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# The effect of tracheotomy timing on short-term prognosis in hypertensive intracerebral haemorrhage patients after craniectomy: a retrospective analysis of early vs late intervention

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### *Abstract*

*Objective:* The present study aimed to compare the clinical outcomes and short-term prognosis in patients with hypertensive intracerebral haemorrhage (HICH) with basal ganglia haematoma volume ≥ 60 mL who underwent early tracheotomy versus late tracheotomy post-craniectomy. *Methods:* A retrospective analysis was conducted based on the data of 102 patients with basal ganglia haematoma volume ≥ 60 mL after craniectomy between 2016 and 2021. Patients were divided into two groups: early tracheotomy and late tracheotomy. This study evaluated the effect of early tracheotomy on prognosis within 90 days and the impact of tracheotomy timing on overall survival in patients with HICH. *Results:* Patients in the early tracheotomy group showed a significant reduction in duration of ventilation and intracranial pressure (ICP) at 24 hours (post-tracheotomy) compared to those in the late tracheotomy group. Multivariable logistic regression indicated that late tracheotomy after craniectomy, old age, Glasgow Coma Scale (GCS) ≤ 6, large haematoma volume, and pneumonia after tracheotomy were risk factors for poor prognosis within 90 days in patients with HICH undergoing tracheotomy postoperatively. In terms of the impact of tracheotomy timing on overall survival in patients with HICH, 46 patients died within a follow-up period of 90 days; 19 in the early tracheotomy group (overall survival rate 62.7%), and 27 in the late tracheotomy group (overall survival of 47.1%). *Conclusions:* Early tracheotomy significantly improved the short-term prognosis of patients with HICH, with a higher overall survival rate compared to late tracheotomy within 90 days of illness.

*Keywords:* Hypertensive intracerebral haemorrhage, basal ganglia, haematoma volume, tracheotomy, short-term prognosis

## INTRODUCTION

Hypertensive intracerebral haemorrhage (HICH) is a spontaneous and non-traumatic cerebral condition accounting for 70% of acute stroke cases. It is associated with high mortality and morbidity, and is more prevalent among middle-aged and elderly individuals.[1] The long-term vascular disease imposed by potential hypertension weakens the elasticity of small and medium artery walls, leading to expanded blood vessels and thinned blood vessel walls, which is prominent in the lenticulostriate artery in the basal ganglia region. Bleeding in other regions such as the thalamus, subcortical white matter, pons, and cerebellum often co-occurs with hypertension, but shows a lower incidence than that in the basal ganglia.[2] When supratentorial haematoma volume reaches ≥ 60 mL, most patients experience lethal events due to intracranial hypertension and herniation. Moreover, the mass effect of the haematoma, the death of neurones and glial cells mediated by inflammatory reaction, vasogenic brain oedema, and damage to the blood-brain barrier can cause damage in the brain, which can promote a poor prognosis or even death.[3,4]

Patients with HICH requiring surgery usually experience more severe conditions, including the inability to discharge airway secretions, dysphagia, pneumonia, and even respiratory failure. Pneumonia is defined as inflammation of the bronchi, alveoli and interstitial spaces of the

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lungs due to pathogens such as bacteria, viruses, mycoplasma chlamydia or other causes. A rapid increase in inflammatory response after stroke onset is closely associated with the development of pneumonia.[5] Using prophylactic antibiotics and general ways to prevent pneumonia have not improved clinical outcomes in acute ICH patients.[6] It is more difficult to prevent pneumonia after craniectomy for HICH patients with basal ganglia hematoma volume ≥ 60 mL. In this condition, tracheotomy is a conducive and indispensable method for improving the prognosis. However, the most appropriate timeframe for tracheotomy after surgery remains unknown. Despite some studies involving patients with craniocerebral trauma and tracheotomy, the results remain controversial.[7-11] A previous canonical randomised trial (SETPOINT) on the time of tracheotomy had divided the patients into an early tracheotomy group (ET) (within 3 days) and a late tracheotomy group (LT) (7–14 days). This study reported that a percutaneous or conventional tracheotomy is usually performed when extubation attempts fail after 2 to 3 weeks of transoral intubation and demonstrated the safety and feasibility of ET. Additionally, the study found a significant reduction in the mortality rate in the ET group.[12]

Few studies have been conducted on the effect of ET on short-term prognosis in patients with HICH with massive haemorrhage. Therefore, we conducted a study to compare the clinical outcomes of ET and LT in patients with HICH with basal ganglia haematoma volume ≥ 60 mL to fill this gap.

