Surgical Neurology International

OPEN ACCESS

For entire Editorial Board visit : http://www.surgicalneurologyint.com

Editor: James I. Ausman, MD, PhD University of California, Los Angeles, CA, USA

Original Article

# A fast cranial drilling technique in treating severe intracranial hemorrhage

Jun-Jie Wei, Hui-Fang Liu, Shuai Chai, Xuan-Min Kang[1]

Department of Neurosurgery, Wenxi People's Hospital, 99 Tai-Feng Xi-Lu, Wenxi, Shanxi, 043800, [1]Shangxi Mental Health Center, 55 Nan-Shi-Fang Street, Taiyuan, Shanxi, 030001, China

E-mail: *Jun-Jie Wei - weijj1970@163.com; Hui-Fang Liu - Liuhuifang123@163.com; Shuai Chai - 135242653@qq.com; Xuan-Min Kang - kongxuanmin@126.com
*Corresponding author

Received: 28 January 15 Accepted: 10 July 15 Published: 07 October 15

## Abstract

**Background:** This study is a retrospective case analysis of 143 patients who suffered from severe intracranial hemorrhage and underwent a fast and simple procedure of cranial drilling followed with external ventricle drain treatment (referred as Fast-D here after) during 2003–2013 to evaluate the clinical effectiveness of the treatment.

**Methods:** Fast-D procedure was conducted on 143 patients with severe acute craniocerebral diseases. Those patients were evaluated using activities of daily living (ADL) scales at hospital discharge and after 6-month of physical therapy, and were compared to 36 patients with similar craniocerebral diseases but received the traditional Dandy's surgical treatment.

**Results:** At discharge, 11% (16 cases) was classified as ADL I (fully functional for physical and social activities); 26% (37 cases) had ADL II (fully functional for physical activities but partially impaired for social activities); 34% (49 cases) was ADL III (require assistance performing physical activities); 9% (13 cases) was ADL IV (being conscious, but completely lost ability of physical activities); 27% (10 cases) was ADL V (vegetative stage); and 13% (18 cased) was ADL VI (died) among the 143 patients. Six-month physical therapy improved ADL in 88% of the patients. Those outcomes are equal or better than the more complicated Dandy's procedure probably due to the time-saving factor.

**Conclusion:** Fast-D procedure is much faster (6.7 min vs. 53.6 min of the Dandy's procedure) and can be performed outside operating rooms (computed tomography room or bedside). This technique could serve as a tool to rapidly release intracranial pressure and reduce subsequent morbidity and mortality of severe craniocerebral diseases when resource and condition are limited and more elaborate operating room procedures are not possible.

**Key Words:** Cranial drill, drainage, intracranial hemorrhages, intracranial pressure

Access this article online

Website: www.surgicalneurologyint.com

DOI: 10.4103/2152-7806.166847

Quick Response Code:

## INTRODUCTION

Intracranial hypertension is a common occurrence for patients suffering from craniocerebral diseases. An elevated intracranial pressure (ICP) is very likely to cause severe nonreversible damage to brain tissues and often times is fatal if prolonged. Prompt medical attention and rapid relief of high ICP can prevent impending mortality



**How to cite this article:** Wei JJ, Liu HF, Chai S, Kang XM. A fast cranial drilling technique in treating severe intracranial hemorrhage. Surg Neurol Int 2015;6:159. http://surgicalneurologyint.com/A-fast-cranial-drilling-technique-in-treating-severe-intracranial-hemorrhage/

