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Technical Note

Intraoperative Support Using a Virtual Fluoroscopic Image in Thrombosis Recovery Treatment

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Objective: It is often difficult and has a potential risk of vessel injury to navigate a catheter or a microcatheter through the difficult types of aortic arches and through an occluded segment of the intracranial arteries under fluoroscopic guidance alone. Herein, we demonstrate a supportive technique of virtual fluoroscopic imaging from a data of non-contrast CT for a case of thrombectomy for acute occlusion of the right middle cerebral artery (MCA).

Case Presentation: An 85-year-old woman was transferred to our hospital with complaints of left-sided paralysis, dysarthria, and aphasia. CT revealed a hyperdense MCA sign, suggesting acute right MCA occlusion. CT showed bovine type of aortic arch too. Subsequently, mechanical thrombectomy was performed with the right brachial approach. A guiding catheter and a microcatheter system were successfully navigated into the target lesion under virtual fluoroscopic imaging guidance, and then thrombolysis in cerebral infarction (TICI) 3 recanalization was obtained in puncture-to-recanalization time of 37 minutes.

Conclusion: Virtual fluoroscopic images helped us to perform thrombectomy in a case of acute MCA occlusion, which provided anatomical information on the artery distal to the occlusion site, and were useful in determining the direction of the wire guidance.

Keywords cerebral thrombosis recovery therapy, intraoperative support, radiology technician

Introduction

Measures that achieve early recanalization within a short duration are recently considered useful because the time-to-recanalization in endovascular thrombectomy has effects, such as sequelae, on prognosis.[1)]

Since January 2019, we have been using virtual fluoroscopic imaging, a new navigation tool for endovascular treatment, because the images are easy to create with the data from CT and can help in the visualization of occluded arteries. Virtual fluoroscopy, which has been already used for interventional radiology for abdominal trauma, is also helpful when trying to find an obstructed approach route that cannot be seen on conventional angiography. In interventional radiology for abdominal trauma, vertical fluoroscopic images created from abdominal plain CT data help find the source of bleeding. We applied this approach to thrombectomy for acute ischemic stroke. This resulted in successful image creation, and a significant improvement was observed in terms of safety.

Furthermore, as a key point for shortening the time to vessel recanalization, we created a virtual fluoroscopic image of the shape of the aortic origin and selected the possible approach prior to the endovascular treatment. We believed that this method would be useful in cases of type III and bovine aortic arches in which the duration of the procedure is long and the outcome is often poor with the transfemoral approach because the catheter is difficult and time consuming to engage.[2–5)] We herein demonstrate the utility of intraoperative support using the virtual fluoroscopic imaging for mechanical thrombectomy in a case of acute middle cerebral artery (MCA) occlusion.

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Virtual Fluoroscopy

Virtual fluoroscopic image is a navigation tool for endovascular treatment in which images can be easily obtained by