## METHODS

The ethics committee of the hospital approved this study. A total of 267 patients who were mechanically ventilated after craniectomy for HICH from January 2016 to December 2021 were screened. Among them, 102 patients who met the study criteria were enrolled, and their clinical data were reviewed through the Hospital Information System. The ET group consisted of patients who underwent tracheotomy within 24 hours after craniectomy with haematoma evacuation, while the LT group included patients who underwent tracheotomy more than 24 hours after craniectomy with haematoma evacuation. (Figure 1)

The inclusion criteria of the study were: (1) Patients aged ≥ 45 years old who stayed in the hospital > 7 days; (2) Patients with a history of hypertension; (3) Patients with cerebral

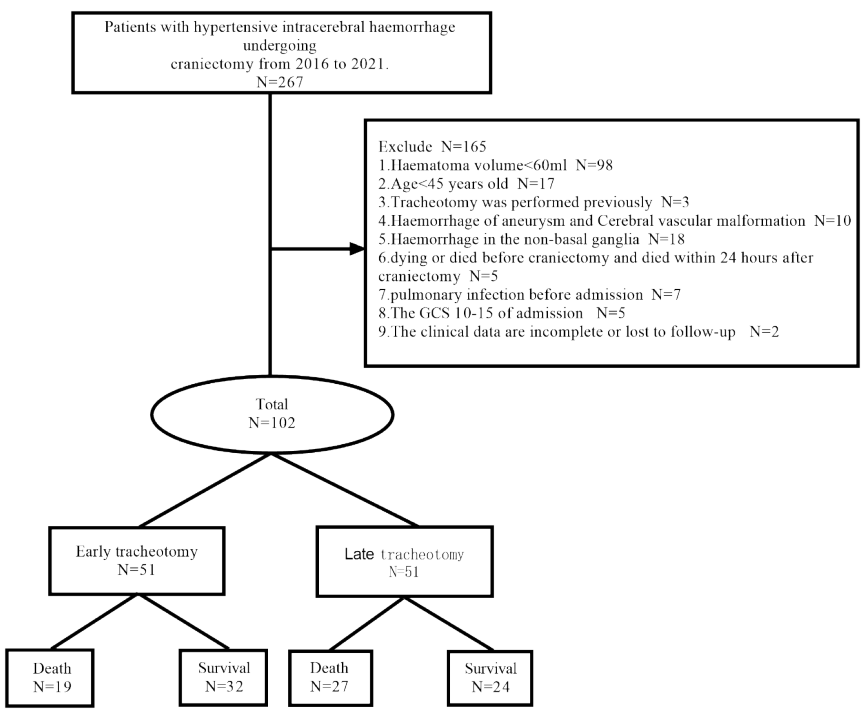


Figure 1. The flow chart shows the number of patients who underwent craniectomy for hypertensive intracerebral haemorrhage, the number of patients after screening according to inclusion and exclusion criteria, the number of patients who underwent early tracheotomy and late tracheotomy and the survival of these patients.

haemorrhage located at the basal ganglia and haematoma volume ≥ 60 mL; (4) Patients admitted to the neurosurgical ICU (NSICU) within 24 hours after onset without a history of tracheotomy; (5) Patients with a Glasgow Coma Scale (GCS) score of 3–9 at admission; (6) Patients who underwent emergency craniectomy within 6–24 hours after admission; and (7)Patients who underwent tracheotomy and mechanical ventilation for pneumonia after craniectomy, , and whose family members provided informed consent.

The exclusion criteria were: (1) Patients with pulmonary infection before admission; (2) Patients with a previous tracheotomy; (3) Patients with intracranial haemorrhage outside the basal ganglia induced by cerebrovascular diseases (aneurysms and arteriovenous malformations); (4) Patients who died within 24 hours after craniectomy or were in a state of near death before craniectomy; (5) Patients with serious diseases of the heart, lungs, liver, kidneys, and blood system; (6) Patients with a GCS score between 10–15 at admission; and (7) Patients with incomplete clinical data or those lost to follow-up.

