |
| **Best NIHSS within 72 h of MT**        |       |
| 0-4                                     | 2     |
| 5-15                                    | 3     |
| 16-20                                   | 3     |
| 21-42                                   | 1     |
| **Immediate change in NIHSS**           |       |
| Improved >10 points                     | 1     |
| Improved 6-10 points                    | 2     |
| Improved 1-5 points                     | 4     |
| Unchanged                               | 1     |
| Worsened 1-5 points                     | 1     |
| **Hemorrhagic transformation**          | 3     |
| Mortality                               | 3     |
| **mRS at discharge**                   |       |
| 0-3                                     | 2     |
| 4-5                                     | 4     |
| 6                                       | 3     |

TICI: Thrombolysis in cerebral infarction, MCA: Middle cerebral artery, NIHSS: National Institutes of Health Stroke Scale, MT: Mechanical thrombectomy, mRS: Modified Rankin Scale
their surgery was complicated by stroke.\textsuperscript{[1,2]} While some of these patients are predisposed to mortality due to the presence of systemic comorbidities such as sepsis and low cardiac output, some patients with low preoperative risk factors demonstrate excess mortality in the setting of AIS complicating CI.\textsuperscript{[1]} Stroke, therefore, likely drives mortality in CI cases that would have otherwise been tolerated without major complication.

It is unclear what percentage of AISs complicating CIs are due to ELVOs. Many of the studies reviewing the epidemiology of AIS complicating CI are from the cardiothoracic surgery and cardiology literature and do not specify the type of ischemic stroke [Table 3]. In addition, much of this work was performed before the recognition of the ELVO concept. Intra-arterial thrombolysis for AIS complicating cardiac catheterization, for example, has been described by multiple authors.\textsuperscript{[8-12]} As reviewed by Hamon \textit{et al.},\textsuperscript{[5]} rates of successful recanalization approximated 50%. Rates of hemorrhagic conversion ranged from 14% to 25% with rates of mortality ranging from 8% to 19%.

Multiple recent randomized control trials have firmly established the efficacy of MT with stent-retrievers for the management of AIS with ELVO.\textsuperscript{[3,13-16]} Accordingly, more recent publications have described successful use of MT with stent-retrievers in four cases of AIS with ELVO complicating three cases of cardiac surgery and one case of transcatheter aortic valve implantation.\textsuperscript{[17-20]} All four patients demonstrated complete recanalization with improved clinical status.

In contrast, outcomes at discharge were largely poor in the present series. Despite excellent rates of recanalization, use of stent-retrievers in two-thirds of the cases, and post-procedure improvement in NIHSS scores in most patients, only two out of nine patients had a mRS at the discharge of 3 or less. Improvement in NIHSS generally correlates with functional improvement as measured by mRS.\textsuperscript{[21,22]} The failure of improvement in NIHSS score following MT to significantly correlate with discharge mRS may reflect the significant burden of comorbidities in this population. Despite the relative improvement in NIHSS, the surviving patients were

| Study (year) | n  | Mean age | Endovascular CI (%) | ET (%) | Successful revascularization (%) | Death (%) |
|-------------|----|----------|---------------------|--------|----------------------------------|-----------|
| Al Mubarak et al. (2002) | 8  | 72       | 63                  | 88     | 50                              | 13        |
| Zaidat \textit{et al.} (2005) | 21 | 72       | 48                  | 100    | 48                              | 19        |
| De Marco \textit{et al.} (2007) | 6  | 61       | 83                  | 66     | 50                              | 17        |
| Khatri \textit{et al.} (2008) | 12 | 72       | 83                  | 42     | 30                              | 25        |
| Arnold \textit{et al.} (2008) | 12 | 60       | 50                  | 100    | 50                              | -         |
| Salinas \textit{et al.} (2013) | 1  | 88       | 100                 | 100    | 100                             | 0         |
| Madeira \textit{et al} (2016) | 3  | 45       | 0                   | 100    | 100                             | 0         |
| Thomas \textit{et al.} (2018) | 1  | 69       | 0                   | 100    | 100                             | 0         |
| Sheriff \textit{et al.} (2018) | 6  | 59       | 0                   | 100    | 57                              | 33        |

CI: Cardiac interventions, ET: Endovascular therapy
frequently noted to have significant difficulty mobilizing and gaining functional independence in the setting of multiple comorbidities and recovery from major cardiac and neurological organ system insults and corrective interventions. In the highlighted case, for example, significant cardiac, renal, and pulmonary comorbidities combined with persistent neurologic deficits following MT resulted in a poor overall functional outcome at discharge.