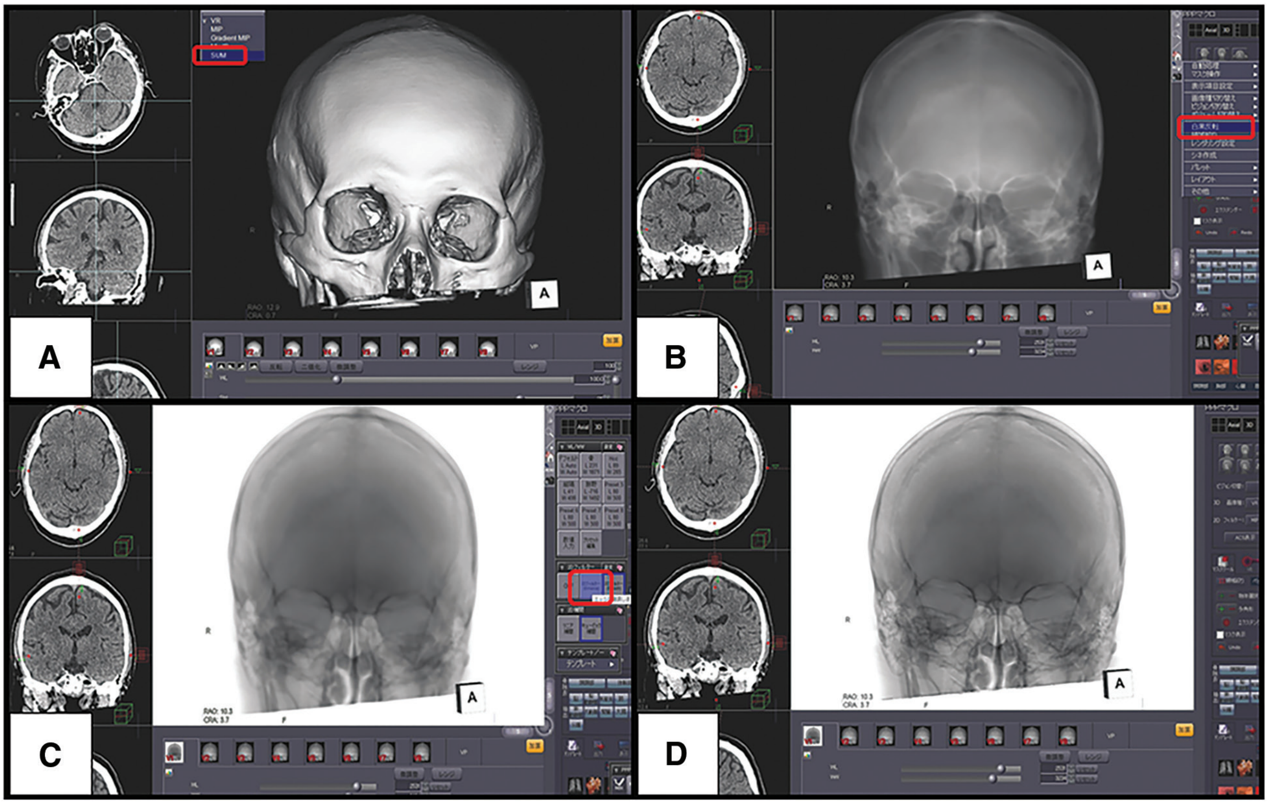

Fig. 1 (**A**) Select SUM from the list of 3D image types to create ray sum images. (**B**) From the Menu, select the black–white inversion button. (**C**) Select Edge enhance (Coeff.Dioff15) in the 2D filter and adjust the filter function. (**D**) A fluorograph-like image is created.

processing CT images at a workstation. Images were obtained using ray summation (ray sum) images from Zio station 2 (Ziosoft, Tokyo, Japan). Images obtained using a Canon Medical Aquilion 64 (Canon Medical Systems, Tochigi, Japan) system at our institution using non-contrast CT of the head, a slice thickness of 4.0 mm with a pitch factor of 0.656, and a helical pitch of 21.0, were reconstructed to a size of 0.5 mm × 0.4 mm and were loaded onto a workstation. The data were retrieved in 3D on a Zio station and were moved to create virtual fluoroscopic images.

A ray sum image was created by selecting SUM from the 3D image type list (**Fig. 1A**), performing black–white inversion (**Fig. 1B**), and applying edge enhancement 2D filter (Coeff.Dioff15) (**Fig. 1C**). Ziostation 2 has high filter processing capability and can be used to create images that closely resemble the fluoroscopic images from CT data (**Fig. 1D**). Pre-procedural planning (PPP) protocol was prepared and the installation was performed. First, one needs to select and open this protocol and the virtual fluoroscope images will automatically be created. In addition, the path creation button and image output button necessary for the analyses are placed together in a pallet to enable smooth selection. Later, there is only a need to select the vessel on the axial image in order to choose the virtual vessel and draw the path of the blood vessel moving toward the target virtual blood vessel in the virtual fluoroscopic images created. This is achieved by storing the created images and linking them to the angiography room so that they can be immediately presented on the multi-monitor. By allowing the doctor to simultaneously perform the procedure and observe the images, it is now possible to easily and quickly provide information that can support the procedure. Next, the path creation function is used to display a virtual blood vessel on the resulting virtual fluoroscopic image because blood vessel tracking, which draws the blood vessel path automatically, cannot be used for non-contrast CT data. First, the axial (AXI) screen will be displayed with the AXI image on the left side in the center. The AXI image of the shooting range is scrolled from the beginning to the end of the cutting to check the route of the target blood vessel. Once the route is understood, the path button is selected and the blood vessel originating from the proximal internal carotid artery is clicked. Approximately three images are skipped,

