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Original Article

The effect of hematoma puncture drainage before decompressive craniectomy on the prognosis of hypertensive intracerebral hemorrhage with cerebral hernia at a high altitude

Lin-Jie Wei ^{a,b,1}, Chi Lin ^{c,1}, Xing-Sen Xue ^a, Guo-Dong Dun ^d, Jian-Bo Zhang ^a, Yan-Xiang Tong ^c, Jia-Xiong Wang ^c, Shi-Ji Yang ^b, Ling Wang ^a, Zhi Chen ^a, Hua Feng ^a, Gang Zhu ^{a,*}

^a Department of Neurosurgery, Southwest Hospital, Third Military Medical University (Army Medical University), Chongqing, 400038, China

^b Department of Neurosurgery, PLA 956th Hospital, Linzhi, Tibet, China

^c Department of Neurosurgery, First People's Hospital of Honghe City, Honghe Yunnan Province, China

^d Department of Clinical Laboratory, PLA 956th Hospital, Linzhi, Tibet, China

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ABSTRACT

Purpose: Rapid decompressive craniectomy (DC) was the most effective method for the treatment of hypertensive intracerebral hemorrhage (HICH) with cerebral hernia, but the mortality and disability rate is still high. We suspected that hematoma puncture drainage (PD) + DC may improve the therapeutic effect and thus compared the combined surgery with DC alone.

Methods: From December 2013 to July 2019, patients with HICH from Linzhi, Tibet and Honghe, Yunnan Province were retrospectively analyzed. The selection criteria were as follows: (1) altitude ≥ 1500 m; (2) HICH patients with cerebral hernia; (3) Glasgow coma scale score of 4–8 and time from onset to admission ≤ 3 h; (4) good liver and kidney function; and (5) complete case data. The included patients were divided into DC group and PD + DC group. The patients were followed up for 6 months. The outcome was assessed by Glasgow outcome scale (GOS) score, Kaplan-Meier survival curve and correlation between time from admission to operation and prognosis. A good outcome was defined as independent (GOS score, 4–5) and poor outcome defined as dependent (GOS score, 3–1). All data analyses were performed using SPSS 19, and comparison between two groups was conducted using separate *t*-tests or Chi-square tests.

Results: A total of 65 patients was included. The age ranged 34–90 years (mean, 63.00 ± 14.04 years). Among them, 31 patients had the operation of PD + DC, whereas 34 patients underwent DC. The two groups had no significant difference in the basic characteristics. After 6 months of follow-up, in the PD + DC group there were 8 death, 4 vegetative state, 4 severe disability (GOS score 1–3, poor outcome 51.6 %); 8 moderate disability, and 7 good recovery (GOS score 4–5, good outcome 48.4 %); while in the DC group the result was 15 death, 6 vegetative state, 5 severe disability (poor outcome 76.5 %), 4 moderate disability and 4 good recovery (good outcome 23.5 %). The GOS score and good outcome were significantly less in DC group than in PD + DC group ($Z = -1.993$, $p = 0.046$; $\chi^2 = 4.38$, $p = 0.043$). However, there was no significant difference regarding the survival curve between PD + DC group and DC group. The correlation between the time from admission to operation and GOS at 6 months ($r = -0.41$, $R^2 = 0.002$, $p = 0.829$) was not significant in the PD + DC group, but significant in the DC group ($r = -0.357$, $R^2 = 0.128$, $p = 0.038$).

Conclusion: PD + DC treatment can improve the good outcomes better than DC treatment for HICH with cerebral hernia at a high altitude.

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Introduction

Hypertensive intracerebral hemorrhage (HICH) with herniation was a very critical condition striving for “golden hour” rescue.

* Corresponding author.

E-mail address: zhugang6666@126.com (G. Zhu).

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¹ These authors contribute equally to the manuscript.