*Pneumonia*

The diagnostic criteria for pneumonia include radiographic and clinical features. Chest radiography or computed tomography can reveal new or progressive and persistent infiltrates, consolidation, or pleural effusion. Clinical features required one of the following two: (1) fever (>38 °C); or (2) leukopenia (<4,000 WBC/$mm^3$) or leukocytosis (>12,000 WBC/$mm^3$), plus two or more of the following symptoms: (1) new onset of purulent sputum, change in character of sputum over a 24-hour period, increased respiratory secretions, or increased suctioning requirements; (2) new onset or worsening cough, dyspnoea, or tachypnoea (respiratory rate >25/min); (3) rales, crackles and/or bronchial breath sounds; and (4) hypoxemia.[13]

*Criteria and details for percutaneous tracheotomy*

Experienced attending physicians independently determined whether to perform percutaneous tracheotomy based on the daily ward rounds independent of the present study. The following criteria were adopted for percutaneous tracheotomy: (1) patients who required prolonged mechanical ventilation; (2) patients with failed extubation; and (3) patients with residual secretions from the lower respiratory tract. Surgery was performed by neurosurgeons in the NSICU.

The operative details of percutaneous tracheotomy: The patients were laid supine with a cushion under their shoulders. If tracheal intubation was performed, the distal end of the tracheal tube was confirmed before the needle was inserted into the trachea. After administering local anaesthesia (2% lidocaine), a transverse incision of approximately 1.5 cm long was made 1.5 cm below the cricoid cartilage (the puncture point). The needle was then inserted vertically into the trachea at the puncture point. Confirmation of correct needle placement was achieved by removing air bubbles from the syringe, after which 2 mL of 2% lidocaine was used for endotracheal anaesthesia. The needle guard was withdrawn, and guide wires were threaded through it. The subcutaneous tissue and tracheal wall were widened using the guide wires. Finally, a tracheal cannula was inserted into trachea along the guide wires and fixed by pumping air into the airbag.

*Data collection*

The clinical data of all the patients were investigated by at least two NSICU doctors. The baseline and clinical characteristics that were investigated included age, sex, smoking, alcohol consumption, comorbidity, GCS score on NSICU admission, National Institutes of Health Stroke Scale (NIHSS) score on NSICU admission, cerebral hernia preoperatively, location of haematoma, volume of haematoma, pneumonia post-tracheotomy, days of antibiotic use, days of ventilation, intracranial pressure (ICP) at 24 h (prior and post-tracheotomy), cerebral perfusion pressure (CPP) at 24 h (prior and post-tracheotomy), and the clinical outcome variables for NSICU stay, hospital stay, death, Glasgow Outcome Scale (GOS) at 1 month, and modified Rankin scale (mRs) at 3 months. In addition, the bacterial distribution in the pneumonia sputum was compared based on the culture results.

*Methods of data measurement*

ICP monitoring: An intracranial pressure probe was placed before surgery to continuously monitor ICP through the intracranial pressure monitor (Codman 82-6635, Johnson & Johnson, USA), and detect ICP by a probe inserted into the brain parenchyma, which was performed hourly for 24 h before and after the tracheotomy.

CPP monitoring: CPP = Diastolic + 1/3 (systolic–diastolic) – ICP.[14] ICP values were monitored by ICP monitor. Simultaneously, an electrocardiograph monitor (Hewlett-Packard,

HPM-1205A) was used to monitor blood pressure and obtain the CPP, which was recorded hourly for 24 h before and after tracheotomy.

*Statistical analysis*

The data were analysed using statistical software SPSS 25.0 and GraphPad Prism 8. The Kolmogorov–Smirnov test was performed to determine the normality of the measured data. Normally distributed data were expressed as mean (± SD), and non-normally distributed data as median (interquartile range). Differences in normally distributed data were compared using the independent-samples t-test, and non-normally distributed data were compared using the Mann–Whitney U test. Categorical variables were compared using chi-square analysis. Univariable logistic regression was performed to identify significant variables in mRs < 4 and mRs ≥ 4. The effect of ET on poor prognosis within 90 days in patients with HICH were finally filtered out by multivariable logistic regression.

