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EMPIRICAL RESEARCH MIXED METHODS

Enhancing blood pressure management protocol implementation in patients with acute intracerebral haemorrhage through a nursing-led approach: A retrospective cohort study

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Abstract

Aim: To evaluate the impact of nurse care changes in implementing a blood pressure management protocol on achieving rapid, intensive and sustained blood pressure reduction in acute intracerebral haemorrhage patients.

Design: Retrospective cohort study of prospectively collected data over 6 years.

Methods: Intracerebral haemorrhage patients within 6 h and systolic blood pressure ≥ 150 mmHg followed a rapid (starting treatment at computed tomography suite with a target achievement goal of ≤60 min), intensive (target systolic blood pressure < 140 mmHg) and sustained (maintaining target stability for 24 h) blood pressure management plan. We differentiated six periods: P1, stroke nurse at computed tomography suite (baseline period); P2, antihypertensive titration by stroke nurse; P3, retraining by neurologists; P4, integration of a stroke advanced practice nurse; P5, after COVID-19 impact; and P6, retraining by stroke advanced practice nurse. Outcomes included first-hour target achievement (primary outcome), tomography-to-treatment and treatment-to-target times, first-hour maximum dose of antihypertensive treatment and 6-h and 24-h systolic blood pressure variability.

Results: Compared to P1, antihypertensive titration by stroke nurses (P2) reduced treatment-to-target time and increased the rate of first-hour target achievement,

retraining of stroke nurses by neurologists (P3) maintained a higher rate of first-hour target achievement and the integration of a stroke advanced practice nurse (P4) reduced both 6-h and 24-h systolic blood pressure variability. However, 6-h systolic blood pressure variability increased from P4 to P5 following the impact of the COVID-19 pandemic. Finally, compared to P1, retraining of stroke nurses by stroke advanced practice nurse (P6) reduced tomography-to-treatment time and increased the first-hour maximum dose of antihypertensive treatment.

Conclusion: Changes in nursing care and continuous education can significantly enhance the time metrics and blood pressure outcomes in acute intracerebral haemorrhage patients.

Reporting Method: STROBE guidelines.

Patient and Public Contribution: No Patient or Public Contribution.

KEYWORDS
adult nursing, evidence-based practice, practice nursing, stroke

1 | INTRODUCTION

Intracerebral haemorrhage (ICH) is associated with higher morbidity and mortality rates compared to other stroke subtypes, with a one-month mortality of about 40%, and merely 20% of patients achieve independence (Van Asch et al., 2010). This devastating impact, combined with the social and healthcare burden, underscores the urgent need for effective treatments to improve outcomes in ICH patients (Greenberg et al., 2022).

Elevated blood pressure (BP) is common in patients with acute ICH and is associated with a higher risk of hematoma expansion and poor outcomes (Qureshi et al., 2007; Rodriguez-Luna et al., 2013; Willmot et al., 2004). The third Intensive Care Bundle with BP Reduction in Acute Cerebral Haemorrhage Trial (INTERACT3) recently demonstrated that intensive lowering of BP, targeting systolic BP (SBP) of <140 mmHg, as part of a care bundle protocol leads to improved functional outcome in patients with acute ICH (Ma et al., 2023). The most likely mechanistic action behind the benefit of intensive BP reduction is its potential to attenuate hematoma expansion, a phenomenon that predominantly occurs within the first 6 h from symptom onset (Cordonnier et al., 2018; Fujii et al., 1994). However, challenges persist in achieving rapid and intensive BP reduction during the acute phase of ICH (Anderson et al., 2013; Ma et al., 2023; Qureshi et al., 2016). Furthermore, not only high BP but also high SBP variability has been related to poor outcome in patients with acute ICH (Manning et al., 2014; Rodriguez-Luna et al., 2013). Therefore, it is important not only to maintain BP low but also to keep it stable avoiding high SBP variability during the acute phase of ICH (Pancorbo & Rodriguez-Luna, 2018).

To achieve rapid, intensive and sustained BP control in patients with acute ICH, we implemented an institutional acute ICH BP protocol centred around nursing care that involved the attention of a stroke nurse at bedside from patient admission (Sanjuan Menendez et al., 2019). We hypothesized that successive changes in nursing care for patients with acute ICH, with a progressive shift towards nurses taking the lead in BP management, would lead to improved time metrics and BP outcomes. The main objective of the present study was to assess the relationship between changes in nurse attention of acute ICH patients and the time taken to achieve an intensive SBP target. Secondarily, we aimed to evaluate the effect of these changes on BP management and the achievement of sustained BP control during the acute phase of ICH.

