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Review Article

Decompressive craniotomy for malignant middle cerebral artery infarction: The quest for an African perspective

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ABSTRACT

Background: Although associated with controversy, decompressive craniotomy (DC) for malignant middle cerebral artery infarction (MMCAI) is an unequivocally lifesaving intervention. DC for MMCAI is rarely performed in lower- to middle-income countries.

Methods: A systemic review was performed in attempt to determine the rates of utilization and outcomes of DC on the African continent.

Results: Only two African studies describing DC for MMCAI were found.

Conclusion: DC for MMCAI is rarely performed and/or reported on the African continent. The African perspective for this needs to be urgently broadened.

Keywords: Resource poo, African perspective, Decompressive craniotomy, Functional outcome, Malignant middle cerebral artery infarction

INTRODUCTION

Malignant middle cerebral artery (MCA) infarction (MMCAI) is a condition characterized by rapid neurological deterioration following a large territory (≥50% of involved hemisphere) infarction of the MCA.[13,21] This deterioration is due to the development of ischemic or cytotoxic edema which acts as a space occupying lesion.[21] Untreated the condition is rapidly fatal, in approximately 80% of patients so affected, due to cerebral and ultimately cerebellar herniations.[13,17,18] MMCAI may occur in up to 10% of stroke patients.[1] The radiological demonstration of a massive infarct area alone does not invariably progress to the syndrome.

Decompressive craniotomy (DC) is a procedure in which a large portion (typically more than 12 cm) of the skull is removed and the dura is opened,[12,20] to accommodate brain swelling and edema and thus prevent the exponential elevation of intracranial pressure (ICP). In the context of malignant MCA infarction, DC is also termed decompressive hemicraniectomy. A large number of case reports suggest a significant survival benefit when performing decompressive craniotomies (particularly within 48 h of symptom onset) for patients with MMCAI and this

benefit is reflected in national guidelines.[13,18,21] The pooled data of three European randomized controlled trials of DC versus best medical management of patients with malignant MCA infarctions suggested that DC significantly improved survival but at the expense of increased numbers of survivors with moderate-to-severe disabilities as measured particularly by the modified Rankin score (mRS).[17] A similar conclusion was reached by the authors of a New England Journal of Medicine systemic review.[12]

The finding of increased survival at the expense of moderate-to-severe disability[3] is not universal. A meta-analysis of Chinese and English Literature found that DC resulted in decreased mortality and good functional outcome, with outcome assessed again using, inter alia, the mRS.[14] A 2011 study found that the rates of DC for MMCAI in the United States were increasing because of perceived benefits in both mortality and functional outcomes.[1] Indeed, DC is considered one of the four most effective acute interventions to reduce stroke related morbidity and mortality.[2,22] The American Heart and American Stoke Associations have jointly published guidelines for the performance of DC in MMCAI in patients under 60 years of age reflecting its increasing acceptance.[18]

The foregoing notwithstanding, the findings of increased survival rates of patients with moderate-to-severe disability (mRSe ≥ 3) continue to raise important ethical considerations,[11,13] particularly in low- to middle-income countries with limited resources and a high prevalence of infectious and nutrition-related disorders, particularly in the very young. For example, in 2010, infectious diseases accounted for 69% of deaths on the African continent.[7] Further, resources for comprehensive stoke care including prevention, and particularly rehabilitation, are severely limited when compared to higher income countries.[15] For these reasons, and indeed, this is our anecdotal experience, clinicians may be reluctant to offer the procedure to patients who may otherwise qualify in higher income countries.

We present a 4-case series of MMCAI with and without DC, all unique with respect to each other, and subsequently sought to determine the rate of utilization of DC for MMACI, and the outcomes thereof, on the African continent. Stated differently, an African perspective for MMCAI was sought at a time when the burden of general stroke care apears to be increasing on the African continient.[16]

CASE 1

This obtained from next of kin presented with a sudden onset of dense left-sided weakness. CT scan approximately 12 h after symptom onset showed a dense right MCA infarction but with minimal mass effect and midline shift [Figures 1 and 2]. An intraparenchymal ICP catheter was inserted. Although initially normal,the patient's intracranial pressure(ICP) rapidly increased over the next few hours resulting in cerebral herniation and brain death.