and may significantly improve functional outcomes of patients with craniocerebral diseases.[4] Compared to a typical craniotomy (removing a bone flap from the skull), drilling a hole to the skull and introduce a drainage passage to remove intracranial hematomas can bring faster ICP relief with less trauma. Such technique is also relatively simple to perform and requires less resource, thus, it can be a suitable treatment option in some circumstances, especially in underdeveloped areas. A manually operated drilling device (Figure 1, Xinhua Medical Instrument, Zibo, Shandong, China) accompanied with a cranial drainage procedure (referred as Fast-D here after) was first developed and used clinically by two Chinese neurosurgeons Drs. Qingling Zhang and Cheng Zhang of Shandong Medical College Hospital in 1963.[6] This 52-year old technique has played a pivotal role in treating severe craniocerebral diseases, especially for patients whose conditions do not allow a craniotomy operation.[9] Our hospital is located in a rural area of China serving patents with limited resource. This provides an opportunity to apply the Fast-D technique in treating patients with severe acute craniocerebral diseases. The current report summarizes clinical treatment data and patient outcomes of 143 cases receiving Fast-D treatment to evaluate the therapeutic potential of this technique. Data from 36 patients who suffered similar conditions but underwent the traditional Dandy's procedure were also presented for comparison.

## MATERIALS AND METHODS

### Patient selection

Between January 2003 and January 2013, a total of 467 patients with severe craniocerebral hemorrhage were admitted to our hospital. Among them 143 patients received the Fast-D treatment. Those 143 patients were selected based on the following combined criteria: (1) Glasgow Coma Scale (GCS, 15-point scale) was between 3 and 8; (2) lack of craniotomy requirement or the operation was refused by family members; and (3) patient's condition was suitable for lateral ventricle external drainage. During the same time period, 36 patients received the traditional Dandy's drilling procedure.

**Figure 1: The fast drilling device used in this study, manufactured by Xinhua Medical Instrument, Zibo, Shandong, China**

### Examinations

Computed tomography (CT) or magnetic resonance imaging (MRI) scans were performed on all the patients. For intracerebral hemorrhage patients, the scans were to determine the location and size (volume) of the bleeding, and the intensity of ventricle penetration. For other patients, the intensity of lateral ventricle compression was evaluated. Those scan images were used to determine whether a patient was suitable for performing the Fast-D procedure. The blood pressure of all patients was within the range of 160–240/100–160 mm Hg.

### Operational procedure and clinical treatments

For Fast-D, while routine treatment measures were performed, patients were placed in supine position. The drill site was generally located at just inside of frontal hairline and 2 cm away from the center line. The exact puncture location was fine-tuned based on CT or MRI images if necessary. After hair removal followed by povidone-iodine cleansing and local anesthesia with 1% lidocaine hydrochloride, drilling was performed to penetrate the scalp, skull, and dura mater in one thrust using a manually powered drilling device [Figure 1] equipped with a bit of 3 or 5 mm in diameter and 2–2.5 cm long. The drilling direction was parallel to the sagittal plane and aimed at an imaginary line connecting the two external auditory canals. Immediately after drilling, one end of a piece of silicon tubing (with metal threads) equipped with a penetrating guiding-pin was inserted into the burr hole in the depth of about 5 cm in the direction of the drill, perpendicular to the imaginary connecting line of the two external auditory canals. Once the cerebrospinal fluid appeared at the other end of the tubing, the guiding pin was removed, and the tubing was gently pushed further for additional 0.5–1 cm in depth before fixing the position. ICP was monitored immediately. The highest tubing position was adjusted at 5–10 cm above the level of the burr hole.

Regular Dandy's procedure was performed in operating rooms with general anesthesia on 36 patients. All other cares were kept the same as the Fast-D patients.

### Postoperation treatments

The shunt tube was kept blockage-free at all times. The color and the volume of the drainage fluid were recorded, and the constitution was routinely tested and monitored. The duration of the shunt was generally <1-week. If it exceeded 1-week, bacterial culture tests were performed regularly to ensure no intracranial infection. For cases of severe intraventricular hemorrhage, 3 ml 0.9%

streptokinase and 30,000 IU urokinase were injected through the tubing followed by 1–2 h of closure. Such practice could be repeated 2–3 times a day to dissolve coagulated blood for easier drainage. The removal of the tubing (end of external drainage) was determined based on the color, volume of the drainage fluid, and the images of CT and MRI scans. After removal, the tubing was cultured for pathogenic bacteria. Antibiotic sensitivity tests were followed if the test was positive. The patients were closely monitored for signs of infection and treated with antibiotics if necessary.

After hospital discharge, all patients with activities of daily living (ADL) of II–V received 6 months of physical therapy treatment.