Decompressive craniectomy (DC) is an effective way to quickly reduce the cranial pressure and save lives,¹ during which the cranial flap is excised and the edematous brain tissue protrudes outward to reduce intracranial pressure.^{2–5}

Cerebral hemorrhage at high altitude areas is more serious than that in plain areas because the edema is more severe and the recovery of neurological function is worse.⁶ In addition, the cerebral blood flow and brain tissue oxygen decrease after brain injury at high altitude.⁷ Hence, HICH with cerebral hernia is more serious at high altitude areas than at low altitude areas. For patients with HICH with cerebral hernia, there is a time interval between admission to surgical intervention, when deterioration may occur. Therefore, this study explored whether early elimination of partial hematoma on admission could improve the prognosis of patients.

The operation time required for hematoma puncture drainage (PD) is short, which decreases the rate of brain edema.^{8,9} However, PD alone is inadequate. For HICH with cerebral hernia, it was hypothesized that PD can be performed first for partial decompression, and then DC should be conducted for full decompression. This study aims to investigate the effect of the combined treatment of PD + DC for HICH with cerebral hernia at a high altitude area (Fig. 1).

Methods

Patient selection

This study was approved by our local ethics committee. This was a retrospective study conducted from December 2013 to July 2019. HICH with cerebral hernia was detected by CT scan (GE Lightspeed 64, USA) and related examinations. The selection criteria were as follows: (1) altitude of the habitual residence of the patients ≥1500 m; (2) diagnosis of HICH with cerebral hernia: bilateral nonreactive pupils or unilateral nonreactive pupil; (3) Glasgow come scale (GCS) score of 4–8 and time from onset to admission ≤3 h (the longer the brain hernia was delayed, the poorer the treatment effect would be); (4) good liver and kidney function; and

(5) complete case data. Patients were excluded if they met any of the following criteria: (1) vascular malformation, aneurysm, tumor, etc. or a hematoma breaking into the lateral ventricle; (2) no cerebral hernia; and (3) an allergic constitution, asthma, hyperthyroidism, etc. All patients were detected by computed tomography angiography (CTA).¹⁰ The size of the parenchymal hematoma was calculated as ABC2.¹¹

Patients were divided into two groups: PD + DC group and DC group. Surgical procedures were described in the following. Patients were followed up for 6 months postoperatively. All data were independently and blindly reviewed by two senior neurosurgeons.

Operation method

Each patient received DC and hematoma removal using a transcortical approach. An approximately 2 cm-long incision was made on the middle temporal gyrus, exposing the hematoma, which was aspirated with great care under a microscope.¹² PD surgery was conducted using a YL-1 puncture needle (Beijing Wan Tie Fu Medical Apparatus Co. Ltd, China). Under local anesthesia, with the help of CT bedside, YL-1 puncture needle was used for drilling after selecting the locating point and partial hematoma was extracted.¹³ Important areas such as the meningeal vessels, lateral fissure, central sulcus, and venous sinus were avoided. The DC procedure (PD + DC group) was performed as mentioned before.

Evaluation and follow-up

After a follow-up of 6 months, the patients were scored with Glasgow outcome scale (GOS): 5 score, good recovery; 4 score, moderate disability; 3 score, severe disability; 2 score, vegetative state; and 1 score, death. The outcome was defined as independent (good outcome, GOS 4-5); and dependent (poor outcome, GOS 1-3).¹⁴ The Kaplan-Meier survival curve was plotted within 6 months postoperatively.

