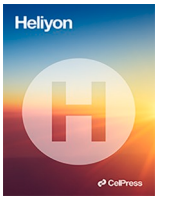
Heliyon 9 (2023) e18112

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon



Hyperacute ischemic stroke treated with carotid-carotid artery bypass surgery "case report"

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ARTICLE INFO

Keywords:
Hyperacute ischemic stroke
Carotid artery bypass
Carotid artery stenting
Tissue plasminogen activator

ABSTRACT

Thrombolytic therapy using heparin, urokinase, and tissue plasminogen activator (tPA) has been the standard treatment for hyperacute ischemic stroke (HIS) with worsening carotid artery stenosis. In recent years, endovascular treatments (thrombectomy and carotid artery stenting) have attracted attention, and neurosurgeons are increasingly participating in these treatments. A 70-year-old Japanese male presented to our hospital with aphasia and right hemiparesis. Emergency computed tomography ([CT] CT angiography and perfusion CT) revealed a small infarct core and a large hemiparesis due to occlusion near the left common carotid artery orifice. Because of hemorrhagic sequelae, tPA was not administered, and emergency endovascular treatment failed. Therefore, a bilateral common carotid artery bypass surgery was performed. Revascularization was performed within 51 min of the start of the surgery, and the time from onset to revascularization was 5 h. Aphasia and right hemiparesis resolved immediately after surgery. The only sequela observed was mild dyskinesia. Our report is the first to show that bilateral common carotid artery bypass is a novel and effective treatment for HIS.

1. Introduction

Stroke is among the most common diseases and the second cause of death worldwide. Ischemic stroke is one classification of stroke. A patient presenting within a few hours of stroke onset is categorized as hyperacute ischemic stroke (HIS). If re-perfusion of cerebral blood flow is achieved during the hyperacute phase, dramatic improvement in symptoms can be expected. Historically, thrombolytic therapy using heparin, urokinase, and tissue plasminogen activator (tPA) has been the standard treatment for HIS with worsening carotid artery stenosis. In recent years, endovascular treatments (thrombectomy and carotid artery stenting) have attracted attention, and neurosurgeons are increasingly participating in these treatments. Surgeons had little surgical involvement in the treatment of acute ischemic stroke until the establishment of endovascular treatment. However, in some cases, thrombolytic therapy is not indicated because of comorbidities or preexisting conditions, and endovascular therapy is not always successful.

To date, there have been no reports of treatment with a carotid artery bypass for HIS due to severe stenosis/occlusion of the

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https://doi.org/10.1016/j.heliyon.2023.e18112
Received 23 March 2023; Received in revised form 4 June 2023; Accepted 7 July 2023
Available online 7 July 2023

common carotid artery, and carotid artery bypass is not listed as a procedure for HIS in the stroke practice guidelines [1–3]. For internal carotid stenoses with stroke-in-evolution or crescendo transient ischemic attack the Clinical Practice Guidelines of the European Society for Vascular Surgery (ESVS) recommend carotid endarterectomy for ultra-early surgery, i.e., within 24 h (recommendation 43, class II/evidence level C) [3]. However, the endarterectomy is not effective in cases involving occluded lesions of the proximal common carotid artery and the guidelines do not include recommendations for HIS due to common carotid artery occlusion. Therefore, physicians in stroke centers do not generally consider carotid artery bypass as a treatment option. In this report, we describe a case in which carotid artery bypass was effective in the treatment of HIS with preexisting carotid artery stenosis and propose it as a new treatment for HIS.

