Utility of intraoperative diagnostic C-arm angiography for management of high grade subarachnoid hemorrhage

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Abstract

The accurate and efficient localization of underlying vascular lesions is crucial for prompt and definitive treatment of subarachnoid hemorrhage (SAH). To demonstrate the utility and feasibility of intraoperative C-arm angiography in cerebrovascular emergencies, we report five cases of high grade SAH and/or intracerebral hemorrhage (ICH) where intraoperative diagnostic C-arm angiography was safely and effectively utilized. Initial evaluations of all patients included a non-contrast head CT scan, which was followed by urgent decompressive hemicraniectomy as a life-saving measure in the presence of markedly elevated intracranial pressure. Further diagnostic evaluations were performed intraoperatively using a multi-purpose C-arm angiography system. The C-arm angiography findings greatly aided the intraoperative planning and led to definitive treatments in four cases of SAH by elucidating the underlying neurovascular lesions. With this treatment strategy, two of the patients made moderately good recoveries from their SAH and/or ICH with a Glasgow outcome score (GOS) of 4. Three of the patients expired despite maximal therapy mostly due to unfavorable presenting grade. These results suggest that C-arm angiography is a reasonable diagnostic and surgical planning tool for selected patients with high grade diffuse SAH who require immediate decompression.

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Introduction

Subarachnoid hemorrhage (SAH) is an acute cerebrovascular event with an overall incidence of 8–11 per 100,000 person-years and a mortality of ~33% among in-hospital patients in the US [1]. Accurate and efficient localization of underlying vascular lesions is crucial for prompt treatment of SAH. Digital subtraction angiography (DSA) is the gold standard in the diagnosis of vascular lesions in SAH. However, DSA may be limited by time constraints during the acute management of critically ill patients with high grade SAH. Recently the use of computed tomography angiography (CTA) in the management of SAH patients has been reported [2]. Although CTA has a shorter acquisition time, it has less sensitivity in the detection of small aneurysms (<5 mm) or aneurysms at certain locations [3]. Here we report the utility of intraoperative C-arm angiography in the urgent management of five critically ill patients with high grade SAH. These cases suggest that C-arm angiography is useful in identifying vascular pathology intraoperatively in acutely unstable SAH patients.

Clinical presentation

Case 1

A 42-year old woman with hypertension was found unresponsive after a fall. Generalized tonic-clonic seizures were noted in the emergency room (ER) with a dilated left pupil and extensor posturing. A head CT showed diffuse SAH and a left temporal intracerebral hemorrhage (ICH) with intraventricular hemorrhage (IVH) (Fig. 1A). The patient received an emergent left-sided decompressive hemi-craniectomy. Following the decompression, an intraoperative C-arm angiogram (ARCADIS Varic system, manufactured by Siemens Medical Solutions USA, Malvern, PA, USA) was performed through the right femoral artery puncture and catheterization of left and right common carotid and vertebral arteries. This demonstrated a bilobed left MCA bifurcation aneurysm measuring 3 mm (Fig. 1B). Subsequently, two small aneurysms, 3 mm each, were identified at the MCA bifurcation and were clipped. After confirming the patency of the MCA branches with indocyanine green (ICG) videoangiography [4], a dural substitute onlay graft was placed without the bone flap due to severe cerebral edema. A complete DSA angiogram confirmed obliteration of the MCA
Aneurysm on postoperative day 1 (Fig. 1C and D). At one year, the patient has a right hemiparesis but requires minimal assistance with activities of daily living (Table 1).

Case 2

A 23-year-old woman with a history of prescription drug abuse experienced a syncopal event. She was found to have a Glasgow Coma Score (GCS) of 3, pinpoint pupils, and decorticate posturing in ER. A head CT showed diffuse SAH with extensive right sylvian fissure ICH, IVH in the fourth ventricle, and diffuse cerebral edema. She then received an emergent decompressive hemicraniectomy. An intraoperative C-arm angiography was performed, and a small, Spetzler Martin grade I AVM nidus fed by MCA branches was visualized in the insular region with drainage into the vein of Labbe (Fig. 2A). ICH evacuation then proceeded in the temporal lobe and a temporal lobectomy was performed. Dura-Guard was then placed as an onlay graft and the skin closed. Postoperatively, the patient’s neurological exam remained poor. She expired after a 2-month hospital stay.

Case 3

A 23-year-old male awoke in the morning with diaphoresis and several episodes of vomiting followed by a fall and loss of consciousness. In the ER, SAH with a large temporal ICH was identified on a head CT. The patient underwent an emergent left decompressive hemicraniectomy and ICH evacuation. The intraoperative C-arm angiography failed to demonstrate any aneurysms, AVMs, or fistulas (Fig. 2B). A repeat angiogram 3 days later revealed a partially thrombosed left giant fusiform MCA aneurysm, and the patient underwent surgical trapping of the aneurysm. Postoperatively, his condition improved significantly. At 1 month after the surgery, his neurological exam was mostly benign except left sided ptosis and blurry vision.