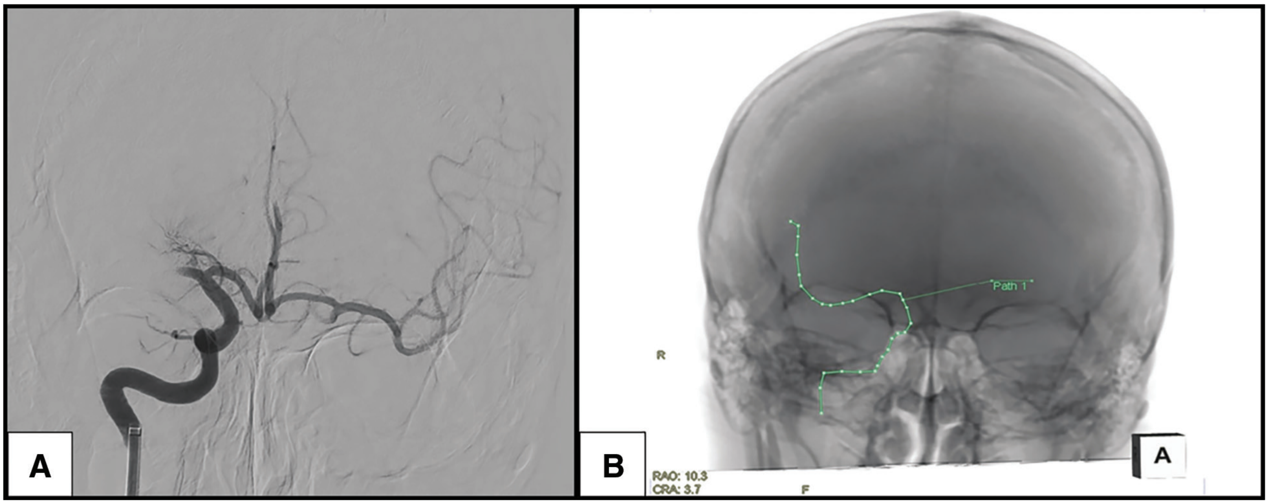

Fig. 2 (**A**) A contrast agent from the right internal carotid artery did not produce any contrast enhancement effects beyond M1 because there was a thrombus in the MCA. (**B**) By plotting the blood vessel based on the axial image, lines can be drawn beyond the thrombotic occlusion, and the vessels distal to the MCA site can be depicted. MCA: middle cerebral artery

