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Technical notes & surgical techniques

Surgical decision-making depending solely on the radiological volume of the ischemic brain can be misleading in the management of patients with malignant stroke

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ABSTRACT

Recent studies suggest that a total ischemic brain tissue volume > 300 cm^3 observed on CT is a significant indicator of an unfavorable outcome with a sensitivity of 100% after DC in patients with malignant ischemic stroke. In this article, we reported a 61-year-old male patient with poor preoperative clinical status and most predictive factors pointed to an unfavorable outcome who nonetheless demonstrated an acceptable functional recovery after DC. On cranial computer tomography, CT angiography, and diffusion MRI, his cortical and subcortical MCA and anterior cerebral artery (ACA) vascular territories showed infarctions that extended toward the basal ganglion. The volume of the ischemic cerebral tissue was calculated using ROI (region of interest) manager tool of OsiriX® DICOM image processing software (Pixmeo SARL, Bernex, Switzerland) and found to be 411 cm^3. Decompressive craniectomy decision-making depending solely on the radiological volume of the ischemic brain can be misleading in the management of patients with malignant ischemic stroke.

1. Introduction

Occlusion of the middle cerebral artery (MCA) or its branches is the most common cause of stroke; it accounts for 90 percent of anterior circulation infarctions and two thirds of all strokes [1]. Malignant MCA infarction is a term first used in 1996 by Hacke et al to describe a large hemispheric infarction with life-threatening massive cerebral edema-involving > 50% of MCA territory or diffusion weighted imaging of ischemic lesion volume on magnetic resonance imaging (MRI) of more than 145 ml within 14 h of stroke onset [2]. Decompressive craniectomy (DC) is an emergency surgical intervention for the treatment of brain swelling and mass effect after various neurological and neurosurgical emergencies including strokes and traumatic brain injury. Recent studies suggest that a total ischemic brain tissue volume > 300 cm^3 observed on computed tomography (CT) scan is a significant indicator of an unfavorable outcome with a sensitivity of 100% after DC in patients with malignant ischemic stroke [3]. In this study, we report on a male patient who demonstrated a satisfactory functional recovery after DC despite a total ischemic brain tissue volume > 300 cm^3 observed on radiologic studies.

2. Case report

A 61-year-old, right-handed male patient was brought from a bus station to our hospital's emergency unit on July 25th, 2017 at ~16:30o'clock after he experienced sudden unconsciousness, right facial paralysis, right hemiplegia, and motor aphasia. The patient had no comorbidities, such as hypertension, diabetes, or renal failure. The patient's only stroke risk factor was his heavy cigarette use (1–2 packs/day for the past 40 years). Upon admission, his vital signs were normal: blood pressure 159/75; heart rate 64–80/min.; respiratory rate 10–23/min.; and blood oxygen saturation (SpO_2) 96% by spontaneous respiration in room air. His lipid profile examination result was high, but there were no other hematologic or biochemical test abnormalities. The patient was assessed by a neurologist in the emergency unit at 17:30o'clock and was found to have a GCS (the Glasgow Coma Scale) score of 11 and an NIHSS (The National Institutes of Health Stroke Scale) score of 19, which is in the range of moderate-to-severe stroke. At 18:00o'clock, a thrombolytic treatment with Actilyse® 6 cc as a bolus dose was injected and continued at a maintenance dose of 54 cc/h infusion while the patient was under observation in the neurology intensive care unit with spontaneous respiration in room air. Despite the

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[1] All authors contributed substantially into the manuscript (conception, collection of data, literature search, revision of the text).

