Admitting Low-Risk Patients With Intracerebral Hemorrhage to a Neurological Step-Down Unit Is Safe, Results in Shorter Length of Stay, and Reduces Intensive Care Utilization: A Retrospective Controlled Cohort Study

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Abstract

Background and Purpose: Patients suffering intracerebral hemorrhage (ICH) are at risk for early neurologic deterioration and are often admitted to intensive care units (ICU) for observation. There is limited data on the safety of admitting low-risk patients with ICH to a non-ICU setting. We hypothesized that admitting such patients to a neurologic step-down unit (SDU) is safe and less resource-intensive. **Methods:** We performed a retrospective analysis of patients with primary ICH admitted to our SDU. We compared this cohort to a control group of ICH patients admitted to a neurologic-ICU (NICU) at a partner institution. We analyzed patients with supratentorial ICH ≤ 15 cc, Glasgow Coma Scale ≥ 13 , National Institutes of Health Stroke Scale ≤ 10 , and no to minimal intraventricular hemorrhage. Primary end points were (re-)admission to an NICU and rates of hematoma expansion (HE). We also compared total NICU days and hospital length of stay (LOS). **Results:** Eighty patients with ICH were admitted to the SDU. Only 2 required transfer to the NICU for complications related to ICH, including 1 for HE. Seventy-four SDU patients met inclusion criteria and were compared to 58 patients admitted to an NICU. There was no difference in rates of NICU (re-)admission (7 vs 2, $P = .17$) or rates of HE (3 vs 5, $P = .28$). Median NICU days were 0 versus 1 ($P < .001$). Step-down unit admission was associated with shorter LOS (3 vs 4 days, $P = .05$). **Conclusions:** Select patients with ICH can be safely admitted to an SDU. This may reduce LOS and ICU utilization. We also propose criteria for admitting patients with ICH to an SDU.

Keywords

intracerebral hemorrhage, step-down unit, transitional care unit, neurologic intensive care unit, intensive care unit utilization

Introduction

Intracerebral hemorrhage (ICH) is a neurologic emergency with a case fatality rate of 30% to 40% within the first month and less than one-third of survivors being able to return to independent living.¹ A significant proportion of death and neurologic deterioration occurs in the first few hours to days after ICH onset attributable primarily to hematoma expansion (HE) and consequences of acute brain injury, including cerebral edema, seizures, and hydrocephalus. Complications such as HE or hydrocephalus portend a poor prognosis, and these patients are likely to need invasive monitoring, neurosurgical procedures, and advanced airway support.² Due to this risk, the majority of patients with ICH are admitted to an intensive care unit (ICU) for observation, monitoring, and blood pressure control.^{3,4} Specifically, patients with ICH admitted to a

specialized neurologic-ICU (NICU) appear to have better outcomes.⁵

However, admitting all patients with ICH to an ICU strains this limited health care resource and can increase costs. The American Stroke Association guidelines recommend admitting patients with ICH to an ICU or “Designated Stroke Unit.”⁶ Well-staffed neurologic step-down units (SDUs; also referred to transitional or intermediate-level care units) can

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reduce ICU wait times, length of stay (LOS), produce cost savings on the order of millions, and are safe for select patient populations.^{7,8} Notably, it is safe and cost-effective to directly admit patients following intravenous tissue plasminogen activator (tPA) for ischemic stroke to an SDU as long as they did not have another ICU indication.⁹ Additionally, a study of medical SDUs showed a significant decrease in ICU days and improved ICU throughput in patients with sepsis and respiratory problems.¹⁰

There is emerging evidence that patients with small, “benign,” ICH are at extremely low risk of HE and other significant complications.¹¹ These patients may not require ICU-level care. Retrospective data suggest that patients with small ICH, no significant intraventricular hemorrhage (IVH) or subarachnoid hemorrhage (SAH), and reassuring clinical measures (ie, Glasgow Coma Scale [GCS] and National Institutes of Health Stroke Scale [NIHSS]) do not require ICU-level care and may be safely managed in an SDU.^{12,13} When low-risk patients with ICH are admitted to an ICU, they usually transfer out in 1 to 2 days.¹⁴ Furthermore, one recent retrospective study found that hospital LOS was shorter when such patients were admitted to an SDU compared with a medical- or neurologic-ICU.¹⁵ Another Swedish study found that admission to a semi-intensive stroke unit resulted in better functional outcomes at 3 months for patients with stroke and ICH than admission to a multidisciplinary ICU with a consulting stroke team.¹⁶ To date, there are no controlled studies comparing patients with ICH managed in an SDU to a similar group in a designated NICU that specifically evaluate acute complications including HE.