### Evaluation criteria

Patient recovery was evaluated at hospital discharge and a follow-up at 6 months after discharge. ADL scales were used to classify the patients as the following: ADL I-fully functional in performing physical and social daily activities; ADL II-fully functional in performing physical daily activities and slightly impaired in social activities; ADL III-partially functional and requires assistance in performing physical daily activities; ADL IV-being conscious, but completely lost ability of performing physical daily activities; ADL V-vegetative stage; and ADL VI-died.

### Data analysis

All data were analyzed using *t*-test or binomial test in MS-Excel. Statistical significance was set at $P < 0.05$ for all comparisons.

## RESULTS

The 143 Fast-D patients were 93 males (65%) and 50 females (35%) aged between 12 and 86 years old with the mean age of 47.8 [Table 1]. The average disease duration was 55 days with a range of 30 days and 4 months. These patients suffered craniocerebral diseases including: (1) Intracerebral hemorrhage followed by ventricle penetration, including 36 cases (25.2%) in basal ganglia, 23 cases (16.1%) in thalamus, 12 cases (8.4%) in brainstem, and 7 cases (4.9%) in cortex; and (2) intraventricular hemorrhage due to various causes, including 13 cases (9.1%) of cerebral vascular malformation, 6 cases (4.2%) of spontaneous brainstem injury, 14 cases (9.8%) of diffuse axonal injury, and 32 cases (22.4%) of severe pons injury [Table 2]. The 36 Dandy's patients were consisted of 20 males (55.6%) and 16 females (44.4%) with age ranged from 18 to 82 years old with the mean of 54.7. The average disease duration was 62 days also ranged between 30 days and 4 months [Table 1]. Twenty patients suffered various intracerebral hemorrhage with ventricle penetration, and 16 suffered intraventricular hemorrhage of various causes [Table 2]. No significant difference in gender and age between the 2 patient groups.

**Table 1: Comparison of some characteristics of patients of Fast-D and Dandy's**

| Indicator (*n*, %) | Fast-D (*n*=143) | Dandy's (*n*=36) | Significance[1] |
|---|---|---|---|
| Male | 93 (65%) | 22 (55.6%) | NS |
| Female | 50 (35%) | 16 (44.4%) | |
| Average age | 47.8±7.6 | 57.7±10.8 | NS |
| Surgery duration (min) | 7.6±2.5 | 53.6±7.3 | ** |
| Disease duration (day) | 55.0±6.7 | 57.4±6.1 | NS |
| Delayed hydrocephalus | 10 (8.2%) | 3 (11.1%) | NS |
| Progression cerebral herniation | 6 (4.2%) | 5 (13.9) | * |
| Fatality | 18 (12.6%) | 9 (25%) | * |

[1]NS=*P*>0.05; *=*P*<0.05; **=*P*<0.01

The entire Fast-D procedure (include drilling and inserting the drainage tube) was completed within 10 min for all the patients with a mean of 6.7 ± 2.5 min. Out of the 143 cases, 136 cases (95.1%) were successful with one attempt. The remaining 7 cases (4.9%) required second attempts. Delayed hydrocephalus occurred in 10 patients (8.2%) requiring a bypass surgery. Six patients (4.2%) suffered progressive cerebral herniation. The Dandy's procedure took an average of 53.6 ± 7.3 min, significantly longer than that of Fast-D. All 36 cases were successful with one attempt. Three patients (11.1%) suffered delayed hydrocephalus, not significantly differ from the Fast-D group. Five patients (13.9%) suffered progressive cerebral herniation, significantly higher than that of the Fast-D patient group (4.2%) [Table 1].

Eighty-seven Fast-D patients (60.8%) required <7 days of the external drainage. Forty-two cases (29.4%) required between 7 and 14 days, and 14 cases (9.8%) required longer than 14 days [Table 2]. Among the 143 patients, intracranial infection occurred in 7 patients (4.9%), and 6 of whom had drain duration >14 days and 1 patient with drain duration between 7 and 14 days. None of the patients with drain duration <7 days had an infection. The 7 patients with infections fully recovered with antibiotic therapy in combination of nutrient support and hyperbaric oxygen therapy. Among Dandy's patients 25 cases (69.4%) required <7 days of external drain, 9 cases (25.0%) needed 7–14 days, and 2 cases (5.6%) had >14 days of external drain [Table 2] and 2 (5.6%) of those patients had intracranial infection.