Interestingly, the one patient who received intravenous tPA had the best functional outcome with an mRS of 0 at discharge, but this patient also had the lowest NIHSS on presentation and it is challenging to draw meaningful conclusions from one case. Recent work has demonstrated the efficacy of MT without IV tPA in selected patients outside the 6-h tPA window. Contraindications for tPA treatment in the remaining eight patients included recent surgery and anticoagulant therapy.

Anticoagulation therapy can significantly challenge management in these patients. Recent work has suggested that patients undergoing MT while on recent anticoagulation may have a generally higher risk of spontaneous ICH after MT. Indeed the rate of ICH following MT in this series (33%) far exceeds reported numbers from previous randomized trials (4.4%). This might reflect the preceding use of anticoagulants during cardiac procedures, challenging blood pressure management in this population, or again highlight the burden of comorbidities in these cases. In addition, initiation of anticoagulants for management of cardiac issues can be made difficult in patients who in fact develop post-MT ICH as was highlighted in the presented case example. Recent authors have argued the safety of anticoagulant therapy if no ICH is identified on a control head computed tomography 1 day after MT.

A larger and ideally prospective series is needed to determine the proportion of ELVO amongst AIS complicating CI and to better ascertain the role of preoperative risk factors in influencing functional outcomes. It is possible that different types of CI are more prone to developing ELVO as their primary mechanism of AIS and that preventative strategies could then be appropriately designed specifically to the intervention. Limitations of the study include the retrospective, single-center design as well as the small number of subjects. However, this represents the largest published experience to date studying MT treatment of ELVO complicating CI.

Conclusions

AIS with ELVO following recent CI is associated with high rates of mortality and poor functional outcomes despite MT recanalization. Further work is needed to understand the key drivers to poor outcomes in this subgroup.

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Conflicts of interest

There are no conflicts of interest.