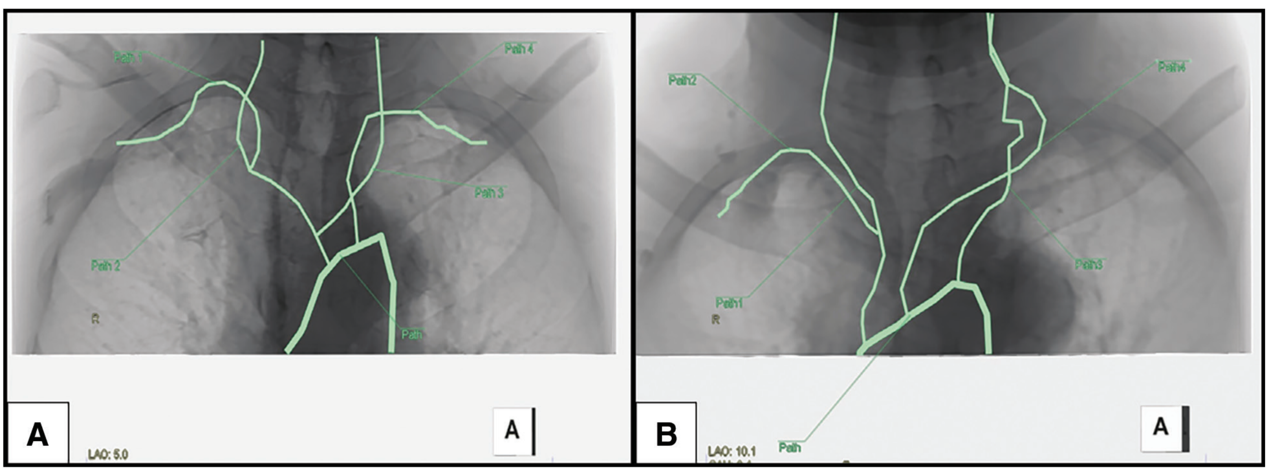

Fig. 3 (**A**) An image of a trifurcated aortic arch, termed as a bovine arch. (**B**) A pre-procedural planning image of a type III aortic arch.

and the blood vessel is clicked to connect to it. The route of the responsible blood vessel is traced toward the distal end to plot the path. The path is created along the vessel beyond the occlusion site, aiming for M2 and M3. After repeated clicks at short intervals, a blood vessel is drawn on the virtual fluoroscopic image. The blood vessel beyond M1, the site of thrombotic occlusion, cannot be visualized using angiography (**Fig. 2A**) but can be traced using non-contrast CT. Therefore, this method can be used to display the vessel route beyond the thrombotic occlusion in M1 (**Fig. 2B**). The blood vessel displayed beyond the occlusion site is used for navigating a microguidewire and microcatheter as a reference.

Accordingly, we believed that the approach site could be identified and the treatment could be smoothly performed if the aortic morphology is known in advance; thus, we prepared virtual fluoroscopic images from CT scan data of the arch according to the method described above.

While the vascular system in the arch consists of thick vessels, which cause some error in plotting, the brachiocephalic artery and common carotid artery could be visualized and bovine and type III aortic arches could be determined without any problem (**Fig. 3**).

Case Presentation

A 75-year-old woman was transported with symptoms of conscious disturbance (Japan coma scale [JCS] 3), right side paralysis, dysarthria, and aphasia.

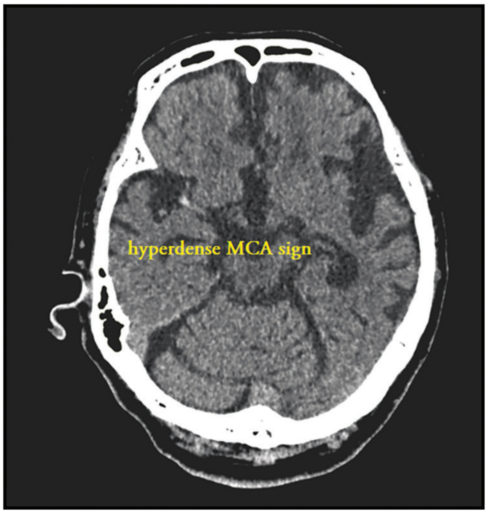

Fig. 4 Plain CT of the head showing a hyperdense sign in the right MCA. MCA: middle cerebral artery