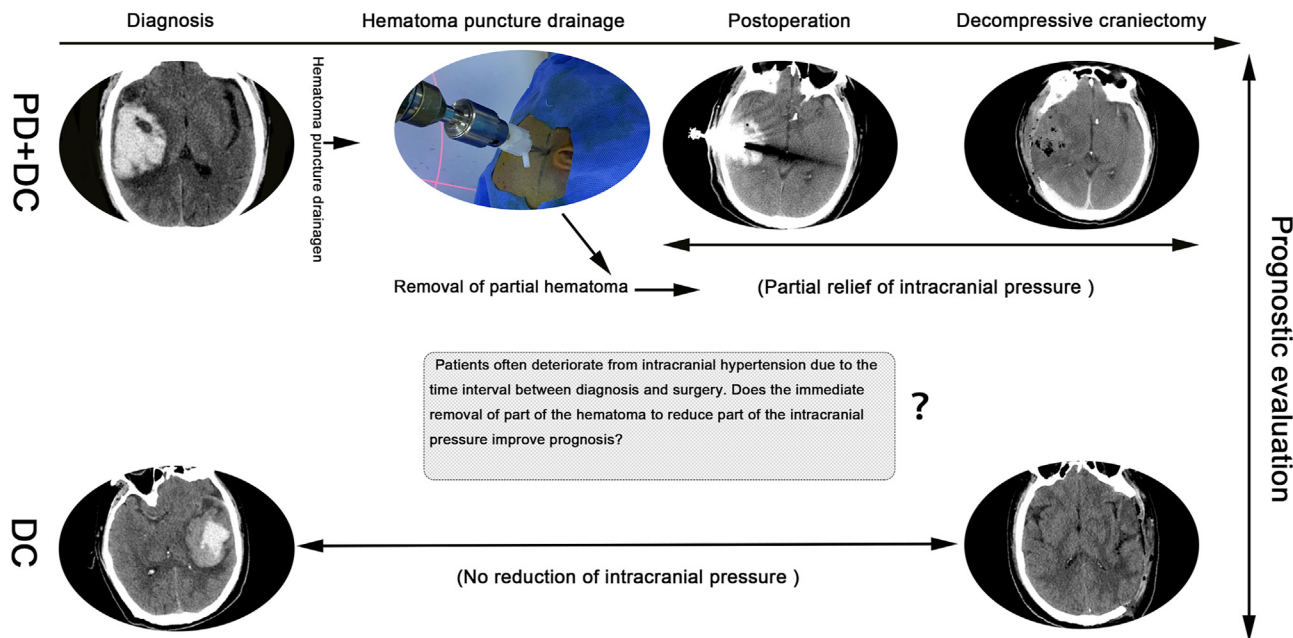


Fig. 1. Schematic diagram of the research purpose.

Correlation between time from admission to operation and GOS outcome

After 6 months of follow-up, a scattergram with a regression line was generated to determine the correlation between time from admission to operation (min) and GOS.

Statistical analysis

All the analyses were performed using SPSS 19 (IBM Corp., Armonk, New York, USA). Normally distributed data were expressed as mean ± SD. Quantitative data were analyzed between the two groups using separate *t*-tests and analysis of variance, whereas categorical data were compared using Chi-square test. Differences were considered significant at *p* < 0.05. A scattergram with a regression line was generated to determine the correlation between time from admission to operation and GOS. Prediction of 6-month individual survival rate was made by Graphpad prism 7.0. All data analysis was conducted by two investigators in a blinded manner.

Results

Participant characteristics

The total number of patients was 65. Age ranged from 34 to 90 years, mean (63.00 ± 14.04) years. Among them, 31 patients had the operation of PD + DC, whereas the other 34 had DC alone. The two groups revealed no significant difference in basic characteristics (Table 1). For the 31 cases in the PD + DC group, partial hematoma was failed to be extracted in 3 cases, and the success rate was 90.32%. The mean surgical time for PD procedure was (9.13 ± 1.94) min. Hematoma of (22.45 ± 7.60) mL was extracted in the PD + DC group. After the PD treatment, the two groups had significant differences in hematoma volume (mL) (77.29 ± 13.03 vs. 53.06 ± 16.75, *p* < 0.001). No intracranial infection was found in any of the 65 patients.

Postoperative follow-up results

The follow-up period was 6 months. The GOS scores of the PD + DC group were: 8 death (GOS score 1), 4 vegetative state (GOS score 2), 4 severe disability (GOS score 3), 8 moderate disability (GOS score 4), and 7 good recovery (GOS score 5); while in the DC group the result was 15 death, 6 vegetative state, 5 severe disability, 4 moderate disability and 4 good recovery. As a result, the rate of good outcome was 15/31 (48.4%) in PD + DC group and 8/34 (23.5%) in DC group. The GOS score of PD + DC group was significantly

higher than that of DC group (*Z* = -1.993, *p* = 0.046, Fig. 2A), and the rate of good outcome was also much higher (χ^2 = 4.38, *p* = 0.043, Fig. 2B). However, Kaplan-Meier survival curve analysis of the mortality showed no significant difference between the two groups (*p* > 0.05, Fig. 2C).

