Novel Minimally Invasive Treatment Strategy for Acute Traumatic Epidural Hematoma: Endovascular Embolization Combined with Drainage Surgery and Use of Urokinase

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BACKGROUND: **Hematoma evacuation is regular treatment for acute traumatic epidural hematoma (ATEDH) patients meeting with surgery indications. However, it is an invasive approach performed under general anesthesia. Here, a novel minimally invasive method of endovascular embolization with subsequent drainage surgery and use of urokinase was established to treat ATEDH under local anesthesia.**

METHODS: **A novel minimally invasive method of endovascular embolization with subsequent drainage surgery and use of urokinase was established to treat ATEDH under local anesthesia. Firstly, 23 ATEDH patients with hematomas in the temporal area underwent digital subtraction angiography detecting the bleeding point. Next, embolization was performed. After embolization, drainage surgery was taken and urokinase was injected into the hematoma cyst by drainage tube to lyse hematoma twice per day.**

RESULTS: **The results showed that the middle meningeal artery was the bleeding source. Embolization immediately ceased bleeding. Most clots were resolved and drained after treatment. No recurrence of hematoma or infection was observed.**

CONCLUSION: **The findings suggest that the combined treatments can be an alternative minimally invasive option for ATEDHs, especially for elderly patients or those contraindicated for general anesthesia.**

INTRODUCTION

Epidural hematomas (EDHs) occur in 1%–2% hospitalized patients with traumatic brain injury and account for 5%–15% of all fatal head injuries.[1] About 70% hematomas occur in the lateral hemisphere at the epicenter of pterion. Arterial bleeding is responsible for 85% hematomas. The middle meningeal artery (MMA) is the most common source of middle fossa EDHs. Emergency surgery for hematoma evacuation is the standard therapy to prevent death or neurologic morbidity for those without surgical contraindications. Although craniotomy can provide a more complete hematoma evacuation, it is also a more invasive approach[2] and not suitable for those who cannot be performed with general anesthesia. It is reported that angiography followed by endovascular intervention can treat the epidural hematoma.[3-5] Some studies have demonstrated that burr hole evacuation followed by drainage is an effective method for emergency management of traumatic EDHs.[6-8]

This article reports our experience with a combination of endovascular treatment and burr hole drainage with additional urokinase to resolve the hematoma as a novel treatment strategy for the management of EDHs, especially those with an obvious occupying mass effect. It will provide an alternative approach for patients who are contraindicated for general anesthesia. To the best of our knowledge, no published study has been reported concerning such a combination treatment method.

METHODS

Patients

A prospective review was made of 23 patients (14 men and 9 women; mean age 42 years, range 15–53 years) who were admitted

Key words
- Drainage surgery
- Embolization
- Endovascular treatment
- Epidural hematoma

Abbreviations and Acronyms
CT: Computed tomography
EDH: Epidural hematomas
GCS: Glasgow Coma Scale
MMA: Middle meningeal artery

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to our emergency department between 1 January, 2015 and 31 December, 2016. The traumatogenic factors were classified as traffic accidents in 13 cases, accidental falls in 4 cases, and impact by falling subjects in 6 cases. The Glasgow Coma Scale (GCS) on admission was higher than 12 in 11 patients and 8–12 in the remaining 12 patients. The most frequent symptoms were headache and vomiting. The mean time from trauma to patient admission to our emergency center was <12 ± 6 hours. The interval time between the injury and surgery was <2 hours.

Computed tomography (CT) scan on admission showed the following: the site of hematoma in the temporal area in 8 cases, frontotemporal area in 9 cases, and temporoparietal area in 6 cases; the volume of hematoma ranging from 22–46 mL (mean 32.5 ± 15.1 mL); midline shift of the brain <10 mm in 18 patients; 10–15 mm in 5 patients; coexistence of linear fracture in 6 cases and comminuted fracture in 5 patients; and no other additional intracranial lesion.

Our study was approved by the Institutional Review Board of the hospital, and written informed consent was obtained from all patients. There was no commercial involvement in the study including design, conduct, or analysis.