The survival rate of patients with HICH within 90 days between ET and LT was compared using the Kaplan–Meier curve, and the log-rank test was applied to test the survival rate between the two groups. Statistical significance was set at $P < 0.05$.

## RESULTS

A total of 102 patients with HICH who underwent craniectomy were included, comprising 57 men (55.9%) and 45 women (44.1%). There were 51 patients each in the ET and the LT groups. The mean age was 63.09 ± 7.93 years (range 45–82 years). Significant differences were observed in the duration of antibiotic use, the duration of ventilation, ICP at 24 h (post-tracheotomy), and CPP at 24 h (post-tracheotomy) ($P < 0.05$). Age, sex, BMI, smoking, alcohol consumption, coronary heart disease, diabetes, hyperlipidaemia, GCS score on NSICU, NIHSS score on NSICU, pre-operative cerebral hernia, location of haematoma, pneumonia post-tracheotomy, volume of haematoma, ICP at 24 h (prior to tracheotomy), and CPP at 24 h (prior to tracheotomy) showed no statistically significant differences ($P > 0.05$) (Table 1).

When patients who died in the NSICU were excluded, the ET group had significantly lower NSICU stay (median 15 days vs. median 20 days) and hospital stay (median 28 days vs. median 36 days) ($P < 0.05$). One month after surgery, patients were divided into two groups: one group with GOS 4–5 (good outcome group; 22 patients) and the other with GOS 1–3 (poor outcome group; 80 patients); the patients who underwent ET were associated with good outcomes ($P > 0.05$). At 3 months after surgery, patients were divided into two groups again: one group with mRs 0–3 (good outcome group, 17 patients) and the other with mRs 4–6 (poor outcome group, 85 patients). Patients who underwent ET had better outcomes than those who underwent LT ($P < 0.05$). (Table 2)

For each patient with HICH and pneumonia after craniectomy, sputum sample was cultured for pathogens at least once, and some patient samples were repeatedly cultured for pathogens as part of their clinical treatment for pneumonia. Different results were obtained from repeated cultures from the same patient, and these were recorded. In the ET group, three patients had a negative pathogen culture. Single pathogens were found in sputum from 11 patients, two types of pathogens were found in cultured sputum from 21 patients, three types of pathogens were found in cultured sputum from one patient, and one patient had prolonged anti-pneumonia therapy, during which pathogen culture results showed four types of pathogenic bacteria. In the LT group, two patients had a negative pathogen culture, single pathogens were found in the sputum from 17 patients, and two kinds of pathogens were found in the cultured sputum from 22 patients. Three types of pathogens were found in cultured sputum from two patients.

Regarding the distribution of pathogens causing pneumonia in patients with HICH, *Staphylococcus aureus* was found in 14 cases (11.0%), haemolytic Streptococcus in one case (0.8%), *Staphylococcus epidermidis* in three cases (2.4%), *Klebsiella pneumoniae* in 19 cases (15.0%), *Pseudomonas aeruginosa* in 46 cases (36.2%), *Acinetobacter baumannii* in 21 cases (16.5%), and *Escherichia coli* in 23 cases (18.1%). Among these, *Pseudomonas aeruginosa* was the most common pathogen causing pneumonia in patients with HICH, followed by *Escherichia coli, Acinetobacter baumannii*, and *Klebsiella pneumoniae* (Figure 2).

Univariable logistic regression revealed that LT, old age, large haematoma volume, and pneumonia after tracheotomy were independently associated with poor prognosis at 90 days of illness in patients with HICH. Collinearity diagnosis confirmed that all variables had a variance inflation factor (VIF) < 5, allowing their inclusion in a multivariable logistic regression model using the stepwise forwards method. The