In this study, the independent variables comprised six sequential stages of nursing care adjustments implemented for patients with acute ICH. Meanwhile, the dependent variables encompassed multiple metrics, including the duration taken from the computed tomography acquisition to the initiation of antihypertensive treatment and from treatment initiation to the achievement of the SBP target. Additionally, variables consisted of the rate of achieving the SBP target within the first hour, the maximum antihypertensive dosage administered during this hour, the mean SBP recorded from hour 1–6 and hour 1–24, along with the SBP variability across these time frames.

What does this paper contribute to the wider global clinical community?

- Titration of antihypertensive treatment by stroke nurses leads to a reduction in the time taken to achieve an intensive systolic blood pressure target.
- Integration of a stroke advanced practice nurse into the stroke care team reduces systolic blood pressure variability and contributes to more stable blood pressure control.
- Ongoing education and training for stroke nurses result in increased confidence in initiating and titrating antihypertensive treatment.

2 | METHODS

The report of this study follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines (Data S1) (von Elm et al., 2007).

2.1 | Study design

We conducted a single-centre, retrospective, observational cohort study using prospectively collected data from consecutive non-comatose patients aged ≥18 years with spontaneous ICH who were scanned within 6 h from symptom onset and had a SBP ≥150 mmHg over a 6-year period. Our study included patients from 1 March 2016, to 31 August 2022. Notably, patients from 1 March 2020, to 31 August 2020, were excluded from the study due to changes in the acute management of ICH patients caused by the COVID-19 pandemic during this 6-month period. Exclusion criteria encompassed patients with a known secondary cause of ICH, those who had care withdrawn following computed tomography scan acquisition, those not treated with antihypertensive agents, and those with missing BP monitoring recordings.

2.2 | Rapid, intensive and sustained BP monitoring and management protocol

Upon admission, relevant demographic characteristics, medical history, clinical presentation, stroke severity and ICH volume were recorded. Brain computed tomography was performed according to standard techniques at baseline. All patients underwent an institutional acute ICH BP protocol, which involved non-invasive BP monitoring started at computed tomography suite and continued in the Stroke Unit, along with a rapid, intensive and sustained BP management plan implemented within the first 24 h following the ICH diagnosis. BP measurements were taken at the following intervals: every 15 min during the first 6 h, every 30 min from 6 to 12 h, and every 60 min from 12 h to 24. More frequent measurements were conducted if significant BP fluctuations were observed.

The rapid, intensive and sustained BP management protocol comprised three key interventions:

1. Rapid Antihypertensive Treatment Initiation: A single bolus of intravenous antihypertensive treatment was administered by a stroke nurse immediately upon computed tomography scan acquisition.

2. Rapid and Intensive BP Reduction: The objective was to achieve a SBP target of <140 mmHg within 1 h from the initiation of antihypertensive treatment.

3. Sustained BP Control: Following the intravenous bolus, a stroke nurse initiated intravenous continuous infusion of antihypertensive medication to ensure a sustained BP reduction and minimise SBP variability.

Intravenous antihypertensive agents were initiated when SBP exceeded 150 mmHg, in accordance with the guidelines published at that time (Hemphill JC III et al., 2015; Steiner et al., 2014). Urapidil was used as the first-line agent, while labetalol was employed as a second-line drug.

2.3 | Study periods

During the years, following the initial implementation of the BP management protocol, we introduced successive changes in nursing care to optimise rapid, intensive and sustained BP reduction. To assess the impact of the successive improvements in nurse attention, we differentiated six periods:

- Period 1, Stroke Nurse at Computed Tomography Suite (1 March 2016 to 28 February 2017; 12 months): We introduced antihypertensive treatment initiation by a stroke nurse at the forefront of the acute ICH care pathway, the computed tomography suite. This period served as the baseline period.

- Period 2, Titration by Stroke Nurse (1 March 2017 to 30 April 2018; 14 months): Stroke nurses took the lead for titrating intravenous antihypertensive treatment during the first 24 h to achieve the SBP target of <140 mmHg earlier and to reduce SBP variability.

- Period 3, Retraining by Neurologists (1 May 2018 to 31 January 2019; 9 months): Stroke neurologists conducted retraining for stroke nurses to reduce the time taken to achieve the SBP target and minimise SBP variability. Additionally, a stroke advanced practice nurse was trained to become an expert in caring for ICH patients.