Among the 143 patients, 102 (71.0%) achieved an ADL performance of level III or better, including 16 (11.2%) of ADL I, 37 (25.9%) of ADL II and 49 (34.3%) of ADL III. There were 13 cases of ADL IV, 10 cases of ADL V, and 18 cases (12.6%) of death [Table 2]. The death was mainly due to respiratory or circulatory failures.

**Table 2: Treatment duration and ADL scales at hospital discharge of the patients underwent the Fast-D and Dandy's procedures**

| Diseases (Hemorrhage) | Procedure | Cases | Drainage duration | | | ADL scales | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | <7 d | 7-14 d | >14 d | I | II | III | IV | V | VI |
| Basal ganglia | Fast-D | 36 | 30 | 6 | 0 | 8 | 18 | 9 | 1 | 0 | 0 |
| | Dandy's | 10 | 8 | 2 | 0 | 1 | 4 | 3 | 1 | 1 | 0 |
| Thalamus | Fast-D | 23 | 17 | 6 | 0 | 0 | 5 | 12 | 3 | 2 | 1 |
| | Dandy's | 5 | 3 | 2 | 0 | 0 | 1 | 2 | 1 | 1 | 0 |
| Brainstem | Fast-D | 12 | 4 | 6 | 2 | 0 | 0 | 3 | 2 | 3 | 4 |
| | Dandy's | 3 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| Cortex | Fast-D | 7 | 6 | 1 | 0 | 6 | 1 | 0 | 0 | 0 | 0 |
| | Dandy's | 2 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| Cerebral vascular malformation | Fast-D | 13 | 8 | 5 | 0 | 1 | 5 | 4 | 1 | 1 | 1 |
| | Dandy's | 3 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| Spontaneous brainstem injury | Fast-D | 6 | 2 | 2 | 2 | 1 | 0 | 2 | 1 | 0 | 2 |
| | Dandy's | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Diffuse axonal injury | Fast-D | 14 | 6 | 5 | 3 | 0 | 1 | 5 | 4 | 2 | 2 |
| | Dandy's | 4 | 3 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 3 |
| Severe pons injury | Fast-D | 32 | 14 | 11 | 7 | 0 | 7 | 14 | 1 | 2 | 8 |
| | Dandy's | 8 | 5 | 2 | 1 | 0 | 1 | 3 | 0 | 0 | 3 |
| Total | Fast-D | 143 | 87 | 42 | 14 | 16 | 37 | 49 | 13 | 10 | 18 |
| | Dandy's | 36 | 25 | 9 | 2 | 2 | 7 | 9 | 6 | 3 | 9 |
| % | Fast-D | | 60.8 | 29.4 | 9.8 | 11.2 | 25.9 | 34.3 | 9.1 | 7.0 | 12.6 |
| | Dandy's | | 69.4 | 25.0 | 5.6 | 5.6 | 19.4 | 25.0 | 16.7 | 8.3 | 25.0 |

Physical therapy of 6 months improved the ADL scores of 96 patients (88.1%). The ADL scores of 36 out of 37 patients improved from II to I; 46 out of 49 patients improved from III to II; 11 out of 13 patients improved from IV to III; and 3 out of 10 patients improved from V to IV after 6 months of physical therapy [Table 3]. For Danty's patients, 2 patient revived ADL I at discharge. Seven patients received ADL II, 9 received ADL III, 6 received ADL IV, 3 received ADL V, and 9 patients (25%) were dead for similar respiratory or circulatory failures as the Fast-D group. The 6-month follow-up showed that 21 patients (84%) made improvement, including 7 with ADL I, 8 with ADL II, 5 with ADL III and 1 with ADL IV [Table 3].