Non-contrast CT scan of the head revealed a hyperdense MCA sign in the right MCA (**Fig. 4**). There were no other abnormal findings including early CT signs or hemorrhage, and a decision was made to perform thrombectomy based on a diagnosis of MCA occlusion. After obtaining non-contrast CT images of the aorta, the patient was moved to the angiography room where preparations, such as securing an intravenous route, were done. The doctor went to the emergency outpatient department and provided the patient's family with an explanation. During that time, the radiology technologists hurriedly prepared PPP from non-contrast CT images of the patient's head and the aorta (**Fig. 5**); this procedure was completed in approximately 10 minutes. Because the resulting PPP of the aorta indicated that it was a bovine arch, the brachial approach was chosen. OPTIMO Dilator Kit (Tokai Medical, Aichi, Japan) was used to insert OPTIMO 8Fr, which was guided to the right common carotid artery using JB2 (Silux, Saitama, Japan) as the inner catheter and Radifocus (Terumo, Tokyo, Japan) for imaging (**Fig. 6A**). CHIKAI14 (Asahi Intecc, Aichi, Japan) was selected as the microguidewire, and Marksman (Medtronic, Tokyo, Japan) and AXS Catalyst (CAT) 6 (Stryker, Tokyo, Japan) were used as the micro and aspiration catheters, respectively. The PPP of the head created by the technologists and displayed on the monitor helped in visualizing the blood vessels distal to the thrombus, which are otherwise invisible. The PPP helped to safely and smoothly guide CHIKAI and Marksman to the vessel distal to the thrombus and CAT6 to a site just proximal to the thrombus. Photographs taken using Marksman confirmed that the tip was positioned distal to the thrombus. Next, CHIKAI was removed, and Trevo 4 × 20 mm (Stryker) was introduced and expanded. Following this step, Marksman was removed by using Trevo as an anchor. Subsequently, Trevo and CAT6 were slowly pulled while aspirating the inflated OPTIMO balloon and CAT6, and the thrombus was confirmed to be in the stent. Photographs captured via OPTIMO (**Fig. 6B**) showed recanalization of thrombolysis in cerebral infarction (TICI) 3, and cone beam CT (CBCT) images acquired after the procedure did not show any bleeding. Hence, the procedure was ended.

The door to puncture time was 75 minutes, and the puncture-to-recanalization time was 37 minutes.

Discussion

Procedures performed during night hours take extra time because the staff are on call and need to arrive. We, as technologists, wanted to use this period for something useful and believed that images pertaining to the treatment made available before the thrombectomy would be helpful. The method of visualizing the blood vessels using virtual fluoroscopic images is similar to the ones reported in the field of interventional radiology for abdominal trauma. It might be applicable to create images from plain head CT data, as described in the Introduction section. As an imaging method that can be completed without using contrast agents while waiting for the on-call staff to arrive, we attempted the above method and could demonstrate the course of the unenhanced blood vessels distal to the site of the thrombotic occlusion. There are a few advantages of this technique as follows: first, virtual fluoroscopic image can be obtained within a short time (usually within 4 minutes for head area); second, it can be obtained without contrast media. High dose of contrast media may deteriorate renal function. However, if the patient moves during scanning, the images are difficult to create and image support is not possible.

This imaging allowed us to decide the site of approach in advance and smoothly perform the procedure up to the point of catheter engagement, which decreased the puncture-to-recanalization time. However, the creation of a virtual fluoroscopic image of the arch took longer (8 minutes and 30 seconds on average) than that of the head because a larger number of blood vessels had to be plotted. Moreover, we created the images only when a patient suspected of having acute cerebral infarction was brought to the hospital. Hence, we now create images regularly as part of daily training to shorten the time further. Unlike virtual