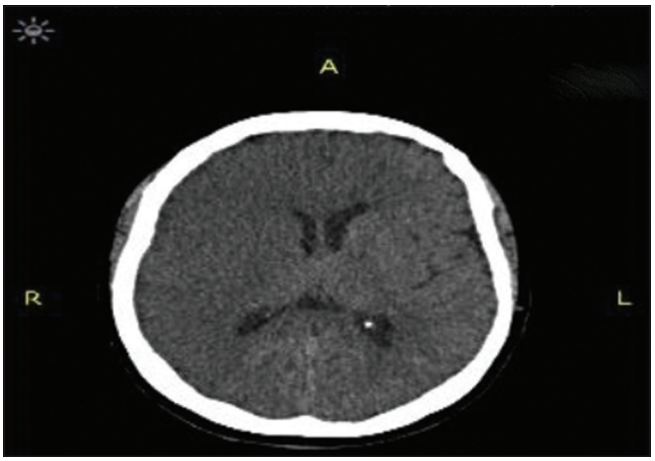

Figure 1: Massive middle cerebral artery infarct with minimal mass effect.

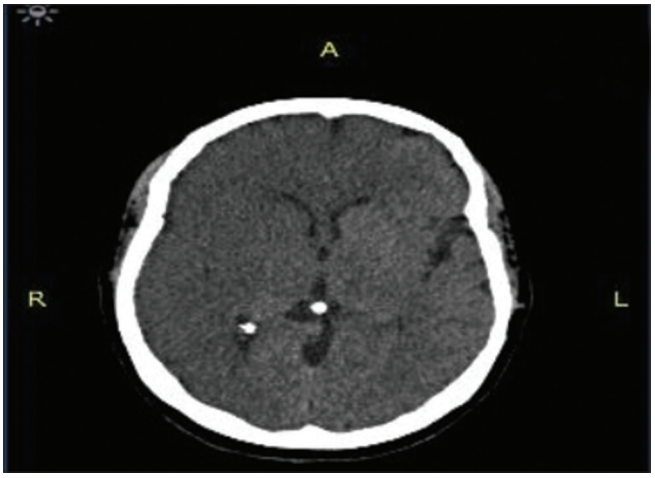

Figure 2: Massive middle cerebral artery infarct with no midline shift.

CASE 2

A 48-year-old female presented to hospital within 6 h of a sudden onset of left-sided weakness. Fully conscious on arrival the patient was given intravenous thrombolytic therapy after an initial CT scan demonstrated no areas of established infarction and no areas of hemorrhage [Figure 3].

The patient gradually becomes more confused and an MRI scan was done ~20 h later. This MRA demonstrated a massive right side MCA infarction with early midline shift and ventricular effacement [Figure 4]. The patient, with the informed consent of her husband, was taken emergently to the operating room where an emergency DC was performed. The bone flap was kept in deep freeze storage.

Figure 3: Normal initial scan.

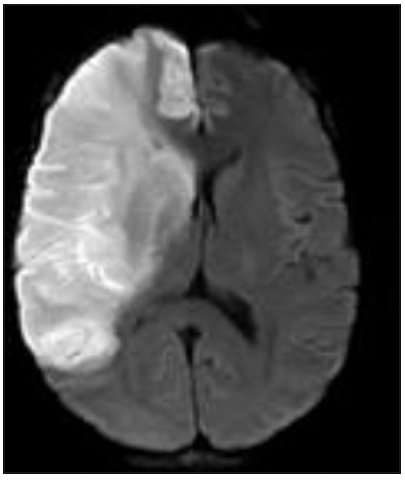

Figure 4: DWI MRI sequence demonstrating large MCA infarction with early midline shift.

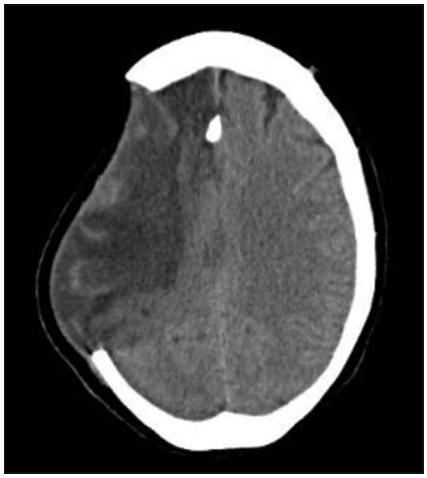

Figure 5: Resolution of brain swelling.

Figure 6: Bone replaced, right-sided gliosis.

Once the brain swelling had settled [Figure 5], the stored bone flop was replaced [Figure 6] approximately 2 months after the surgery. Although hemiplegic and confined to a wheelchair the patient was able to temporarily return to work I year later. Difficulty in transportation to work meant that she was unable to continue.

CASE 3

A 53-year-old man with multiple cardiac comorbidities was admitted to the hospital with left-sided weakness sided weakness and obtundation. CT scan demonstrated a massive right sided MCA infarction [Figure 7] with ipsilateral ventricular effacement and visible thrombus within the right MCA [Figure 8]. The patient was taken to the operating room for emergency DC but developed progressive irreversible intracranial hypertension as measured by invasive ICP monitoring. Intravenous thrombolytic therapy was not considered because of the established infarction. The patient was declared brain dead 6 days after the DC at which point his organs were harvested for transplantation. Although the patient demised, it is believed that the DC postponed fatal brain herniation allowing for successful organ harvesting and transplantation.