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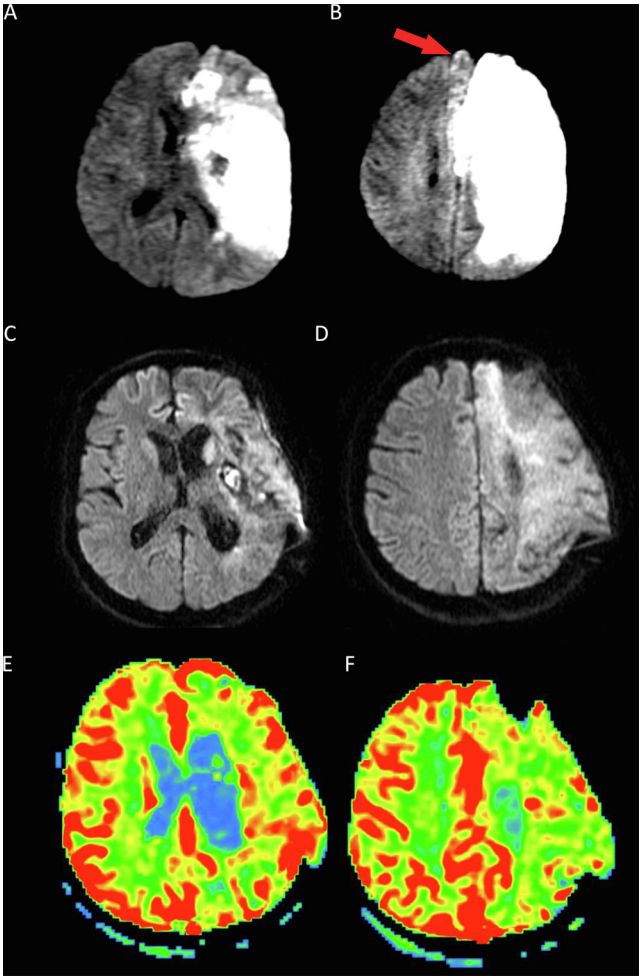

Fig. 1. A, B: Pre-operative diffusion weighted MR images. A massive left hemispheric infarction is seen. Red arrow shows ischemic cortical areas on the contralateral side. C, D: Post-operative diffusion weighted MR images. The infarction and brain shift are seen to be resolved. E, F: Post-operative perfusion weighted radiologic images, which show adequate perfusion in both cerebral hemispheres.

medical and supportive treatment (47.5 h after admission), on July 27th, 2017 at 16:00o'clock, the patient began to deteriorate neurologically, with an abnormal respiratory pattern, a decrease in his consciousness level to a GCS score of 9, and anisocoria, which were in addition to his previously found facial paralysis, aphasia, and a right-sided hemiplegia. However, his vital signs remained stable, including no fever; a heart rate of 64/min.; a blood pressure of 153/91 mm Hg; a respiratory rate of 15–21/min.; and a blood SpO_2 of 96%. At ~16:30o'clock of that same day, a repeat brain CT revealed ischemia on the left hemisphere, specifically on the blood supply territories of the left MCA and bilateral ACAs (Fig. 1A and B). Diffuse left hemisphere edema, which led to subfalcine herniation with part of the uncus leaning upon the brain stem, as well as a 9-mm brain shift were detected. At 19:20o'clock on July 27th, 2017, a diffusion MRI confirmed the same findings, with hyperintensity on the left MCA and bilateral ACA blood supply territories. The volume of the ischemic cerebral tissue was calculated using ROI (region of interest) manager tool of OsiriX® DICOM image processing software (Pixmeo SARL, Bernex, Switzerland) and found to be 411 cm^3 (Fig. 2). Meanwhile, a neurosurgery consultation was done, and the decision to perform a decompressive craniectomy was made. In summary, the time between the symptoms' onset and the hospital admission was 1–2 h; the time to clinical deterioration was ~48 h; and the time of the beginning of surgery from hospital admission was ~50 h. He underwent decompressive hemicraniectomy ~52 h after initial hospital admission. The latest CT picture before surgery showed the basal cisterns were compressed, especially the contralateral one (Fig. 3). The difference in the appearance of basal sites before and after surgery was remarkable. Postoperatively, the patient was placed in a medically-induced coma in the neurology intensive care unit. He was intubated with mechanical ventilation support and received an infusion of