- Period 4, Integration of Stroke Advanced Practice Nurse (1 February 2019 to 28 February 2020; 13 months): We integrated the stroke advanced practice nurse into the stroke unit staff to offer support to stroke nurses during the monitoring and management of BP for patients with acute ICH.

- Period 5, After COVID-19 Impact (1 September 2020 to 31 August 2021; 12 months): In response to the COVID-19 pandemic's impact, we progressively reintroduced the practice of directly admitting patients from the computed tomography suite to the Stroke Unit, bypassing the emergency room, which had been temporarily halted at the beginning of the pandemic.

- Period 6, Retraining by Stroke Advanced Practice Nurse (1 September 2021 to 31 August 2022; 12 months): The stroke advanced practice nurse conducted retraining sessions for stroke nurses with the aim of reducing the time required to achieve the SBP target and minimising SBP variability.

2.4 | Outcomes

The primary outcome was the achievement of a SBP target of <140 mmHg within the first hour after the initiation of antihypertenive treatment. Secondary outcomes included the time elapsed from computed tomography acquisition to the initiation of antihypertensive treatment and from the initiation of antihypertensive treatment to the achievement of the SBP target, along with the maximum dose of the antihypertensive agent used during the first

hour of treatment. Additionally, we assessed the mean SBP and SBP variability from hour 1–6 and from hour 1–24 to evaluate sustained BP control. SBP variability was defined as the standard deviation of the mean SBP (Parati, 2005; Rodriguez-Luna et al., 2013).

2.5 | Statistical analysis

The statistical analysis was performed using R 3.6.2 statistical Software (R Foundation for Statistical Computing, Vienna, Austria). Categorical variables are presented as absolute values (%) and continuous variables as means ± standard deviations or medians (interquartile intervals). Normality of continuous variables was assessed using the Shapiro–Wilk test. Statistical significance for differences between groups was determined using the Pearson χ^2 test for categorical variables and the Kruskal-Wallis test for continuous variables, followed by the Dunn test for multiple comparisons. The adjusted p values reported for the Dunn tests were adjusted for multiplicity using the Bonferroni method, derived by multiplying the unadjusted p value by the number of comparisons. This approach ensured stringent control over the familywise error rate, maintaining a significance level below 0.05. Hence, a p value of <0.05 was considered statistically significant for all tests.

2.6 | Ethical considerations

The study protocol was approved for waiver of consent on November 18th, 2022, by the Vall d'Hebron University Hospital Ethics Committee (PR[AG]426/2022).

3 | RESULTS

3.1 | Study population

A total of 200 patients (mean age 70.7 ± 13.5 years, 135 [67.5%] male) were included in the current study (Figure 1): 28 (14.0%) patients in Period 1, 29 (14.5%) in Period 2, 30 (15.0%) in Period 3, 40 (20.0%) in Period 4, 27 (13.5%) in Period 5, and 46 (23.0%) in Period 6.

None of the continuous variables showed a normal distribution (Table 1). Key baseline characteristics of the study population are summarised in Table 2. The mean SBP on admission was 179.3 ± 20.6 mmHg, and no statistically significant differences were observed across the various study periods (Table 2), as confirmed by the Dunn's test (adjusted $p > 0.050$ for all combinations). The median time from symptom onset to computed tomography acquisition was 120 (75.8–216) min, and the median baseline ICH volume was 12.8 (5.7–29.2) mL.

3.2 | Rapid and intensive BP reduction

All 200 patients received intravenous BP-lowering treatment, with the treatment initiated at a median time of 8 (4–17) min following the acquisition of the computed tomography scan. There was a trend towards a reduction in the time interval between the computed tomography scan acquisition and the commencement of antihypertensive treatment across study periods 1 to 6 (Table 3, $p = 0.084$) and, compared with Period 1, this time was statistically significantly shorter in Period 6 (14 [7–30] vs. 7 [4–11] min, adjusted $p = 0.029$).

The median time from antihypertensive treatment initiation to achieving the SBP target was 52 (30–85) min and exhibited variations