Correlation between time from admission to operation and GOS

The correlation between time from admission to operation (min) and GOS at 6 months was analyzed by generating a scatter diagram, which showed no significant difference in the PD + DC group (*r* = -0.41, *R*² = 0.002, *p* = 0.829, Fig. 3A), but significant difference in the DC group (*r* = -0.357, *R*² = 0.128, *p* = 0.038), Fig. 3B).

Case presentation

The image of 2 typical cases were presented, respectively a 65-year-old male in the PD + DC group with the initial GCS score of 6 (Fig. 4A-E), and a 61-year-old male in the DC group whose initial GCS score was 7 (Fig. 4F-H).

Discussion

The results showed that for cases of HICH with cerebral hernia, the PD + DC treatment could improve the recovery of neurological function. The time from admission to operation was correlated with the GOS outcomes: the longer the time from admission to operation, the worse the prognosis. Hypertension was the main cause of cerebral hemorrhage. When the amount of hematoma reached a certain amount, the hematoma could compress the brain tissue from the high-pressure area to the low-pressure area, so that the deutocerebrum, nerves, and blood vessels are compressed, resulting in hernia.^{10,15} Cerebral hernia caused by supratentorial hematoma oppresses the brain stem, which easily leads to severe neurological dysfunction and even death.¹⁵

HICH with hernia is a critical condition, and the rescue time is the key. However, it takes a certain process from admission to operation, which might aggravate the patient's condition. Therefore, once HICH with cerebral hernia was diagnosed after admission, PD operation should be performed to remove part of the hematoma, reduce the volume of intracranial hematoma and part of the intracranial pressure, so as to win time for DC. The average time of this operation was about 10 min, which is short and did not delay the DC, but in return can alleviate the intracranial pressure and delay the deterioration of the disease. The success rate was high in our study and only 3/31 patients (9.7%) failed to extract partial hematoma.

Table 1
Patient characteristics of the PD + DC group and DC group.

Characteristics	PD + DC group (n = 31)	DC group (n = 34)	<i>t</i> / χ^2 value	<i>p</i> value
Age (years)	63.51 ± 12.68	62.53 ± 15.35	0.281	0.780
Men	19	24	0.626	0.429
Hematoma volume (mL)	75.51 ± 13.97	77.29 ± 13.03	0.531	0.597
Comorbidities				
Diabetes	7	9	1.460	0.227
Heart disease	6	10	0.884	0.399
Pulmonary disease	7	8	0.008	0.928
Other diseases	6	6	0.031	0.859
Glasgow coma scale ^a	6 (5, 7)	6 (5, 7)		0.733
Time from admission to surgery (min)	98.74 ± 12.18	90.08 ± 18.33	2.219	0.030
Operation time (min)	173.13 ± 30.58	171.79 ± 28.95	0.181	0.857

Data are presented as mean ± SD, frequency, or median (Q1, Q3). PD: puncture drainage; DC: decompressive craniectomy.

^a Mann-Whitney *U* test.