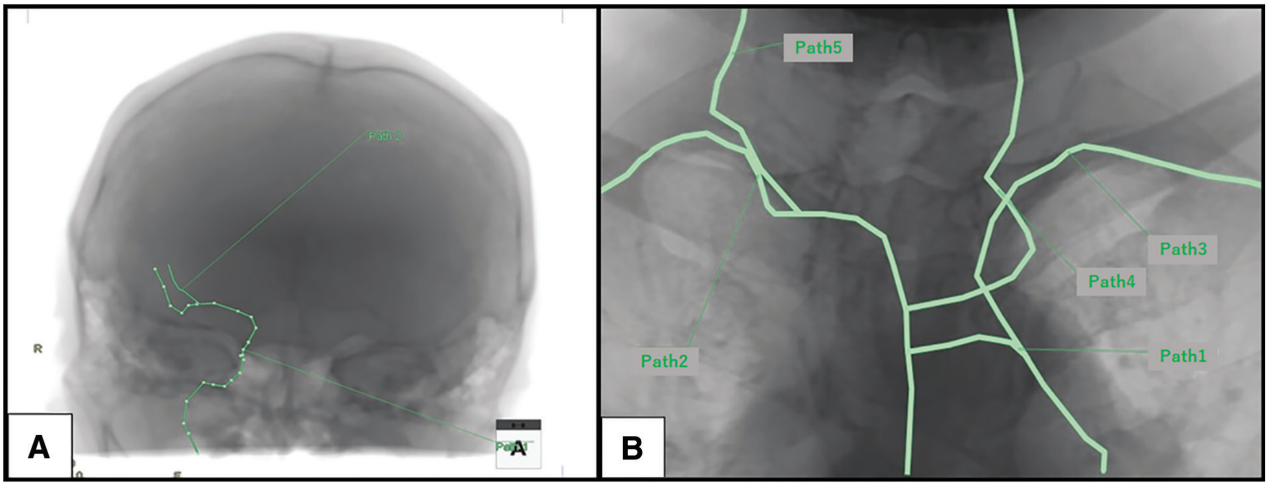

Fig. 5 (**A**) An image was reconstructed in detail after a plain head CT image and PPP were created. (**B**) The arch was found to be a bovine arch after the arch was scanned using CT, and a PPP was created. PPP: pre-procedural planning.

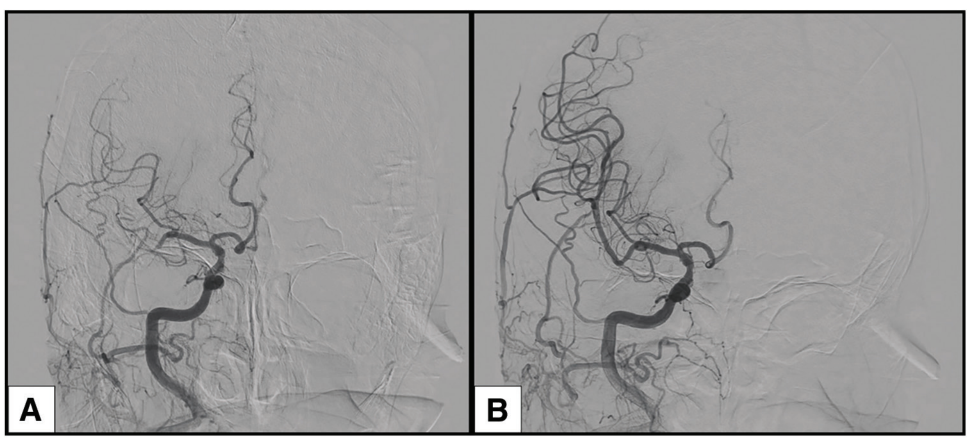

Fig. 6 (**A**) An image taken from the right common carotid artery showing obstruction in the right M1. (**B**) A contrast-enhanced image after thrombectomy showing recanalization beyond M1.

fluoroscopic images that take some time to create, coronal section images from plain CT are easier to create and allow for more accurate evaluation. However, the following advantage of virtual fluoroscopic images helped smooth catheter engagement and made this method very effective: as virtual fluoroscopic images are rotatable, images from any angle, including lateral, oblique, and frontal views, can be displayed to check the catheter engagement with the target blood vessel.

Of the several methods available to shorten the time-to-recanalization in thrombectomy, we focused on the puncture-to-recanalization time in this study. We felt that the use of virtual fluoroscopy images to identify the puncture site prior to the treatment is an effective technique to complete the procedure within a short period of time.

There are some institutions where contrast-enhanced CT routinely perform before acute ischemic stroke (AIS) treatment. Whole-body contrast-enhanced CT can provide exact information about the access route from the femoral artery to the carotid artery. However, access route beyond the occlusion site cannot be visualized by the original CT image alone or CT angiography.Virtual visual imaging, a minimally invasive examination method that does not require contrast media and minimizes radiation exposure, is very useful in institutions that do not use contrast CT routinely.

Conclusion

Virtual fluoroscopic images were easily created and may contribute to the safe procedure.

Ethical Approval

The research within our submission has been approved by the Ethical Review Committee of Higashi-Totsuka Memorial Hospital.

Disclosure Statement

All authors have no conflicts of interest to disclose in relation to this study.

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