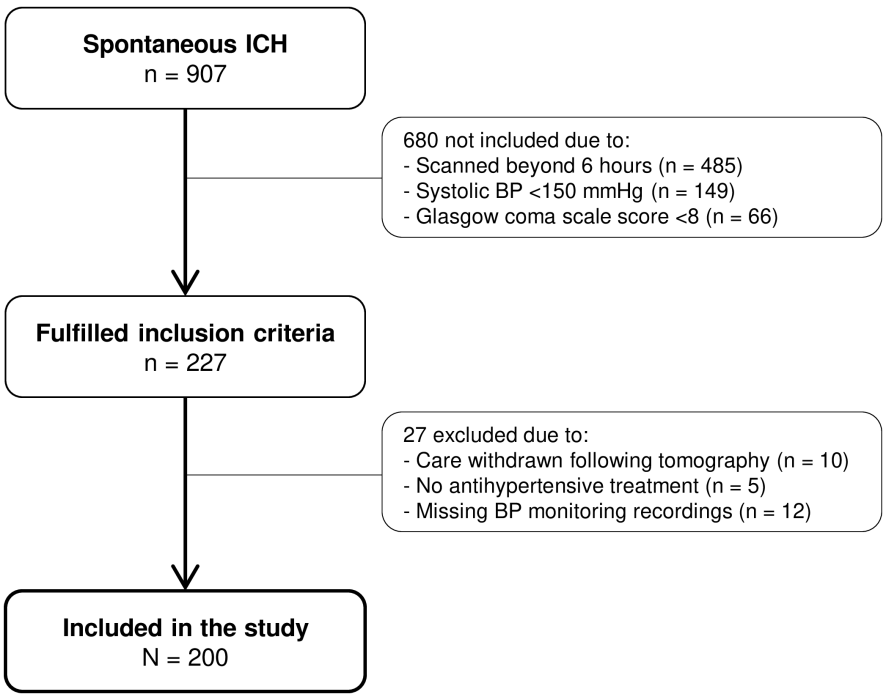

FIGURE 1 Flowchart of patients included in the study. BP, blood pressure; ICH, intracerebral haemorrhage.

TABLE 1 Normality assessment of continuous variables.

	Shapiro–Wilk test	
	W statistic	*p* value
Main baseline characteristics		
Age	0.96	<0.001
SBP	0.95	<0.001
DBP	0.98	0.002
Onset-to-imaging time	0.83	<0.001
ICH volume	0.83	<0.001
Outcomes		
Time from CT to antihypertensive treatment initiation	0.19	<0.001
Time from treatment initiation to SBP target achievement	0.66	<0.001
Maximum dose of urapidil during first hour	0.79	<0.001
Mean SBP from hour 1–6	0.94	<0.001
Mean SBP from hour 1–24	0.88	<0.001
SBP variability from hour 1–6	0.94	<0.001
SBP variability from hour 1–24	0.93	<0.001

Abbreviations: CT, computed tomography; DBP, diastolic blood pressure; ICH, intracerebral haemorrhage; SBP, systolic blood pressure.

across the different study periods (Table 3, $p=0.002$). Compared to Period 1 (120 [57–240] min), this time was statistically significantly shorter in Periods 2 (49 [25–63] min, adjusted $p=0.025$), 4 (40 [20–59] min, adjusted $p<0.001$), and 6 (51 [31–73] min, adjusted $p=0.047$).

A total of 130 (65.0%) patients achieved the SBP target within the first hour. The frequency of reaching the SBP target within the first hour increased across periods (Table 3, Figure 2, $p=0.002$). The frequency was statistically significantly higher than in Period 1 (8 [28.6%]) in Periods 2 (20 [69.0%], adjusted $p=0.003$), 3 (21 [70.0%], adjusted $p=0.003$), 4 (32 [80.0%], adjusted $p<0.001$) and 6 (32 [69.6%], adjusted $p=0.013$). However, compared with Period 1, there was no statistically significant differences in the frequency of SBP achievement within the first hour in Period 5 following the COVID-19 pandemic (8 [28.6%] vs. 17 [63.0%], adjusted $p=0.208$).

Out of the total, 198 (99.0%) patients received urapidil as the first-line antihypertensive treatment, while two (1.0%) patients were administered labetalol. Within the first hour after the initiation of antihypertensive treatment, 32 (16.2%) of the 198 patients treated with urapidil required the addition of a second agent to achieve intensive BP reduction. The mean maximum dosage of the urapidil administered during the first hour was 65.1 ± 50.3 mg/h, and showed an increase across the six study periods (Table 3, Figure 2, $p=0.021$), with a statistically significant difference between Periods 1 and 6 (45.0 ± 42.7 vs. 78.4 ± 56.9 mg/h, adjusted $p=0.018$).

3.3 | Sustained BP control

After the first hour of antihypertensive treatment initiation, the mean SBP was 131.7 ± 19.1 mmHg from hour 1–6 and 131.6 ± 13.8 mmHg from hour 1–24. There were no statistically significant differences in the mean SBP from hour 1–6 ($p=0.554$) nor from hour 1–24 ($p=0.487$) across the different study periods (Table 3).