Procedures

A quick head CT scan was performed on admission of each patient in the emergency department. Digital subtraction angiography was then conducted under local anesthesia with sedation. High-resolution digital fluoroscopy (Artis zee Biplane, Siemens AG, Germany) with biplane road-mapping capability was used. A 4-French angiocatheter with a 0.035-inch inner diameter was used when angiography began, and it can also be used as a guiding catheter for the microcatheter. Bilateral angiography was selectively performed including the common, internal, and external carotid arteries. In all cases, angiography demonstrated the active extravasation from the MMA, indicating the presence of active bleeding from the MMA. The bleeding point was embolized by advancing the catheter to the bleeding point with Gelfoam particles (Hangzhou Alicon Pharm Sci&Tec, Linan, China; diameter: 350–560 μm, **Figure 1**). Then a burr hole evacuation and drainage surgery were performed in the operating room under local anesthesia. The burr hole was made in the center of the hematoma guided by CT scanning images. The hematoma was sucked with a soft-tipped aspirator in all directions. A drainage tube was implanted into the hematoma cyst to aspirate some clots. Urokinase (20 ku resolved in 3-mL saline) was injected into the hematoma cyst through the tube with the tube kept closed for 3 hours before connecting it to the negative-pressure vacuum ball. The wound was closed in layers. After completion of the operation, urokinase was repeatedly injected into the hematoma cyst twice a day, and CT scan was performed 3 days after injection of urokinase or according to changes of the clinical manifestations in individual patients. The drainage tube was removed when the drain fluid became yellow and most clots had disappeared as shown by CT scans.

Data about the procedural and clinical outcomes, procedure-related complications, and patient survival were obtained from the medical records of the patients.

Statistical Analysis

Data were analyzed using the SPSS 13.0 edition. A Student's t-test was performed to compares changes in hematoma volume before surgery and after removal of the drain tube, GCS score at the time of admission and discharge, and Glasgow Outcome Scale–Extended score at the time of discharge and at 6-month follow-up.

RESULTS

The MMA was discovered as the corresponding meningeal artery in all 23 patients in our series. After embolization, bleeding was stopped immediately without complications. The mean time for angiography and embolization was 42.3 ± 8.2 minutes (range 25–50 minutes). The operation time for skull drilling and tube implantation was 26.5 ± 7.6 minutes (range 20–35 minutes). The mean time for hematoma drainage was 4.5 ± 2.5 days (range 3–6 days). The mean volume of hematoma before tube removal was 5.5 ± 4.2 mL (range 0–9 mL). Compared with the preoperative mean volume of 32.5 ± 15.1 mL, the hematoma volume before tube removal reduced by 83.1% ($P = 0.003$).

The consciousness status of the patients originally with conscious disturbances quickly improved within 3 days after surgery. The GCS score was significantly improved from 10 ± 2 at admission to 14 ± 1 at discharge ($P < 0.001$, **Figure 2A**). The major symptoms, including headache and nausea or vomiting, disappeared at the time of discharge. During the 6-month follow-up period, the Glasgow Outcome Scale–Extended score significantly improved to 5.6 ± 1 versus 7.3 ± 0.7 at discharge ($P < 0.001$, **Figure 2B**). No recurrence of EDHs was observed in any patient, nor were complications including cerebral infarction or dysfunction of cranial nerve observed after the embolization therapy. No surgery-related infection occurred.

DISCUSSION

Urgent evacuation of hematoma is the standard treatment for traumatic EDHs to prevent death or neurologic morbidity. In recent years, burr hole evacuation and drainage with/without urokinase was reported as a new minimally invasive strategy for the treatment of EDHs, especially those not suitable for general anesthesia.[6,7] However, this method only reduced the volume without eliminating the bleeding factor. Rebleeding is probably the most devastating complication, which limits the application of the method to acute patients in the first 24 hours after injury. Arterial bleeding is responsible for about 85% of hematomas. Some reports showed that angiography and possible embolization treatment could find and cease the bleeding point in EDH patients who do not require surgery for clot evacuation. Thus endovascular embolization in combination with skull drilling and injection of urokinase can find and remove the bleeding factor, thus decreasing the volume effect. Theoretically, it should be a safe and effective treatment for EDH patients. The data obtained from our study have provided clinical evidence for safe and effective use of this novel method.

Temporal region–related lesions were selected in our study, including the temporal area, frontotemporal area, and temporoparietal area. Head CT showed more cases in the frontotemporal area than those in the temporal area. The MMA has generally been considered the most common source of middle fossa EDHs. Angiography in our study showed that MMA injury was the major bleeding factor, and active extravasation from the MMA was the common bleeding point. Bleeding ceased immediately after embolization in all our cases.