Case 4

A 47-year-old woman with a history of cigarette smoking and heavy alcohol use was found unresponsive. On exam, she had GCS 3 T, dilated nonreactive pupils, and minimal cough and gag reflexes. A head CT demonstrated massive left hemispheric subdural hematoma (SDH)

Fig. 1. Imaging studies for case 1. (A) The initial computed tomography (CT) scan showing a left temporal intracerebral hemorrhage (ICH) in coronal view, diffuse subarachnoid hemorrhage (SAH), and intraventricular hemorrhage (IVH). (B) The intraoperative diagnostic C-arm angiography demonstrating a bilobed aneurysm at the left middle cerebral artery (MCA) bifurcation, as indicated by the arrow in left anteroposterior view. (C) The post-operative digital subtraction angiography (DSA) (obtained with biplanar angiography 1 day postoperatively) showing the two aneurysm clips in anteroposterior view. (D) The subtracted view of post-operative catheter angiography (1 day postoperative) demonstrating no filling of the aneurysm, as indicated by the arrow in anteroposterior view.
with a 4 cm left temporal ICH and IVH. She received an emergent decompressive hemicraniectomy and evacuation of the SDH. An intraoperative C-arm angiogram demonstrated a left 7 mm MCA bifurcation aneurysm (Fig. 2C). Evacuation of the temporal hematoma and partial anterior temporal lobectomy were performed to prepare for the sylvian fissure dissection with subsequent aneurysm clipping. Patency of the distal MCA branches was demonstrated on intraoperative angiogram. Unfortunately, on post-operative day 1, she demonstrated trace brainstem reflexes and developed coagulopathy. She expired two weeks postoperatively.

Case 5

A 43-year old woman with a history of hypertension, IV drug use, and cigarette smoking experienced a sudden onset of headache. She then had a seizure and became unresponsive. On arrival to our institution, she had dilated pupils with minimal brainstem reflexes and a GCS of 3 T. A head CT demonstrated a large left frontotemporal ICH, extensive SAH, and IVH. She underwent an emergent decompressive hemicraniectomy. An intraoperative C-arm angiogram demonstrated a 6 mm left laterally projecting MCA bifurcation aneurysm (Fig. 2D). A corticectomy was performed in the anterior superior temporal gyrus to evacuate the ICH. The aneurysm was clipped utilizing temporary arterial occlusion of the distal M1. Patency of the distal MCA branches with aneurysm obliteration was demonstrated on a second intraoperative angiogram. Postoperatively, the patient continued to have a poor neurological examination with cardiopulmonary failure despite maximal medical therapy. She expired two weeks postoperatively.

Discussion

Fast and accurate localization of underlying vascular abnormalities is paramount in the preoperative workup for SAH patients. While DSA is the gold standard for aneurysm detection, a number of studies have documented the role of CTA as an adjunct or alternative method to DSA in the acute management of SAH patients [2]. In a recent meta-analysis, Menke et al. [2] concluded that CTA had an overall sensitivity of 97.2% and specificity of 97.9% in aneurysm detection. Further, the application of multisection CT scanner such as 64-section scanner has enabled 3D reconstruction with further shortened acquisition time [5]. Such findings have led to the practice where only CTA was used for pre-surgical planning in SAH cases [6].

However, replacing DSA with CTA in preoperative workup of SAH has not been straightforward. While the multisection CTA has excellent efficacy in identifying perimesencephalic bleed of SAH, it has higher false negative rate for diffuse aneurysmal SAH [7]. Also, aneurysms near the skull base, Pcom aneurysms, and small aneurysms are still more likely to be associated diagnostic errors with CTA, and these errors are operator rather than scanner-dependent [3]. Finally, the accuracy of CTA may be lower than previously reported [8].

In light of the challenges in the management of high grade SAH patients, our experience suggests that intraoperative C-arm angiography may provide a valuable strategy for the diagnostic workup of critically ill SAH patients with diffuse aneurysmal SAH. The use of intraoperative C-arm angiography in patients with high grade SAH decreased the time interval between the diagnostic imaging and urgent decompressive hemicraniectomy. It also facilitated intraoperative planning without a delayed standard biplane DSA.
The diagnostic power of the intraoperative C-arm angiography is greatest when the laterality of the lesion is clearly demonstrated on the preoperative CT scan, as in case 1, where a left temporal hematoma was first visualized on the non-contrasted CT scan (Fig. 1A). However, in cases where the laterality of the lesion is ambiguous from the initial scan, the diagnostic and imaging quality of the intraoperative C-arm angiography can be compromised. This could be due to relatively restricted imaging angle, reduced resolution, and single plane imaging mode of the C-arm angiography compared to a standard biplane DSA. These factors may have contributed to the negative intraoperative diagnostic findings in case 3. If the patient were sufficiently stable, a repeat standard DSA would be utilized to delineate the anatomy of the underlying pathology and facilitate surgical planning and treatments.

Of note, Ayuzawa et al. [9] previously reported using intraoperative portable DSA in an emergent aneurysm surgery without preoperative angiography. Our study extended the applicability of such a strategy to critically ill patients with space-occupying hematomas caused by different cerebrovascular lesions such as aneurysms and AVMs. Further, this strategy of C-arm angiography is valuable and practicable especially considering the limited availability of hybrid operating rooms with both endovascular and microsurgical capabilities.

Conclusion

C-arm angiography is valuable in identifying vascular lesions intraoperatively to allow expedited decompressive procedures for high grade SAH. C-arm angiography combines the anatomical details attainable with DSA with a shortened acquisition time. These characteristics make it a reasonable alternative to CTA or standard biplane DSA in unstable patients with diffuse SAH when immediate surgical decompression is warranted. Due to the small number of patients in which this management algorithm has been utilized, it remains unclear whether this approach has any impact on the outcome for patients with high grade SAH. Further examination of more selected patients is necessary to elucidate any potential improvements this method may have on patient outcome.
References