The mean SBP variability was 16.2 ± 8.0 mmHg from hour 1–6 and 18.2 ± 6.7 mmHg from hour 1 to 24. The SBP variability differed from hour 1–6 ($p=0.007$) and from hour 1–24 ($p=0.012$) across the various study periods (Table 3). Compared to Period 1, the integration of the stroke advanced practice nurse in Period 4 showed a statistically significantly lower SBP variability from hour 1–6 (19.4 ± 8.5 vs. 13.5 ± 7.9 mmHg, adjusted $p=0.019$) and from hour 1–24 (20.3 ± 6.1 vs. 16.5 ± 8.6 mmHg, adjusted $p=0.035$). Conversely, compared to Period 4, SBP variability was statistically significantly higher in Period 5 following the COVID-19 pandemic from hour 1–6 (13.5 ± 7.9 vs. 19.0 ± 8.3 mmHg, adjusted $p=0.039$).

4 | DISCUSSION

The present study shows the positive impact of successive changes in nursing care, showcasing the evolving leadership of nurses in a BP management protocol designed to achieve rapid, intensive and sustained BP reduction in acute ICH. Commencing with the initiation of antihypertensive treatment by a stroke nurse in the computed tomography suite as the baseline (Period 1), the subsequent transition to stroke nurses taking responsibility for titrating antihypertensive treatment in Period 2 resulted in a dramatic and statistically significant reduction in time to achieve the SBP target after treatment initiation and an increased rate of achieving the target within the first hour. The retraining of stroke nurses by the stroke neurologists in Period 3 maintained a higher rate of first-hour SBP target achievement compared to Period 1. The integration of a stroke advanced practice nurse in Period 4 not only maintained a shorter time to reach the SBP target but also reduced 6-h and 24-h SBP variability. However, in Period 5, following the impact of the COVID-19 pandemic, no improvements were observed, and 6-h SBP variability increased compared to the previous period. Retraining of stroke nurses by the stroke advanced practice nurse in Period 6 not only consolidated the achievements made in rapid and intensive BP reduction before the pandemic but also statistically significantly reduced the time from computed tomography scan to antihypertensive treatment initiation and led to an increase in the maximum dose of antihypertensive agents administered by stroke nurses in the first hour.

Elevated BP is a significant modifiable determinant of hematoma expansion and poor outcomes in patients with acute ICH (Cordonnier et al., 2018). BP control represents one of the few effective treatments available to mitigate the consequences of acute

TABLE 2 Main baseline characteristics of the cohort based on the different study periods.

	All patients (*N* = 200)	Period 1: Stroke nurse at CT suite (*n* = 28)	Period 2: Titration by Stroke nurse (*n* = 29)	Period 3: Retraining by neurologists (*n* = 30)	Period 4: Integration of Stroke APN (*n* = 40)	Period 5: After COVID-19 impact (*n* = 27)	Period 6: Retraining by Stroke APN (*n* = 46)	Statistic	*p* value
Age, years	70.7 ± 13.5	68.6 ± 15.7	71.8 ± 12.8	69.9 ± 13.2	70.1 ± 13.1	72.3 ± 11.9	71.2 ± 14.2	1.2[a]	0.944[a]
Sex, male	135 (67.5)	19 (67.9)	19 (65.5)	23 (76.7)	28 (70.0)	15 (55.6)	31 (67.4)	3.1[b]	0.689[b]
History of hypertension	154 (77.0)	26 (92.9)	19 (65.5)	23 (76.7)	30 (75.0)	21 (77.8)	35 (76.1)	6.3[b]	0.282[b]
Antihypertensive drugs use	130 (65.0)	20 (71.4)	14 (48.3)	19 (63.3)	28 (70.0)	19 (70.4)	30 (65.2)	4.9[b]	0.429[b]
Antiplatelet drugs use	43 (21.5)	7 (25.0)	10 (34.5)	7 (23.3)	7 (17.5)	5 (18.5)	7 (15.2)	4.8[b]	0.446[b]
Anticoagulant drugs use	30 (15.0)	3 (10.7)	5 (17.2)	4 (13.3)	6 (15.0)	5 (18.5)	7 (15.2)	0.9[b]	0.967[b]
GCS score	15 (14–15)	15 (12–15)	15 (14–15)	15 (14–15)	15 (14–15)	15 (14–15)	15 (14–15)	2.3[a]	0.807[a]
NIHSS score	13 (7–18)	16 (10–20)	13 (6–17)	12 (5–16)	10 (6–17)	16 (8–18)	13 (6–16)	7.0[a]	0.220[a]
SBP, mmHg	179.3 ± 20.6	183.4 ± 19.9	180.6 ± 21.3	185.9 ± 18.4	174.6 ± 19.9	182.7 ± 25.1	174.0 ± 18.2	11.0[a]	0.051[a]
DBP, mmHg	93.8 ± 20.0	95.1 ± 17.7	92.0 ± 16.1	101.1 ± 17.1	91.6 ± 19.2	93.4 ± 24.3	91.5 ± 22.9	9.4[a]	0.095[a]
Onset-to-imaging time, min	120 (76–216)	140 (70–195)	103 (82–146)	108 (76–219)	146 (78–277)	139 (83–238)	119 (72–214)	3.1[a]	0.689[a]
ICH volume, mL	12.8 (5.7–29.2)	11.9 (5.0–29.0)	15.2 (3.0–29.1)	11.8 (7.2–25.1)	11.7 (5.5–27.7)	24.6 (7.5–43.2)	10.5 (5.0–20.8)	5.0[a]	0.416[a]
Lobar ICH location	55 (27.5)	4 (14.3)	7 (24.1)	10 (33.3)	10 (25.0)	10 (37.0)	14 (30.4)	4.7[b]	0.456[b]