CASE 4

A 41-year-old male presented with sudden onset right-sided hemiplegia and aphasia, the patients Glasgow Coma Score was $11/11V_A$. CT scan done the following day showed massive left-sided MCA infarct with loss of sulcation (mass effect) but no midline shift [Figure 9]. DC was not considered because the patient's condition remained stable and because of the dominant hemisphere involvement. Repeat CT 10 days later showed near complete resolution of the mass effect [Figure 10]. This case illustrates that the progression to death

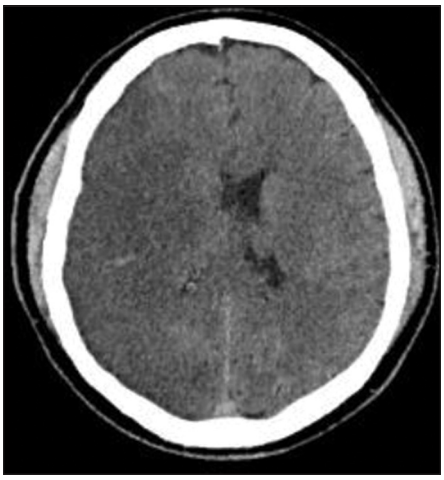

Figure 7: Massive right-sided infarction.

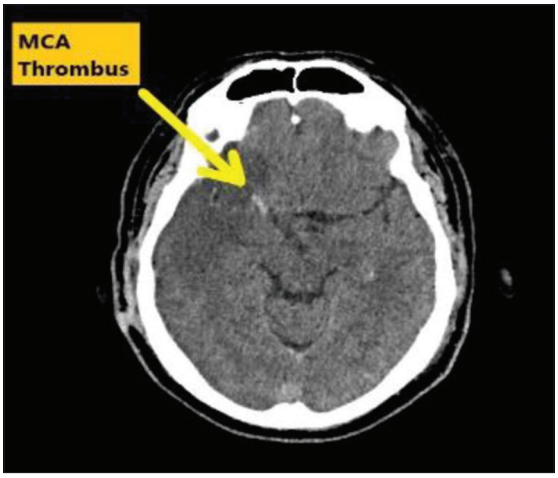

Figure 8: Thrombus in the right middle cerebral artery.

Figure 9: Massive left-sided infarction in a 41-year-old immunocompromised male.

Figure 10: Complete resolution of ventricular effacement.

following massive MCA infarction is not inevitable in the absence of surgical decompression.

SYSTEMIC REVIEW

Objective

Using the **PICOS** framework, the objectives of the review were as follows;

Patients, the identification of studies involving patients on the African continent with malignant MCA syndrome.

Interventions, patients on the African continent with MMCAI who had undergone DC.

C, the comparator to the intervention would be nonoperative treatment of malignant MCA infarction, synonyms for nonoperative treatment include medical or conservative treatment.

Outcomes, we intended to describe both patient survival rates and neurological outcomes, using the mRS for the latter.

Study design, study designs were not specified particularly because there was intended to be qualitative in nature and because an initial scouting review suggested a paucity of studies.

The review was conceptualized in accordance with the Preferred Reporting Items for Meta-Analysis and Systemic Reviews principles. The strategy involved a search of Medline (via PubMed) and Web of Science and African Journals Online (AJOL) databases.

The initial abstract search was done using the terms malignant MCA (stroke OR infraction OR syndrome) AND decompressive (craniectomy OR craniotomy OR hemicraniectomy).

The search was limited to scholarly literature published in the English language. All article types were considered for inclusion including editorials, opinion pieces, and letters to editors.

No outcome measures were specified for the abstract search.

Inclusion criteria

The following criteria were included in the study:
1. Patients with MMCAI
2. Adult patients
3. Patients with massive MCA infarction who underwent decompressive cranial surgery at any stage after the diagnosis.

Exclusion criteria

The following criteria were excluded from the study:
1. Studies not, wholly or partially, carried out on the African content
2. Studies confined to pediatric patients
3. Patients with confirmed MMCAI treated medically only
4. DC performed for cerebellar stroke or condition other than MMCAI (such as venous sinus thrombosis)
5. MMCAI patients treated with strokectomy with or without preservation of skull integrity
6. Studies not conducted on human subjects.