**Table 1: Patients' baseline and clinical characteristics**

| Variables | Early Tracheotomy (n=51) | Late Tracheotomy (n=51) | Total (n=102) | $X^2$/t/Z | *p*-value |
|---|---|---|---|---|---|
| Age (year) | 62.61±8.43 | 63.57±7.44 | 63.09±7.93 | -0.61 | 0.543 |
| Sex; n (%) | | | | 0.04 | 0.842 |
| Male | 28(54.9) | 29(56.9) | 57(55.9) | | |
| Female | 23(45.1) | 22(43.1) | 45(44.1) | | |
| BMI | 25.4(23.4,27.0) | 26(24,28) | 25.6(23.7,27.6) | -1.21 | 0.227 |
| Smoking; n (%) | 24(47.1) | 26(51.0) | 50(49.0) | 0.157 | 0.692 |
| Alcohol consumption; n (%) | 19(37.3) | 21(41.2) | 40(39.2) | 0.165 | 0.685 |
| Comorbidity; n (%) | | | | | |
| Coronary heart disease | 12(23.5) | 13(25.5) | 25(24.5) | 0.053 | 0.818 |
| Diabetes | 7(13.7) | 10(9.8) | 17(39.2) | 0.635 | 0.425 |
| Hyperlipemia | 19(37.3) | 26(51.0) | 45(44.1) | 1.949 | 0.163 |
| GCS score on NSICU Admission; n (%) | | | | 3.022 | 0.082 |
| ≤ 6 | 32(62.7) | 40(78.4) | 72(70.6) | | |
| >6 | 19(37.3) | 11(21.6) | 30(29.4) | | |
| NIHSS score on NSICU Admission | 34(29,35) | 34(31,37) | 34(30,37) | -1.53 | 0.126 |
| Cerebral hernia pre-operative; n (%) | 36(70.6) | 38(74.5) | 74(72.5) | 0.197 | 0.657 |
| Location of haematoma; n (%) | | | | 0.628 | 0.428 |
| Left | 23(45.1) | 27(53.0) | 50(49.0) | | |
| Right | 28(54.9) | 24(47.0) | 52(51.0) | | |
| Pneumonia post tracheotomy; n (%) | 37(72.5) | 43(84.3) | 80(78.4) | 2.086 | 0.149 |
| Volume of haematoma | 73(66,84) | 73(67,81) | 73(67,82) | -0.234 | 0.815 |
| Days of antibiotic use | 9(6,11) | 13(11,15) | 11(7.75,14) | -4.430 | <0.001 |
| Days of ventilation | 11(6,14) | 15(10,17) | 13(9,17) | -3.473 | 0.001 |
| ICP at 24h(prior-tracheotomy) | 17(16,18) | 17(16,19) | 17(16,18) | -0.221 | 0.826 |
| ICP at 24h (post-tracheotomy) | 15(14,17) | 17(15,18) | 16(14,18) | -2.290 | 0.022 |
| CPP at 24h (prior-tracheotomy) | 79(73,83) | 79(74,83) | 79(74,83) | -0.755 | 0.45 |
| CPP at 24h (post-tracheotomy) | 83(78,85) | 79(75,83) | 81(76.75,84.25) | -1.992 | 0.046 |

SD, Standard deviation; BMI, Body mass index; GCS, Glasgow Coma Scale; NIHSS, National Institutes of Health Stroke Scale; NSICU, Neurosurgical intensive care unit; ICP, Intracranial pressure; CPP, Cerebral perfusion pressure

results showed that LT after surgery (OR 10.601, 95% CI 1.612–69.724), old age (OR 1.128, 95% CI 1.001–1.272), GCS ≤ 6 (OR 5.936, 95% CI 1.178–29.902), large haematoma volume (OR 1.151, 95% CI 1.006–1.316), and pneumonia after tracheotomy (OR 12.333, 95% CI 3.793–40.107) were risk factors for poor prognosis at 90 days in post-operative patients with HICH undergoing tracheotomy (Table 3).

During the 90-day follow-up period, 46 patients died, including 19 in the ET group (overall survival 62.7%) and 27 in the LT group (overall survival of 47.1%). The Kaplan–Meier curve revealed a significant statistical difference in overall survival between the two groups (Log-rank $X^2$=4.138, *P*=0.04). The ET group did not reach the median survival time, whereas the median survival time in the LT group was 61 days (Figure 3).