Note: Data are *n* (%), median (interquartile interval) or mean ± standard deviation.

Abbreviations: APN, advanced practice nurse; CT, computed tomography; DBP, diastolic blood pressure; GCS, Glasgow coma scale; ICH, intracerebral haemorrhage; NIHSS, National Institutes of Health stroke scale; SBP, systolic blood pressure.

[a] H statistic with 5 degrees of freedom and *p* values from Kruskal-Wallis test.

[b] $\chi 2$ statistic with 5 degrees of freedom and *p* values from Pearson $\chi 2$ test.

TABLE 3 Outcomes based on the different study periods.

	All patients ($N=200$)	Period 1: Stroke nurse at CT suite ($n=28$)	Period 2: Titration by Stroke nurse ($n=29$)	Period 3: Retraining by neurologists ($n=30$)	Period 4: Integration of Stroke APN ($n=40$)	Period 5: After COVID-19 impact ($n=27$)	Period 6: Retraining by Stroke APN ($n=46$)	Statistic	*p* value
Rapid and Intensive BP Reduction									
Time from CT to antihypertensive treatment initiation, min	8 (4–17)	14 (7–30)	8 (5–18)	9 (4–11)	8 (4–15)	9 (6–14)	7 (4–11)	9.7[a]	0.084[a]
Time from treatment initiation to SBP target achievement, min	52 (30–85)	120 (57–240)	49 (25–63)	55 (42–67)	40 (20–59)	54 (30–89)	51 (31–73)	19.3[a]	0.002[a]
Achievement of SBP target within the first hour	130 (65.0)	8 (28.6)	20 (69.0)	21 (70.0)	32 (80.0)	17 (63.0)	32 (69.6)	18.5[b]	0.002[b]
Maximum dose of urapidil during first hour, mg/h	65.1 ± 50.3	45.0 ± 42.7	52.6 ± 43.3	71.2 ± 53.1	67.6 ± 46.3	65.2 ± 50.3	78.4 ± 56.9	13.3[a]	0.021[a]
Sustained BP Control									
Mean SBP from hour 1 to hour 6, mmHg	131.7 ± 19.1	137.6 ± 26.6	128.7 ± 15.7	133.1 ± 18.1	129.6 ± 17.1	134.5 ± 20.4	129.5 ± 17.3	4.0[a]	0.554[a]
Mean SBP from hour 1 to hour 24, mmHg	131.6 ± 13.8	135.9 ± 19.1	130.5 ± 10.6	134.8 ± 16.9	129.0 ± 9.8	131.4 ± 14.2	129.7 ± 11.6	4.5[a]	0.487[a]
SBP variability from hour 1 to hour 6, mmHg	16.2 ± 8.0	19.4 ± 8.5	14.1 ± 6.5	16.0 ± 8.4	13.5 ± 7.9	19.0 ± 8.3	16.3 ± 7.4	16.1[a]	0.007[a]
SBP variability from hour 1 to hour 24, mmHg	18.2 ± 6.7	20.3 ± 6.1	16.0 ± 5.1	19.0 ± 6.7	16.5 ± 8.6	19.4 ± 6.4	18.4 ± 6.2	14.6[a]	0.012[a]

Note: Data are median (interquartile interval) or mean ± standard deviation.

Abbreviations: APN, advanced practice nurse; BP, blood pressure; CT, computed tomography; SBP, systolic blood pressure.