**Table 3: Effect of 6 months physical therapy on patient' ADL scores**

| ADL score | # of patients at discharge | # of patients 6 months after | % improved |
|---|---|---|---|
| Fast-D | | | |
| I | | 36 | |
| II | 37 | 46 | |
| III | 49 | 11 | |
| IV | 13 | 3 | |
| V | 10 | | |
| Total | 109 | 96 | 88.1 |
| Dandy's | | | |
| I | | 7 | |
| II | 7 | 8 | |
| III | 9 | 5 | |
| IV | 6 | 1 | |
| V | 3 | | |
| Total | 25 | 21 | 84.0 |

## DISCUSSION

Severe intracranial hemorrhage is an acute condition that constitutes immediate medical emergency as the condition can progress rapidly resulting in diffuse brain edema as fast as in 20–30 min.[12] The resulting rapid increase of ICP may induce brain herniation and respiratory arrest.[9,11] Fast and effective relief of elevated ICP is crucial in reducing high rates of morbidity and mortality of craniocerebral diseases. The Fast-D technique employed in the current study has direct advantages of rapid implementation (completed in under 7 min), convenience (performed at the bedside by one surgeon) and less invasive (no stitches are necessary) compared to the traditional Dandy's air ventriculography procedure. The Fast-D procedure saves the patients nearly 50 min or more of valuable time that would have been required in craniotomy surgery preparations. In addition, the rapid continuous removal of blood by Fast-D also provided rapid relief of secondary injury to cerebrovascular and brain tissues due to metabolic cascades of the hemorrhage.[1,2] The speedy drainage of blood reduces the risk of red

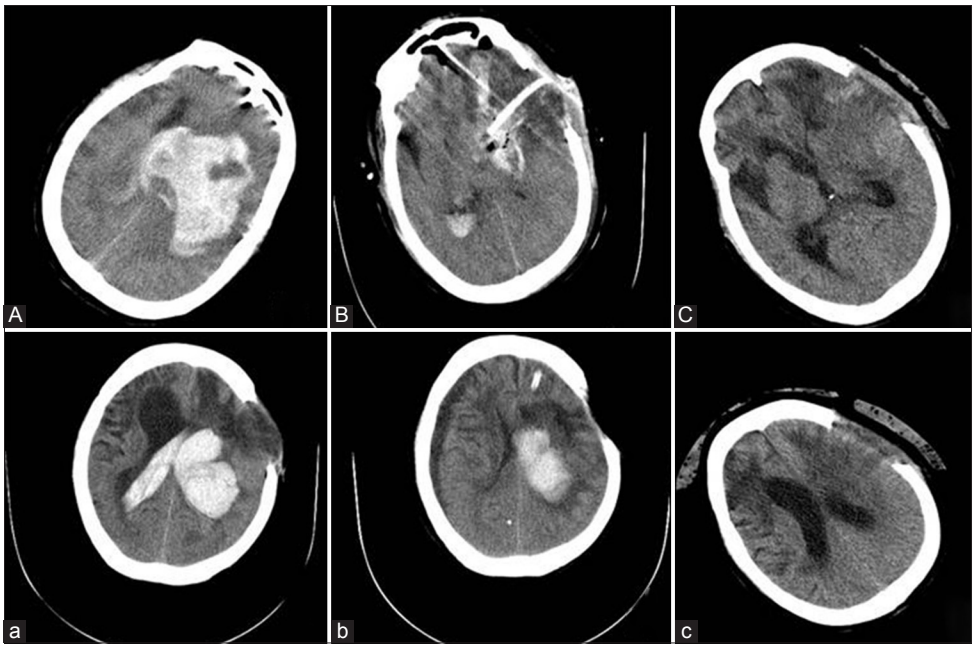


**Figure 2: Computed tomography images of a patient who underwent both the craniotomy and the Fast-D treatment. (A) Left basal ganglia hemorrhage (165 ml) before craniotomy; (B) Two days after craniotomy; (C) One month after craniotomy; (a) Left basal ganglia hemorrhage (103 ml) (2 years later); (b) Two days after Fast-D drainage treatment; (c) One month after Fast-D treatment**