We hypothesized that patients with low-risk ICH can be safely and efficiently managed in an SDU. To this end, we performed a retrospective cohort analysis of patients with ICH admitted to an SDU at an institution where low-risk patients are triaged to the SDU. Then, we compared this cohort to matched controls from a neighboring institution where all patients with ICH are admitted to a designated NICU. We predicted that there would be no difference in rates of admission or readmission to an NICU, HE, or disposition outcomes between the 2 groups.

Methods

This study was approved by the institutional review boards at Washington University in St. Louis (WU) and St. Louis University (SLU). At Barnes-Jewish Hospital (BJH, affiliated with WU), patients with ICH may be admitted to the neurologic-SDU if they meet the following triage criteria: (1) ICH is supratentorial; (2) ICH volume ≤ 5 mL, by the ABC/2 method,¹⁷ if symptom onset is less than 24 hours from presentation (or ≤ 30 mL if over 24 hours from onset); (3) GCS ≥ 13 ; (4) NIHSS ≤ 10 ; (5) no IVH or hydrocephalus; (6) no evidence of active bleeding on noncontrast head computed tomography (CT) and/or computed tomography angiography (CTA; ie, swirl sign on CT or spot sign on CTA);

(7) absence of coagulopathy: international normalized ratio (INR) ≤ 1.4 , partial thromboplastin time (PTT) ≤ 40 , platelets ≥ 100 ; and (8) no significant respiratory distress, seizures on presentation, or other medical problems requiring intensive care.

In the SDU, patients' vital signs can be monitored with continuous telemetry and pulse oximetry and frequent blood pressure measurements. Antihypertensive drips can be used in the SDU. The nursing ratio is between 1:3 and 1:4 and nurses can perform neurological checks and vitals every 2 hours.

We performed a retrospective chart review of patients with ICH admitted to the BJH SDU between 2014 and 2016. Charts of all patients with a diagnosis code of ICH admitted to the NICU or SDU between 2014 and 2016 were evaluated for inclusion. We included all patients with primary ICH admitted to the SDU. We excluded patients with hemorrhagic conversion of an ischemic stroke, primary SAH, primary IVH, and hemorrhage due to an underlying mass or vascular lesion.

We then compared patients in this cohort to a control group of patients at SLU (a neighboring tertiary care center with similar catchment), where all patients with ICH are admitted to the NICU for initial observation and management. We included patients admitted to the NICU at that institution over the same 3-year time period. We included patients with the following: (1) supratentorial ICH; (2) ICH volume ≤ 15 mL, by the ABC/2 method;¹⁷ (3) GCS ≥ 13 ; (4) NIHSS ≤ 10 ; (5) no to minimal IVH (Graeb score ≤ 2)¹⁸; (6) no evidence of active bleeding on noncontrast head CT and/or CTA; (7) absence of coagulopathy: INR ≤ 1.4 , PTT ≤ 40 , platelets ≥ 100 ; and (8) no other medical problems requiring intensive care. The inclusion criteria differ from our SDU triage recommendations in which we included ICH volumes up to 15 mL and small IVH. Patients with these characteristics were admitted to the BJH SDU, and there is evidence that patients with mild IVH and supratentorial ICH volumes of this size can be safely managed in an SDU.^{11,12,14,15} We also chose a volume of 15 mL as the upper limit because this included 95% of our SDU cohort. We excluded patients with infratentorial ICH since they are at higher risk for clinical deterioration if HE or edema occurs and there is insufficient data to suggest that observation of infratentorial ICH in a non-ICU setting is safe.

Analysis

Primary end points were (1) NICU admission (for the SDU cohort) or readmission (for the ICU cohort) and (2) HE (associated with clinical deterioration). Secondary end points were events of clinical deterioration prompting repeat imaging, NICU LOS, total hospital LOS, and discharge disposition.

Data analyses were performed using SPSS (version 24; IBM Corp). The χ^2 analyses were used to compare categorical variables and Mann-Whitney *U* tests were used to compare continuous variables (ICH score, ICH volume, NIHSS, GCS, NICU LOS, and total hospital LOS).