**Table 2: Clinical outcomes**

| Variables | Early Tracheotomy (n=51) | Late Tracheotomy (n=51) | Total (n=102) | Z/X$^2$ | *p*-value |
|---|---|---|---|---|---|
| NSICU stay (days) | 15(12,21) | 20(18,24) | 19(14,23) | -3.117 | 0.002 |
| hospital stay (days) | 28(24,34) | 36(30,39) | 33(25,37) | -3.411 | 0.001 |
| death; n(%) | 19(37.3) | 27(52.9) | 46(45.1) | 2.534 | 0.111 |
| GOS at 1 month; n(%) | | | | 2.086 | 0.149 |
| ≤ 3 | 37(72.5) | 43(42.2) | 80(78.4) | | |
| > 3 | 14(27.5) | 8(57.8) | 22(21.6) | | |
| mRs at 3 month; n(%) | | | | 11.929 | 0.001 |
| < 4 | 15(29.4) | 2(3.9) | 17(16.7) | | |
| ≥ 4 | 36(70.6) | 49(96.1) | 85(83.3) | | |

NSICU, Neurosurgical intensive care unit; GOS, Glasgow Outcome Scale; mRs: modified Rankin scale

## DISCUSSION

Several studies have used a cut-off value of 30 mL to determine the adverse effects of haematoma volume on the prognosis of HICH, including the ATACH-I and ATACH-II clinical grading scales and well as the ICH scoring scale. However, these scales excluded patients with haematoma volumes > 60 mL, leading to incomplete or meaningless study results, as higher mortality rates of these patients resulted in missing trial results before patients death. In a study by Broderick *et al*., which covered 162 patients with HICH having haematoma volumes > 60 mL, the mortality rate of deep cerebral haemorrhage and lobar haemorrhage was 71%–93% and 71%, respectively.[15] A retrospective cohort study in 2009 found an undetermined prognosis for haematoma volumes between 30 and 59 mL, whereas haematoma volumes of > 60 mL were associated with higher mortality within 30 days after onset.[16] Another study in 2017, which covered 27 patients with HICH undergoing operative treatment, concluded

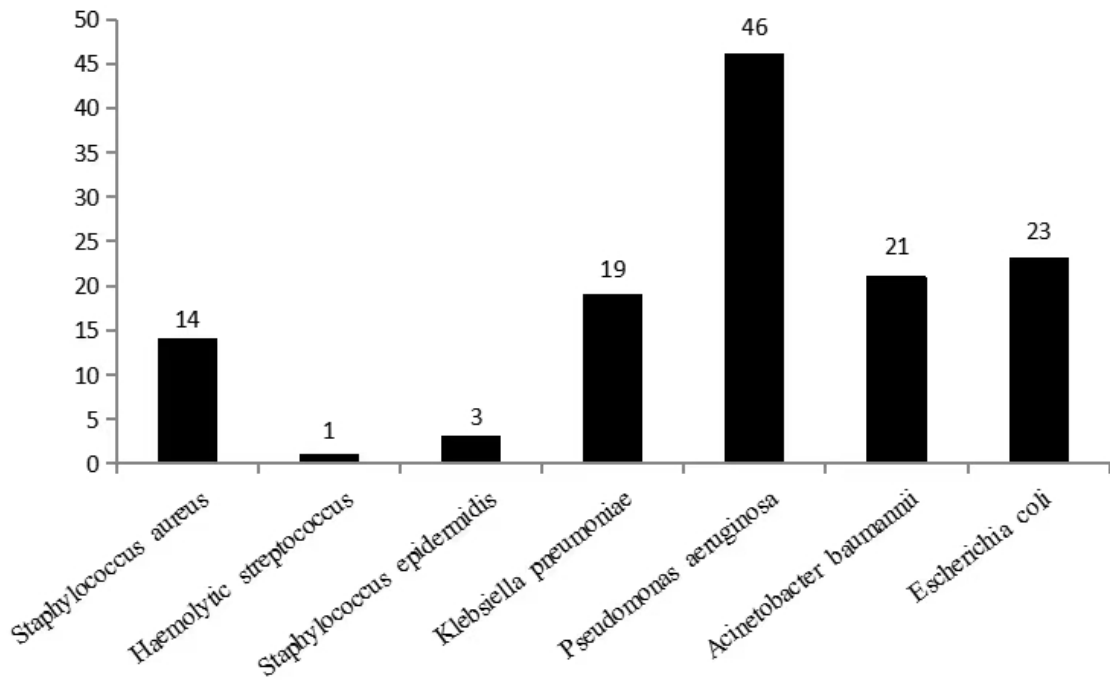


Figure 2. The bacterial distribution of sputum culture of 102 patients

**Table 3: Univariate regression and multivariate regression analysis on the risk factors of poor outcome in tracheotomy patients with hypertensive intracerebral haemorrhage**