blood cell breakdown and prevents the occurrence of cerebral vasospasm and cerebral infarction, and the continuous drain also creates a pressure gradient that facilitates fluid discharge and disrupts development of brain edema.[8] The current case analysis demonstrated that the Fast-D technique could effectively lower the ICP rapidly and is a life-saving tool for patients with severe brain bleeding and unfavorable vital signs, and for patients with limited resources that more elaborate operating room procedure is not an option. This simple technique also provides an additional tool for rural area hospitals to better serve their patients. The CT images of a patient who underwent both the craniotomy and the Fast-D treatment (2 years later) demonstrate the effectiveness of Fast-D comparing to the much complicated craniotomy procedure evidenced by showing similar recovery [Figure 2].

More than 60% of the 143 patients had <7 days of hospitalization period, and the mortality rate was 13% that is, lower than previous reports of patients with GCS of 3–8 (21.2–25.7%) that received other types of treatments such as conservative drug therapy.[3,5,7,10] Our experience suggests that the Fast-D procedure should be performed as early as possible. The best result was achieved when the drain tubing was installed within 2 h of intracranial hypertension and acute cerebral edema when the lateral ventricles have not yet been affected by extrusion. However, one should note that craniotomy operation might still be the optimal option for some of our patients. Our experience with the Fast-D technique suggests that it serves very well as the next line of treatment for patients with limited resources or a craniotomy operation could not be performed for various reasons. In those situations, the Fast-D technique could reduce mortality and preserve the quality of life of patients as showed in this report.

## Financial support and sponsorship
Nil.

## Conflicts of interest
There are no conflicts of interest.

## REFERENCES

1. Cheng HD. Treatment of 67 cases of severe spontaneous intracerebral hemorrhage. Chin J Clin Neurosurg 2005;10:227.
2. Gao XG. Primary intracerebral hemorrhage. Chin Gen Pract 2005;8:1647-8.
3. Jia JM, Jiang XF, Xie P. Clinical analysis of 156 cases of severe traumatic brain injury. Clin Med 2011;31:45-7.
4. Nieuwkamp DJ, de Gans K, Rinkel GJ, Algra A. Treatment and outcome of severe intraventricular extension in patients with subarachnoid or intracerebral hemorrhage: A systematic review of the literature. J Neurol 2000;247:117-21.
5. Roozenbeek B, Chiu YL, Lingsma HF, Gerber LM, Steyerberg EW, Ghajar J, *et al*. Predicting 14-day mortality after severe traumatic brain injury: Application of the IMPACT models in the brain trauma foundation TBI-trac® New York State database. J Neurotrauma 2012;29:1306-12.
6. Shandong Medical School Hospital Neurosurgical Department. Clinical application and animal study of a cranial fine-drilling device. Chin Med J 1975;55:641-3.
7. Sim SK, Lim SL, Lee HK, Liew D, Wong A. Care of severe head injury patients in the Sarawak General Hospital: Intensive care unit versus general ward. Med J Malaysia 2011;66:138-41.
8. Todo T, Usui M, Takakura K. Treatment of severe intraventricular hemorrhage by intraventricular infusion of urokinase. J Neurosurg 1991;74:81-6.
9. Wei L, Li G, Jin P, Wang CW, Fei C, Wang DK, *et al*. Rapid pore cranial drilling and ventricular drainage treatment in ventricular hemorrhage: A clinical

analysis of 3571 cases. Chin J Neuromed 2011;10:731-4. [in Chinese with English abstract].
10. Yang SZ, Li LN, Li SD, Peng YB, Yang XK, Wei YJ, *et al*. Research of clinical epidemiology of 6690 cases of craniocerebral injury. Chin J Neuromed 2006;5:274-7. [in Chinese with English abstract].
11. Yao ML, Lin SH. Cerebrovascular Diseases. Beijing, China: People Health Publishing House; 2002.
12. Yoshino E, Yamaki T, Higuchi T, Horikawa Y, Hirakawa K. Acute brain edema in fatal head injury: Analysis by dynamic CT scanning. J Neurosurg 1985;63:830-9.