[a] H statistic with 5 degrees of freedom and *p* Values from Kruskal-Wallis test.

[b] $\chi 2$ statistic with 5 degrees of freedom and *p* Values from Pearson $\chi 2$ test.

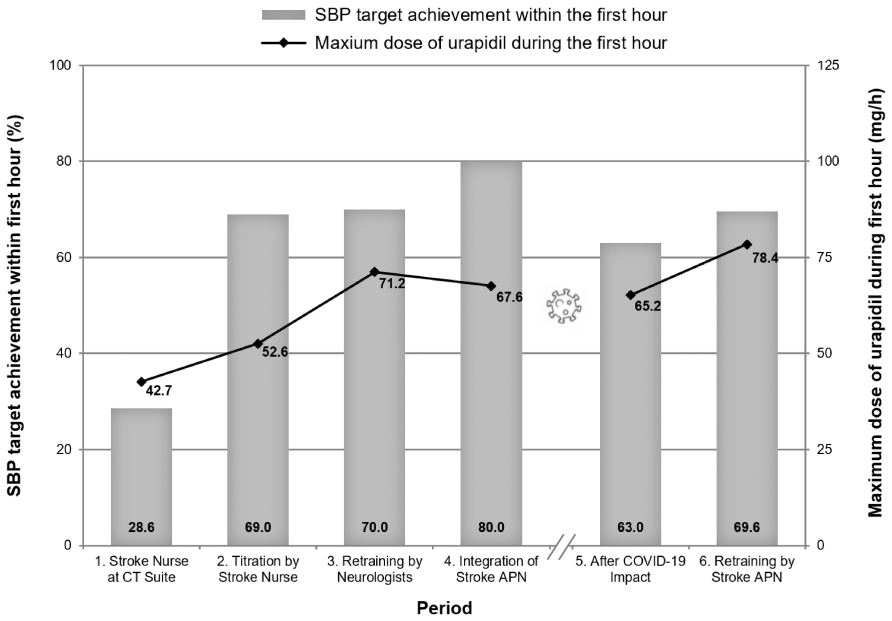

FIGURE 2 Systolic blood pressure target achievement within the first hour and maximum dose of urapidil administered during the first hour based on the different study periods. A broken X-axis slash mark indicates the 6-month period during which no patients were included due to changes in the acute management of patients caused by the COVID-19 pandemic. APN, advance practice nurse; CT, computed tomography; SBP, systolic blood pressure.

ICH, including normalisation of coagulation in patients under anticoagulant treatment and, in certain cases, neurosurgical intervention (Greenberg et al., 2022; Ma et al., 2023; Parry-Jones et al., 2019). Unlike these other treatments, from which only a minority of patients currently benefit, elevated BP is common in patients with acute ICH, necessitating BP reduction for the majority of patients (Qureshi et al., 2007).

Because up to a quarter of patients experience substantial hematoma expansion within the first hour after computed tomography scan acquisition, it is probable that a delay in achieving the SBP target may mitigate beneficial effects of BP reduction on outcomes (Brott et al., 1997; Carcel et al., 2016; Li et al., 2023). However, prior clinical trials have illuminated the challenges associated with reaching an intensive SBP target within the first hour in acute ICH patients (Anderson et al., 2013; Ma et al., 2023; Qureshi et al., 2016). The findings of our study underscore the critical role of nursing care and protocol optimization in the management of BP in acute ICH patients. The improvements made in nursing care across successive study periods show the feasibility of achieving rapid, intensive and sustained BP control which has the potential to mitigate hematoma expansion and enhance clinical outcomes in acute ICH patients.

The initial change in our institutional acute ICH BP protocol, which involved the initiation of antihypertensive treatment by a stroke nurse at the computed tomography suite (Period 1), represented a significant departure from the traditional approach, where antihypertensive treatment was initiated only after admission to the Stroke Unit (Sanjuan Menendez et al., 2019). This change allowed for the initiation of treatment at the earliest point in the patient's care pathway. The subsequent transition to stroke nurses taking responsibility for titrating antihypertensive treatment (Period 2) was associated with a dramatic reduction in the time to achieve the SBP target and, consequently, a notable increase in the proportion of patients reaching the target within the first hour. Thus, empowering stroke nurses to manage BP in a more independent and proactive manner was a pivotal step in expediting BP control.