| Characteristic | Univariate logistic regression | | Multivariate logistic regression | |
|---|---|---|---|---|
| | Odd ratio (95% confidence interval) | *p*-value | Odd ratio (95% confidence interval) | *p*-value |
| early tracheotomy versus late tracheotomy | 6.667(1.794,24.776) | 0.005 | 9.712(1.518,62.146) | 0.016 |
| Age | 1.101(1.025,1.182) | 0.008 | 1.128(1.001,1.272) | 0.049 |
| Sex | | | | |
| male versus female | 1.155(0.402,3.321) | 0.789 | | |
| BMI | 1.013(0.852,1.204) | 0.884 | | |
| GCS score on NSICU Admission | | | | |
| > 6 versus ≤ 6 | 13(3.761,44.936) | <0.001 | 5.936(1.178,29.902) | 0.031 |
| NIHSS score on NSICU Admission | 0.948(0.824,1.090) | 0.452 | | |
| Cerebral hernia pre-operative | | | | |
| yes versus no | 2.889(0.985,8.474) | 0.053 | | |
| Location of haematoma | | | | |
| left versus right | 1.877(0.636,5.537) | 0.254 | | |
| Volume of haematoma | 1.171(1.064,1.289) | 0.001 | 1.151(1.006,1.316) | 0.04 |
| Pneumonia post tracheotomy | | | | |
| yes versus no | 10.429(3.335,32.611) | <0.001 | 7.332(1.396,38.505) | 0.019 |

BMI: Body mass index; GCS, Glasgow Coma Scale; NIHSS, National Institutes of Health Stroke Scale; NSICU, Neurosurgical intensive care unit

that haematoma volumes > 60 mL could result in the worst outcomes at the third month after surgery.[17] Based on previous studies, our study selected 102 patients with HICH having haematoma volumes of > 60 mL. According to evaluations by neurosurgeons, the possibility of

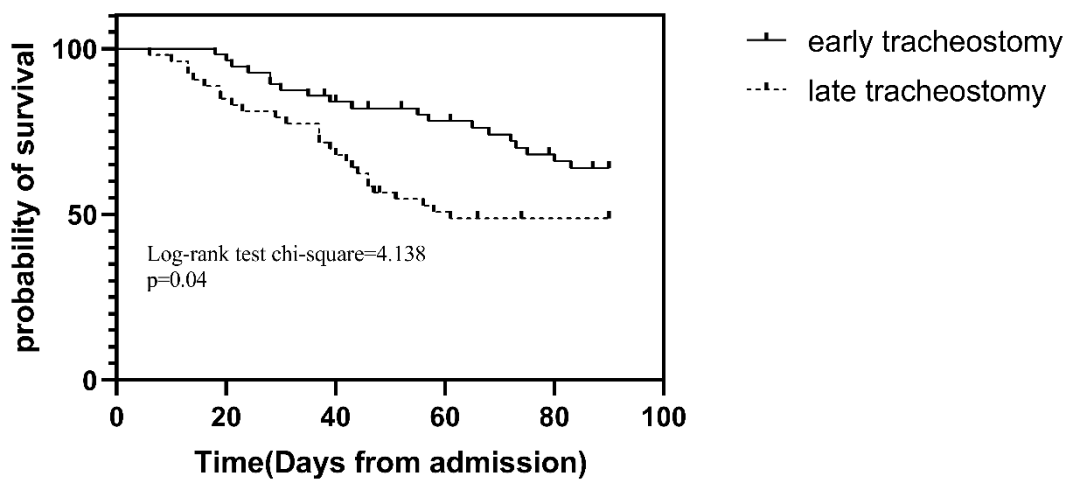


Figure 3. K-M survival curve within 90 days of illness

extubation within 1–3 weeks post-intubation is limited; therefore, tracheotomy was adopted to optimise nursing interventions and respiratory tract care, restore brain cell oxygen uptake, prevent pulmonary and throat injury, reduce the use of sedatives, improve patient comfort, and achieve a prominently improved prognosis.