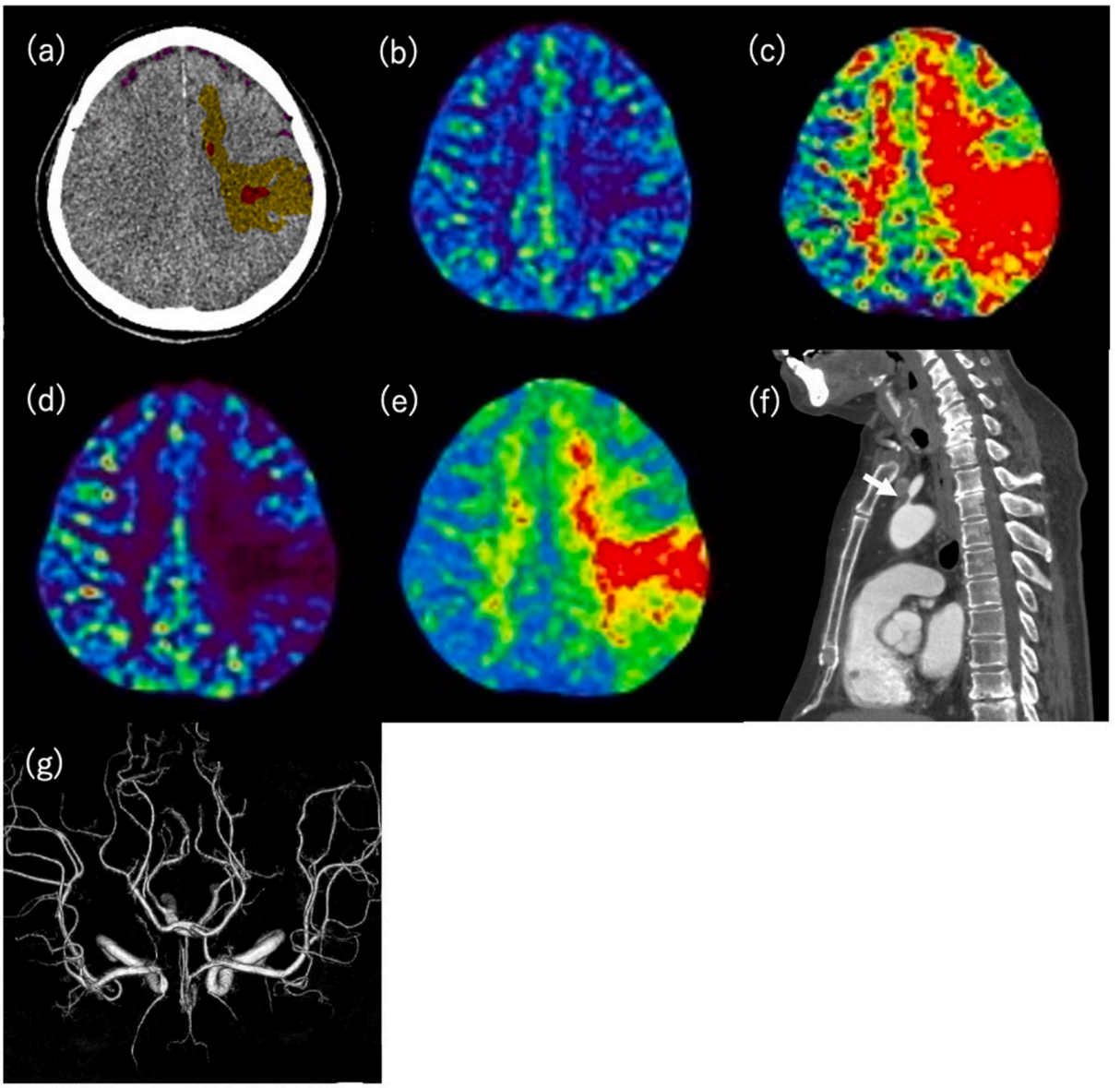

Fig. 1. Preoperative CT and MRI images. a–e: A contrast-enhanced perfusion head CT scan with a Bayesian Vitrea CT perfusion analysis reveal an infarcted area in the left cerebrum and penumbra region extending around the infarcted area. Our hospital CT perfusion setting for contralateral hemisphere thresholds are as follows: A 40% reduction in CBV (with 2.2 s increase in Tmax) indicated an infarct core, while a 2.2 s increase in Tmax (without CBV reduction) indicated a penumbra. 1a: summary map. 1b: CBV. 1c: MTT. 1d: CBF. 1e: Tmax. 1f: A contrast-enhanced CT shows a severely stenotic lesion in the orifice of the left common carotid artery before 1 year (white arrows). 1g: MRA image; the preoperative circle of Willis. CT, computed tomography; MRI, magnetic resonance imaging; CBV, cerebral blood volume; CBF, cerebral blood flow; MTT, mean transit time; MRA, magnetic resonance angiography.