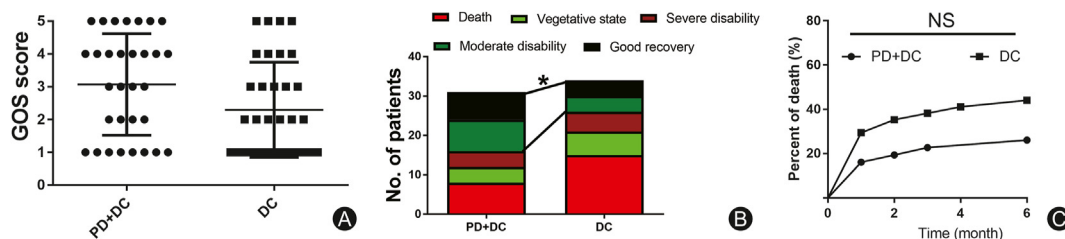


Fig. 2. (A) The GOS score of 31 cases of hypertensive intracerebral hemorrhage with cerebral hernia in the PD + DC group and 34 counterparts in the DC group at 6 months after surgery. (B) Good outcomes were significantly less in the DC group than in the PD + DC group (* $p < 0.05$, determined by Chi-square and Mann-Whitney U tests). (C) Kaplan-Meier survival curves: 8 deaths in PD + DC group and 15 deaths in DC group (NS = indicates no significant difference, log-rank test). PD: puncture drainage; DC: decompressive craniectomy; GOS: Glasgow outcome scale.

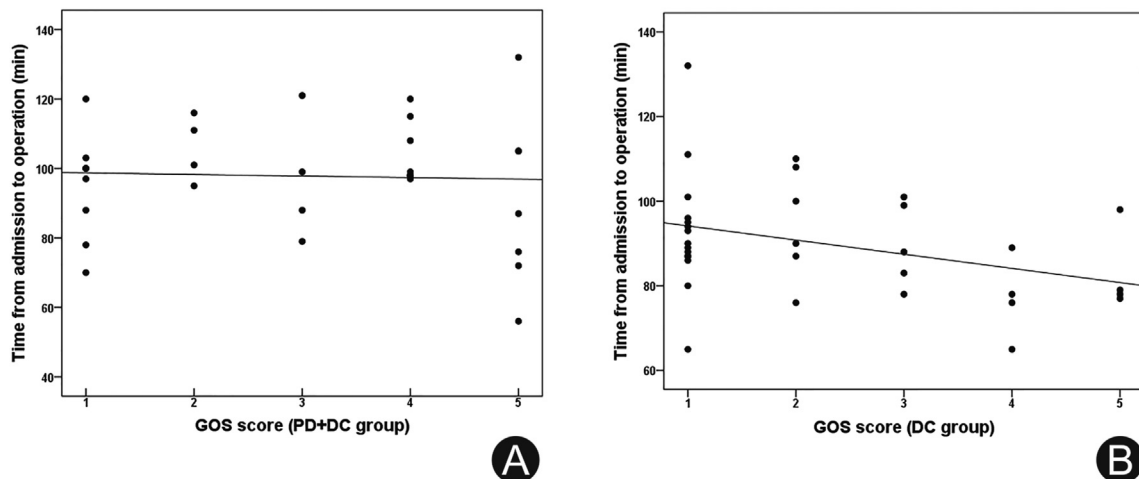


Fig. 3. A scatter diagram is depicted for the correlation between time from admission to operation (min) and GOS. The correlation was not linear in the PD + DC group ($p > 0.05$) at 6 months, whereas linear in the DC group ($p < 0.05$). PD: puncture drainage; DC: decompressive craniectomy; GOS: Glasgow outcome scale.