midazolam, prophylactic anti-epileptic drugs, and an anti-edema drug (mannitol). After the operation, the patient showed gradual improvement. We followed up the patient in both the pre- and post-operative periods via neurological examinations and radiological scans. Unfortunately, we did not have the availability of intracranial pressure monitoring systems to follow the ICP (intracranial pressure), MAP (mean arterial pressure), and CPP (cerebral perfusion pressure) at the time of this patient's management. Five days after the operation, the patient was also given dexamethasone; the delay was due to the neurologists' initial hesitation about its potential benefit in the circumstance at hand, as it is still a controversial topic in some studies. On the 9th day postoperatively, the patient had an arterial oxygen saturation of 100%, with a respiratory rate of 12–23/minute with the ventilator in spontaneous mode support. On the 10th day postoperatively, the patient was on tracheal T-Tube respiration with O_2 support. At that time, the patient's general condition and his radiological findings continued to improve. (Fig. 1C–F) On the 12th day postoperatively, the patient was still on tracheal T-Tube respiration but without the need for O_2 support; his arterial SpO_2 was 92–99%. On the 14th day postoperatively, the patient was extubated, and his saturation was 92–97 under an O_2 mask. On the 15th day postoperatively, the patient could breathe room air spontaneously, with a mean saturation of 92–96% and a mean respiratory rate of 12–29/min. Over the next few days, the patient's vital signs were stable, and he was clinically improving. On the 19th day postoperatively, the patient was discharged from the intensive care unit to the ward and bed physiotherapy was prescribed. However, there was still no prominent neurological improvement. The patient remained in the neurology unit and continued to demonstrate gradual clinical improvement, after which he was discharged from the hospital and transferred to a physiotherapy center. At the time of discharge the patient was conscious, comprehension was normal. He had dysphasia and a muscle strength grade of 3 on the Medical Research Council Manual Muscle Testing scale. A follow-up at 2.5 years post-surgery revealed that the patient was living with his family at home after having regained consciousness with good responses to stimuli and a good awareness of his environment with spontaneous respiration, but his dysphasia and right hemiparesis continued. The patient had a score of 4 on the modified Rankin scale (mRS).