2. Case presentation

A 70-year-old Japanese male was admitted to our hospital because of aphasia and right hemiparesis (National Institutes of Health Stroke Scale [NIHSS] score, 23). Emergency computed tomography ([CT], CT angiography and perfusion CT) revealed a small infarct core and a large penumbra due to occlusion near the left common carotid artery orifice (Fig. 1a–e, 1f). The circle of Willis was classified as a unilateral absent A1 in the anterior cerebral artery and an ipsilateral absent posterior communicating artery [4] (Fig. 1g). There was no stenosis/occlusion of the circle of Willis that could have caused the stroke. Moreover, there were no significant findings in the laboratory data and the electrocardiogram. Because of a history of subarachnoid hemorrhage, tPA therapy was not administered. Therefore, emergency endovascular therapy was attempted; however, the 0.035-inch wire failed to pass through the lesion (Fig. 2a). The stroke center team requested the cardiovascular surgeon to expose the left common carotid artery and place a sheath for endovascular therapy. However, the cardiovascular surgeon suggested that if the carotid artery was to be exposed, an artificial vascular bypass would be the better option to shorten the operative time to revascularization. After discussion between the stroke center team and the cardiovascular surgery team, bilateral common carotid artery crossover bypass was selected and performed on an emergency basis. The left cerebral hemisphere was revascularized 51 min after the start of surgery, and the time from onset to revascularization was 5 h. Postoperative CT angiography confirmed the patency of bilateral common carotid artery crossover bypass (Fig. 2b). Postoperative head magnetic resonance imaging confirmed salvage of the ischemic penumbra (Fig. 2c). Aphasia and right hemiparesis were relieved immediately after surgery. The only sequela was mild dyskinesia (NIHSS score, 1). No complications due to overperfusion such as cerebral hemorrhage, cerebral edema, or seizures occurred during reperfusion after carotid bypass surgery.

3. Discussion

Thrombolytic therapy has significantly contributed to the treatment of HIS. Thrombolysis with tPA has been shown to be effective, and medical treatment has become the standard treatment for HIS. Furthermore, endovascular therapy has begun to be used by neurosurgeons to a limited extent. Surgeons had little surgical involvement in the treatment of HIS until the establishment of the current treatment, and carotid artery bypass has never been reported as a treatment for patients with HIS due to common carotid artery stenosis/occlusion. To the best of our knowledge, this is the first report of carotid artery bypass surgery for HIS. Currently, stroke treatment guidelines do not include carotid artery bypass grafting for common carotid artery stenosis/occlusion in HIS. Therefore, carotid artery bypass surgery has not been considered as a treatment option for doctors in cerebral ischemia centers. Strokes caused by atherosclerotic lesions are reported to account for 29.8–31.2% [5,6] of all ischemic strokes. Strokes due to internal carotid artery stenosis/occlusion are more frequently caused by carotid artery occlusion than common carotid artery stenosis/occlusion. The rate of cerebral infarction caused by internal carotid artery occlusion (29.8%) [5] is higher than that caused by common carotid artery occlusion (2–4%) [7]. Considering the total number of stroke causes, occlusion of the common carotid artery is rare. Thus, there are few case reports, and treatment methods have not been established. Therefore common carotid artery bypass surgery is not included in the guidelines. However, in the field of cardiovascular surgery, carotid bypass surgery is a well-established procedure involving a series of thoracic endovascular aortic repairs (TEVAR) for arch aortic aneurysms [8], and cardiovascular surgeons are under the impression that carotid bypass is an effective treatment for common carotid artery stenosis/occlusion.