The integration of a stroke advanced practice nurse into the care team during Period 4 was a pivotal development. Although 24-h mean SBP values were stable across the study periods, this integration led to a statistically significant reduction in SBP variability. Higher SBP variability during the initial hours of acute ICH is a powerful determinant of neurological deterioration and poor outcome (Manning et al., 2014; Rodriguez-Luna et al., 2013; Tanaka et al., 2014). Thus, close BP monitoring and avoiding high SBP variability controlling BP fluctuations represent key elements in the management of BP in patients with acute ICH (Andalib et al., 2020; Greenberg et al., 2022). The expertise, complex real-time decision-making and clinical competencies of the stroke advanced practice nurse in caring for acute ICH patients likely played a crucial role in achieving a significant reduction in SBP variability in the present study. Their ability to provide guidance, monitor BP trends and adjust antihypertensive treatment strategies in real-time contributed to more stable BP control.

However, the study revealed a notable interruption in the trajectory of improvement coinciding with the impact of the COVID-19 pandemic (Period 5). The challenges posed by the pandemic, including changes in patient flow and care pathways, disrupted the gains made in BP control and increased the SBP variability compared to previous period, despite our adaptation of the approach by progressively reintroducing the practice of directly admitting patients from the computed tomography suite to the Stroke Unit after a 6-month interruption (period not included in the present study). This interruption serves as a stark reminder of the vulnerability of healthcare systems to external events and the importance of adaptability in clinical practice.

Our study also suggests that ongoing education and training are essential components of sustaining protocol improvements. While in Period 3, characterised by retraining of stroke nurses

by stroke neurologists, the continued emphasis on achieving the SBP target within the first hour was successful, the retraining of the stroke nurses by the advanced practice nurse in Period 6 consolidated the gains on rapid and intensive BP reduction made before the pandemic. Further, the reduction in the time from computed tomography scan to antihypertensive treatment initiation and the increased maximum doses of antihypertensive agents administered during the first hour, which align with our goal of achieving rapid and intensive BP reduction, reflect the increased confidence of stroke nurses in initiating and titrating antihypertensive treatment after retraining by the stroke advanced practice nurse.

The outcomes of the study demonstrate the pivotal role of nurse-led interventions and protocol optimization in rapidly and effectively managing BP among acute ICH patients. This highlights the potential benefits of integrating specialised nursing roles and empowering nurses in the acute care pathway. The disruptions observed during the COVID-19 period stress the importance of healthcare system adaptability. Moreover, the sustained improvements achieved through continual education and training underscore the significance of ongoing professional development for nursing staff. Ultimately, these insights emphasise the value of nurse-centred approaches and adaptable protocols in optimising patient care strategies for acute ICH management.

The strengths of this study include a six-year duration, facilitating a long-term assessment of changes in nursing care, a real-world clinical setting that includes severe patients and well-established high-frequency BP monitoring. The study has some limitations, however. Firstly, despite the prospective data collection from consecutive patients, the study's design was retrospective. This led to the exclusion of patients with missing BP monitoring recordings, although minority. Second, the study was single-centre in nature. Prospective, multicentre studies are warranted to further validate the effectiveness of such protocol-driven approaches and to assess their generalizability across diverse healthcare settings. Third, the sample size of 200 patients, derived from those meeting inclusion and exclusion criteria over the 6-year study period, was not determined through a power analysis, thus warranting caution in generalising the findings. Finally, we were unable to conduct a comparison of BP control before and after the implementation of stroke nurse involvement at the computed tomography suite (P1, baseline period) due to insufficient quality data available for the period before this intervention.

5 | CONCLUSIONS

The present study indicates that changes in nursing care, characterised by a progressive shift towards nurses taking the lead in BP management, and continuous education, coupled with the implementation of a comprehensive BP management protocol, can significantly enhance the time metrics and BP outcomes in acute ICH patients. These findings underscore the importance of a coordinated and evolving approach to BP management, with a focus on rapid, intensive and sustained control ultimately improving the care of ICH patients. This highlights the potential benefits of integrating specialised nursing roles, empowering nurses within the acute care pathway, and continually updating protocols. Further research is needed to assess the impact of these interventions on hematoma expansion and clinical and functional outcomes in acute ICH patients while continually refining the management strategies for this challenging condition.

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CONFLICT OF INTEREST STATEMENT

None.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request, subject to approval by the corresponding research ethics committees. Figshare (https://figshare.com/), Protocol number: 24624966, Link to the registration site: dx.doi.org/10.6084/m9.figshare.24624966.

ETHICS STATEMENT

Study protocol was approved by the Clinical Research Ethics Committee of Vall d'Herbon Research Institute. Reference: PR(AG)426/2022.

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SUPPORTING INFORMATION

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