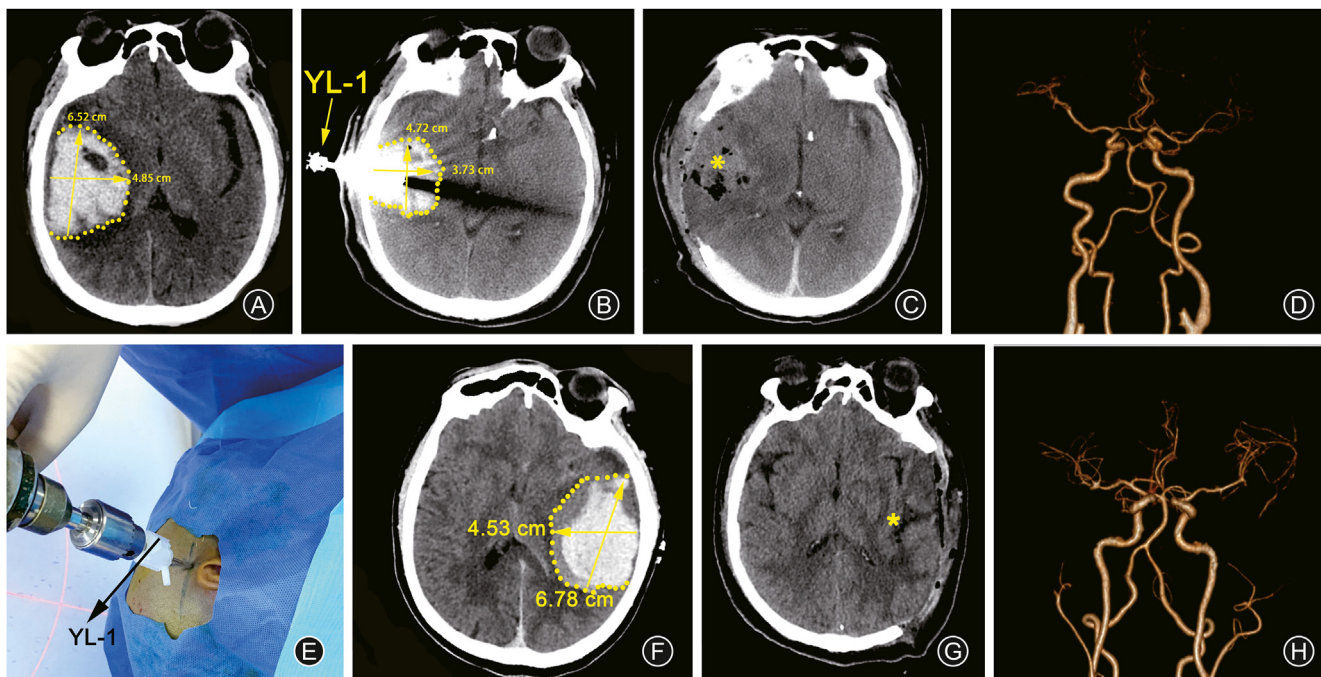


Fig. 4. Two typical cases. (A–E) A 65-year-old male in the PD + DC group. (A) Brain CT scan shows a right hemisphere hemorrhage. (B) Before decompressive craniectomy, the patient is treated by PD operation. (C) CT scan after DC operation. (D) CTA shows normal result. (E) Drilling with YL-1. The yellow dots denote the hematoma area. The double arrows denote the maximum diameter of the hematoma. The stars denote the hematoma removal area. The arrow denotes the YL-1 needle. DC: (F) Brain CT scans showed a left hemisphere hemorrhage. (G) CT scan after DC operation. (H) CTA was normal. PD: puncture drainage; DC: decompressive craniectomy; CTA: computed tomography angiography.

After 6 months of follow-up, the GOS score showed that the neurologic function of the PD + DC group was significantly better than that of the DC alone group. However, no significant difference has been revealed for the survival rate between the two groups, which might be caused by the small sample size.

Due to the low temperature and hypoxia at a high altitude, hypertension and heavy cerebral edema are frequent after cerebral hemorrhage in these areas¹⁶ and thus the recovery of nerve functions is poor.⁶ In this study, only patients whose time from onset to admission less than 3 h were selected, due to HICH, the onset time was long and the prognosis was very poor. The time from admission to operation in DC group was negatively correlated with the GOS outcomes, while PD + DC group was not significantly correlated. Therefore, it was an effective operation to extract part of the hematoma to decrease the intracranial pressure in patients with HICH and cerebral hernia in time. PD alone without DC operation is hard to achieve enough decompression, which will affect the prognosis of patients. HICH's edema is severe, and complete decompression of the bone flap is also critical.

This study was limited by the case load and retrospective design. These insufficiencies might limit the generalizability of our findings. To sum up, PD + DC was an effective treatment for patients with HICH and cerebral hernia.

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Ethical statement

Approval of the retrospective study was obtained from the research ethics committee at the Third Military Medical University (Army Medical University).

Declaration of competing interest

No potential conflict of interest was reported by the author(s).

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