Previous studies have suggested a significantly reduced incidence of pneumonia resulting from ICH brain injury with ET, which can improve oxygenation by promoting the clearance of lung secretions and the exchange of alveolar air, as well as reducing the dead space of mechanical ventilation and work done by breathing muscles.[18] Furthermore, sputum culture has indicated Pseudomonas aeruginosa, Acinetobacter baumannii, and Escherichia coli as the primary bacteria in the most serious patients.[19] with the first two organisms being commonly seen in immobilised patients with pneumonia and characterised by antimicrobial resistance. Methicillin-resistant *Staph. aureus* (MRSA) is a type of secondary bacterium that is sensitive to antibiotics and relatively easy to cure. After surgery, patients with HICH mainly exhibit a high lung infection rate, excessive phlegm, and weak breathing, requiring strengthened sputum aspiration, airway inhalation, and humidification by nurses. Our study further proved that ET has some advantages in reducing pneumonia, minimising antibiotics time, and reducing the nurses' workload.

We expected age to be a significant factor affecting the short-term prognosis in patients with HICH undergoing tracheotomy. Patients aged between 45 and 82 years generally suffer from severely high blood pressure. On one hand, patients with coronary artery and double renal arteries disease are more likely to experience atherosclerosis, resulting in irrigation insufficiency and a decline in organ function. On the other hand, older patients with HICH may not tolerate surgery and anaesthetisation, leading to more severe neurological injury caused by massive haemorrhage and surgery, which contributes to a poor prognosis. The GCS score on admission was strongly correlated with the state of consciousness and cognition after onset. A lower GCS score indicated more severe damage to neurological function. The consciousness of each patient was promptly assessed using the GCS on admission, and 97.1% of all patients had a GCS score of 3–8. The International Surgical Trial in Intracerebral Hemorrhage study conducted in 2005 showed that GCS 5–8 after surgical treatment was associated with a poor prognosis in patients with ICH.[20] This outcome could be related to the probable connection with larger blood loss. Studies have demonstrated a 5% increase in the risk of death for every 10% increase in the volume of haematoma, or a 7% increase in the risk of death for every 1 mL increase in the volume of haematoma.[21]

NSICU and hospital stays exhibited a remarkable disparity between the two groups, which served as significant outcome variables as measures of the patient's condition. That is, ET significantly reduced NSICU and hospital stays after excluding the deceased patients. This result is in accordance with the research of others[22-24], which may be due to two main reasons. On the one hand, patients with LT tend to have a relatively high incidence of pneumonia, weak immunity, and prolonged recumbence. On the other hand, ET can effectively improve patients' respiratory function, alleviate breathing resistance, promptly relieve the symptoms of cerebral ischaemia and hypoxia, and reduce the incidence of secondary brain injury or oedema, thereby reducing ICP and increasing CPP. Moreover, compared to LT, ET can speed up the recovery of neural function and elevate the survival rates of patients after surgery for hypertensive cerebral hemorrhage.[25]

However, our study had several limitations. It was a small-sample, single-centre study that has not been verified in other hospitals or agencies. Some patients with HICHs who underwent tracheotomy exhibited a relatively high incidence of mortality within 90 days of illness due to diverse treatments and nursing measures. We studied the effects of short-term prognosis on the timing of tracheotomy; however, the long-term prognosis remains unknown.

In conclusion, for patients with HICH treated with craniectomy evacuation of the haematoma, ET reduced the number of days required for respiratory support and antibiotics, ICP within 24 hours (post-tracheotomy), days of NSICU stay, and hospital stay. Moreover, ET improved patient prognosis within 90 days of illness onset. Conversely, LT after surgery, old age, large haematoma volume, and pneumonia after tracheotomy were identified as risk factors for poor prognosis at 90 days in patients with HICH undergoing tracheotomy postoperatively. The overall survival rate in the ET group was significantly higher than that in the LT group within 90 days of illness.

## DISCLOSURE

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Conflict of interest: None

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