Study selection and data extraction

All potential studies, screened at the abstract stage by all authors, that met the inclusion criteria were imported into a reference manager to avoid duplication. A fundamental assumption of the study was that, unless specifically stated otherwise, the author affiliation was reflective of the study setting except for meta-analyses and systemic reviews.

The abstracts of all studies were analyzed for exclusion criteria and where this could be determined the study was discarded without full-text screening. Full-text screening was performed when inclusion and exclusion criteria could not be assessed by abstract screening.

To be included in the final analyses, studies had to meet all the inclusion criteria and not meet any of the exclusion criteria.

RESULTS

The database search yielded the following results:
- Web of Science: 483 results (accessed on February 21, 2021)
- PubMed: 395 results (accessed January 25, 2021)
- AJOL: 1 result (accessed January 31, 2021).

Only three studies did not meet the exclusion criteria, all originated from Egypt.

The first study was a prospective randomized study comparing delayed DC (Group 1) versus early DC (Group2) for MMCAI. In the first group, patients were only operated on once their conscious levels began to deteriorate. In the second group, surgery was performed within 6 h of MMCAI. Group 1 compromised 27 patients and Group 2 19 patients.[9] Final follow-up was at 12 months. Mortality was 52% in Group 1 and 10.5% in Group 2. Functional outcome was poor in Group 1 but significantly improved (as measured by the mRS) in Group 2. Patients with both dominant and nondominant hemisphere infarctions were included in the study.

The second noncontrolled study prospectively analyzed 24 patients who underwent DC for MMCAI and refractory intracranial hypertension over a 3-year period.[10] The authors used a standard surgical technique, storing the bone flap in a deep freeze. Again, dominant hemisphere infarction was not considered an exclusionary criterion. The case fatality rate was 33% (eight patients) and three patients died at a later stage due to infectious complications. The poor outcome rate was 33% (eight patients) and the moderate outcome was 9% at 3 months (two patients). However, at 12 months, the number of patients with a moderate outcome had increased to 16.5% (four patients).

The third study described a novel technique using glue for the fixation of skull flaps following craniotomy.[19] Among the 24 paitients undergoing surgery were 2 patients who had had previous decompressive craniotomies for MMCAI. No other detail was provided for the two patients with MMCAI.

The single article from the AJOL search was a Nigerian review article on DC focused largely on the performance of DC for trauma.[8]

DISCUSSION

Large multicenter controlled cohort studies are unlikely to be undertaken in Africa and indeed even the developed world, given the proven benefit of DC for MMCAI. Instead, case reporting such at the included illustrative cases and the two from Egypt may help guide decision-making for those who find themselves in similar contexts.

The paucity of studies of DC for MMCAI on the African continent may be reflective of the relative lack of regional stroke literature.[2,4] A 2017 systemic review of acute stroke care on the African continent yielded only four acceptable quality studies, none of which assessed DC for MMCAI.[2] It may reflect a lack of knowledge of the condition, for example, a 2017 South African follow-up survey of national contemporary neurosurgical practice did not even consider the issue of DC for MMCAI.[5] It may also be due to a lack of expertise of many hospitals to perform DC even in the more developed African countries such as South Africa.[4]

The most likely reason for the paucity of literature describing DC for MMCAI on the African continent, however, is

likely the reluctance of clinicians to offer DC to patients with MMCAI because of a pervasive perception that the procedure would lead, inevitably, to dependent and poor neurological outcomes. Das *et al*. in their meta-analysis of professional and patient views of DC for MMCAI concluded that "professionals think that surgery is not worth the high disability rate."[6] Indeed, this perception was the dominant reason for not considering DC for our illustrated patients 1 and 4. Importantly, the same Das *et al*. study[6] also found that both patients and their caregivers were satisfied with patient quality of life post-DC. African studies, similar to the Das one, are crucial to assess the regional perspectives of both patients and their caregivers, the latter whom in the African context will frequently comprise family and community members and not skilled professionals.[15] It is noteworthy, however, that the lack of trained caregivers for stroke survivors does inevitably not lead to inferior outcomes.[15]

DC for malignant MCA syndrome is an unequivocally lifesaving procedure and an essential component of modern-day stroke care.[13,18,21] Its use nevertheless continues to remain controversial despite a number of studies reporting positive outcomes with respect mortality and occasionally functional outcome.[14]

The two Egyptian studies (although neither being controlled),[9,10] and our illustrated case 2, certainly suggest that DC for MMCAI on the African continent, like elsewhere, can be a worthwhile intervention.

CONCLUSION

DC for MMCAI will continue to be performed on an individual,[22] case-by-case basis, everywhere. Nevertheless, it is important to further develop the currently lacking African body of literature, controlled, or otherwise so that these individual decisions on the African continent can be guided by locally relevant and applicable perspectives.

Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

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