3. Discussion

In this article, we reported a 61-year-old male patient with poor preoperative clinical status and most predictive factors pointed to an unfavorable outcome who nonetheless demonstrated an acceptable functional recovery after DC. In our patient, there were cerebral infarction in ACA territories bilaterally in addition to the left MCA territory infarction. The complete infarction of both MCA and ACA territories causes severe post-ischemic edema leading to raised intracranial pressure, brain herniation, clinical deterioration, coma, and death. Particularly, if there is contralateral hypoplasia of ACA or azygos type of ACA as congenital vascular variations, both the left and the right ACA territory infarction can be seen like the case of our patient.

Clinical deterioration in stroke patient is not only related to primary effect of the brain tissue infarct initiated by emboli or thrombus occlusion of vessels. The clinical condition worsening is also due to secondary events created by direct compression of patent cerebrovascular vessels (arteries or veins) by effect of increased ICP as result of brain edema and herniation. The penumbra zone, which surrounds the

Fig. 2. Pre-operative cranial DWI MRI scan with ROI (region of interest) images at the bottom. The volume of the ischemic cerebral tissue was calculated using ROI manager tool of OsiriX® DICOM image processing software (Pixmeo SARL, Bernex, Switzerland) and found to be 411 cm^3.

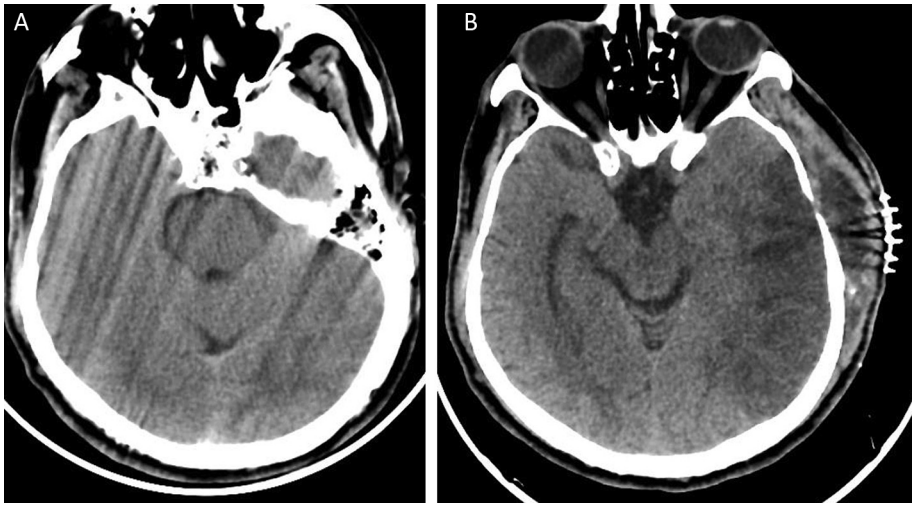

Fig. 3. A: The latest pre-operative cranial CT scan, which shows the compression of the basal cisterns. B: The early post-operative cranial CT scan, which shows that the basal cisterns were decompressed.

location of the original insult, may be spared if blood flow is restored early. We observed in our patient that postoperative cerebral perfusion regained totally in the right cerebral hemisphere and, to some extent in the left hemisphere, with subsequently a surprising improvement in the patient's clinical condition. In general, an adequate craniectomy needs to cover a large surface area, ideally beyond the margins of the infarction in all directions. The relatively favorable result in this case may have been due to good and timely assessment of the patient in the preoperative period, his proper preparation for the decompressive hemicraniectomy, and the meticulous care that was taken to protect his brain parenchyma and its vessels during surgery. The excellent teamwork among the staff who cared for him and good collaboration with the patient's family during the post-operative period would have also contributed to a relatively favorable result in this patient.

Unless emergent treatment measures are taken to reverse the edema, compression of patent brain vessels, brain tissue herniations and neural destruction, clinical deterioration, coma, and death will result. The edema and subfalcian herniation were confirmed radiologically in our patient by cranial CT, CT-angiography and MRI examinations. Herniation at the anterior part of the falx cerebri, especially at this point the falx cerebri is more widely separated from the corpus callosum where proximal branches of the ACA exhibit greater shift and compression, thereby occlusion of one or the two ACA is inevitable, the midline shift in our case was 9 mm, Many studies have indicated that midline shift is the most important factor that influences DC outcome and mortality can increase up to 61.9% in patients with midline shift of

more than 5 mm [4]. In our patient, the midline shift was 9 mm, which is typically considered an indicator of unfavorable DC outcome. In addition, there was subfalcian herniation, especially at the anterior part of the falx cerebri where it is more widely separated from the corpus callosum, where the more proximal branches of the ACA exhibit greater shift.

Finally, successful DC outcomes depend upon not only extremely abnormal radiological examination findings but also a wide variety of other factors, which need to be determined early in the patient's evaluation. These factors that include age; gender; preoperative clinical findings, timing and technics of the surgery, and potential postoperative complications [5]. Our patient's age (older than 60), late operation time (52 h post stroke), involvement of both right and left ACA infarctions in addition to MCA infarction, the severity of his clinical and radiological findings (brain shift and subfalcian herniation), and intractability to aggressive medical treatment all would seem to have predicted an unfavorable DC outcome. However, the patient still had only mild disability at the discharge from hospital. We think that unfavorable outcome predictors, including involvement of multiple cerebrovascular territories associated with MCA infarction as the case of our patient, should not be overestimated in patient selection for DC.

4. Conclusion

Decompressive craniectomy decision-making depending solely on the radiological volume of the ischemic brain can be misleading in the management of patients with malignant ischemic stroke.

CRediT authorship contribution statement

Baha Eldin Adam: Conceptualization, Writing - original draft, Data curation, Validation. **Emin Mehmet Eminoglu:** Data curation, Investigation, Writing - review & editing, Validation. **Zeynep Karaoglu:** Data curation, Validation. **Naci Balak:** Supervision, Methodology, Writing - review & editing, Validation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Ethical issues

The ethical issues for this study involving human subjects have been carefully considered in line with the Declaration of Helsinki (1964).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.inat.2020.100672.

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