References

1. Ananyuw AC, Filsoufi F, Salzberg SP, Bronster DJ, Adams DH. Epidemiology of stroke after cardiac surgery in the current era. J Thorac Cardiovasc Surg 2007;134:1121-7.
2. Bucerus J, Gummert JF, Borger MA, Walther T, Doll N, Onnisch JF, et al. Stroke after cardiac surgery: A risk factor analysis of 16,184 consecutive adult patients. Ann Thorac Surg 2003;75:472-8.
3. Berkhemer OA, Fransen PS, Beumer D, van den Berg LA, Lingsma HF, Yoo AJ, et al. A randomized trial of intraarterial treatment for acute ischemic stroke. N Engl J Med 2015;372:11-20.
4. Boeken U, Litmathe J, Feindt P, Gams E. Neurological complications after cardiac surgery: Risk factors and correlation to the surgical procedure. Thorac Cardiovasc Surg 2005;53:33-6.
5. Hamon M, Baron JC, Viader F, Hamon M. Periprocedural stroke and cardiac catheterization. Circulation 2008;118:678-83.
6. Stortecky S, Windecker S, Pilgrim T, Heg D, Buellesfeld L, Khattab AA, et al. Cerebrovascular accidents complicating transcatheter aortic valve implantation: Frequency, timing and impact on outcomes. EuroIntervention 2012;8:62-70.
7. Werner N, Zeymer U, Schneider S, Bauer T, Gerckens U, Linke A, et al. Incidence and clinical impact of stroke complicating transcatheter aortic valve implantation: Results from the German TAVI registry. Catheter Cardiovasc Interv 2016;88:644-53.
8. Al-Mubarak N, Vitek JJ, Mousa I, Iyer SS, Mjøiøeth S, Moses J, et al. Immediate catheter-based neurovascular rescue for acute stroke complicating coronary procedures. Am J Cardiol 2002;90:173-6.
9. Arnold M, Fischer U, Schroth G, Nedeltchev K, Isenegger J, Remonda L, et al. Intra-arterial thrombolysis of acute iatrogenic intracranial arterial occlusion attributable to neuroendovascular procedures or coronary angiography. Stroke 2008;39:1491-5.
10. De Marco F, Antonio Fernandez-Diaz J, Lefèvre T, Balecels J, Araya M, Routledge H, et al. Management of cerebrovascular accidents during cardiac catheterization. Catheter Cardiovasc Interv 2007;70:560-8.
11. Khatiri P, Taylor RA, Palumbo V, Rajajee V, Katz JM, Chalela JA, et al. The safety and efficacy of thrombolysis for strokes after cardiac catheterization. J Am Coll Cardiol 2008;51:906-11.
12. Zaidat OO, Slikvsa AP, Mohammad Y, Graffagnino C, Smith TP, Enterline DS, et al. Intra-arterial thrombolytic therapy in peri-coronary angiography ischemic stroke. Stroke 2005;36:1089-90.
13. Campbell BC, Mitchell PJ, Kleing T, Dewey HM, Churilov L, Yassi N, et al. Endovascular therapy for ischemic stroke with perfusion-imaging selection. N Engl J Med 2015;372:1009-18.
14. Goyal M, Demchuk AM, Menon BK, Eesa M, Rempel JL, Thornton J, et al. Randomized assessment of rapid endovascular treatment of ischemic stroke. N Engl J Med 2015;372:1019-30.
15. Jovin TG, Chamorro A, Cobo E, de Miquel MA, Molina CA, Rovira A, et al. Thrombectomy within 8 hours after symptom onset in ischemic stroke. N Engl J Med 2015;372:2296-306.
16. Saver JL, Goyal M, Bonafe A, Diener HC, Levy EI, Pereira VM, et al. Stent-retriever thrombectomy after intravenous t-PA vs. t-PA alone in stroke. N Engl J Med 2015;372:2285-95.
17. Madeira M, Martins C, Koukoulis G, Marques M, Reis J, Abecassis M. Mechanical thrombectomy for stroke after cardiac surgery. J Card Surg 2016;31:517-20.

18. Salinas P, Moreno R, Frutos R, Lopez-Sendon JL. Neurovascular rescue for thrombus-related embolic stroke during transcatheter aortic valve implantation. JACC Cardiovasc Interv 2013;6:981-2.

19. Thomas MC, Delgado Almazdoz JE, Todd AJ, Young ML, Fease JL, Scholz JM, et al. A case of right middle cerebral artery ‘tendonectomy’ following mitral valve replacement surgery. BMJ Case Rep 2017;2017:bcr2016012951.

20. Sheriff F, Hirsch J, Shetton K, D’Alessandro D, Stapleton C, Koch M, et al. Large-vessel occlusion stroke after cardiothoracic surgery: Expanding time windows offer new salvage opportunities. J Thorac Cardiovasc Surg 2019;158:186-96.e2.

21. Ghandehari K. Challenging comparison of stroke scales. J Res Med Sci 2013;18:906-10.

22. Saver JL, Altman H. Relationship between neurologic deficit severity and final functional outcome shifts and strengthens during first hours after onset. Stroke 2012;43:1537-41.

23. Nogueira RG, Jadhav AP, Haussen DC, Bonafo A, Budzik RF, Bhuva P, et al. Thrombectomy 6 to 24 hours after stroke with a mismatch between deficit and infarct. N Engl J Med 2018;378:11-21.

24. Černík D, Šaňák D, Divíšová P, Köcher M, Cihlář F, Zapletalová J, et al. Mechanical thrombectomy in patients with acute ischemic stroke on anticoagulation therapy. Cardiovasc Interv Radiol 2018;41:706-11.

25. Goyal M, Menon BK, van Zwan WH, Dippel DW, Mitchell PJ, Demchuk AM, et al. Endovascular thrombectomy after large-vessel ischaemic stroke: A meta-analysis of individual patient data from five randomised trials. Lancet 2016;387:1723-31.

26. Wilkinson DA, Koduri S, Anand SK, Daou BJ, Sood V, Chaudhary N, et al. Mechanical thrombectomy improves outcome for large vessel occlusion stroke after cardiac surgery. J Stroke Cerebrovasc Dis 2021;30:105851.