The time to revascularization by carotid bypass was approximately 1 h from the start of the surgery. Time required for reperfusion is the most important aspect of HIS treatment; therefore, treatments that require a shorter time are likely to be effective. During the initial consultation, doctors at the stroke center requested that a cardiovascular surgeon insert a sheath catheter for endovascular treatment, with exposure of the carotid artery. In contrast, cardiovascular surgeon being aware that the carotid artery bypass procedure is a

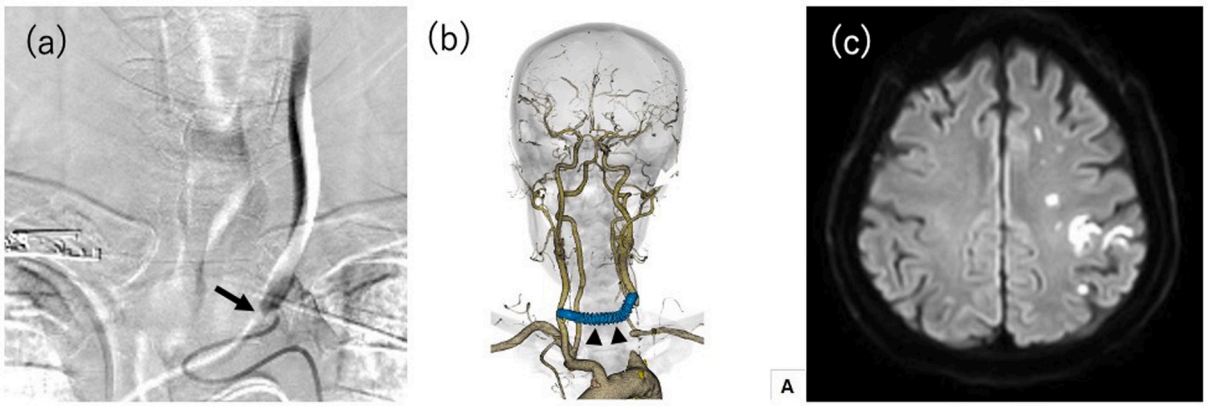

Fig. 2. Intraoperative angiography and postoperative CT & MRI images. 2a: Angiography shows a severely stenotic lesion in the orifice of the left common carotid artery (black arrow). 2b: CT angiography after carotid artery bypass surgery (posterior esophageal tunnel) (arrow heads). 2c: Postoperative head diffusion-weighted MRI showing salvation of the ischemic penumbra. CT, computed tomography; MRI, magnetic resonance imaging.

reliable treatment with a short revascularization time proposed it to the doctors at the stroke center. After discussion, we performed a carotid artery bypass surgery and confirmed its effectiveness in our case of HIS. Therefore, we propose carotid artery bypass as a new treatment option for HIS due to common carotid artery stenosis/occlusion. We believe it is important to have new concepts like carotid artery bypass surgery as an effective treatment for HIS, and we hope it will be added to national guidelines as a means of treating HIS.

4. Limitations

Although no post-revascularization hyperperfusion complications occurred after carotid artery bypass surgery in this case, we could not determine whether complications would occur in future cases as this was a study of only one case. There are still issues such as the emergence of complications caused by hyperperfusion after bypass surgery that need to be investigated in the future based on many case reports.

5. Conclusion

The carotid artery bypass surgery is effective in the treatment of HIS due to carotid artery stenosis/occlusion.

Ethics statement

The justification for this treatment and ethics in publication were discussed and approved by the ethics committee of Kagoshima City Hospital at a later date (Approval number: R4-7).

The patient provided informed consent at the pre-operation. The treatment results were informed to the patient and his family at the discharge of the patient.

Funding

None.

Data accessibility

Not applicable.

Author contribution statement

All authors listed have significantly contributed to the investigation, development and writing of this article.

Data availability statement

We do not consider it useful to release the data since it is only image data from one case treatment. Of course, if requested, we will consider providing the data after removing personal information.

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

Acknowledgements

We would like to thank Editage (www.editage.com) for English language editing.

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