Table 1. Characteristics of Patients Transferred From the SDU to the NICU.

Age, sex	ICH score	ICH volume (mL)	ICH location	Reason for NICU transfer	Time of transfer from admission (hours)	Disposition
63, M	0	3	Right thalamus	Hematoma expansion to 7.8 mL with altered mental status	<24	SNF
87, F	1	1.7	Right lobar	NCSE and concern for airway protection	24-48	SNF
70, M	1	13	Right lobar	Complications of pancreatic cancer and need for anticoagulation for cardiac thrombus	<24	Hospice
68, F	0	1.1	Left thalamus	Septic shock and DKA	<24	SNF
71, M	0	0.5	Left thalamus	Hypertensive urgency requiring nicardipine drip	<24	Home

Abbreviations: DKA, diabetic ketoacidosis; F, female; ICH, intracerebral hemorrhage; M, male; NCSE, nonconvulsive status epilepticus; NICU, neurologic intensive care unit; SDU, neurologic step-down unit; SNF, skilled-nursing facility.

Results

In total, 1064 patients with ICH were admitted to the neurology or neurosurgery services at BJH between 2014 and 2016, of whom 80 (8%) with primary ICH were admitted to the SDU. The median ICH volume of patients admitted to the SDU was 1.75 mL (interquartile range [IQR]: 0.5-4.5), median ICH score 0 (IQR: 0-1), GCS 15 (IQR: 14-15), and NIHSS 2 (IQR: 1-4). Fifty-six percent of ICHs were located in the thalamus and/or basal ganglia and 41% were in lobar. Most patients admitted to the SDU met the triage criteria outlined above. However, 2 patients with cerebellar ICH and 2 patients with IVH and Graeb scores ≤ 2 were admitted to the SDU. Additionally, 8 patients with supratentorial ICH between 5 and 19 mL were admitted to the SDU despite symptom onset less than 24 hours prior to presentation. One patient with a lobar ICH volume of 40 mL was admitted to the SDU after presenting over 48 hours from symptom onset. None of these patients required transfer to the NICU or had significant complications.

Seventy-five patients were discharged from the SDU without requiring NICU admission. Five patients were transferred to the NICU, but only 1 for HE (Table 1). One patient was transferred to the NICU for management of nonconvulsive status epilepticus. Two patients were transferred for medical complications: one with pancreatic cancer with hypercoagulable state and need for anticoagulation and a second for septic shock with diabetic ketoacidosis. One patient was quickly transferred from the SDU to the floor due to the need for SDU beds. On the floor, the patient developed hypertensive urgency requiring nicardipine infusion and was transferred to the NICU instead of back to the SDU due to lack of SDU bed availability. All but one transfer to the NICU occurred within 24 hours of admission. None of the patients transferred to the NICU required osmotic agents, external ventricular drain (EVD), or craniotomy. Median NICU LOS in these 5 patients was 4 days (range: 1-6 days). There was no significant difference in demographics, blood pressure, or ICH characteristics between patients requiring NICU admission and those who did not. However, discharge disposition was worse for patients admitted to the NICU from the SDU. Only 1 (20%) patient was

Table 2. Demographics of Patients Managed in the SDU and Those Requiring Transfer to the NICU.^a

Variable	Managed in SDU (n = 75)	Transferred to NICU (n = 5)	P value
Age	69 $\pm$ 15	72 $\pm$ 9	.70
Gender (female)	33 (44%)	2 (40%)	.62
History of	66 (88%)	5 (100%)	.54
Hypertension			
Admission SBP	165 $\pm$ 28	182 $\pm$ 21	.20
Coagulopathy/anticoagulation	10 (13%)	1 (20%)	.53
Antiplatelet	30 (40%)	1 (20%)	.35
Smoking	15 (20%)	2 (40%)	.29
Drug abuse	6 (8%)	2 (40%)	.08
ICH score	0 (0-1)	0 (0-1)	.88
ICH volume (mL)	1.8 (0.5-4.75)	1.7 (1-3)	.98
NIHSS	2 (1-4)	2 (1-4)	.88
GCS	15 (14-15)	15 (15-15)	.75
Disposition to home/rehabilitation vs SNF/LTAC/hospice	67 (89%) vs 8 (11%)	1 (20%) vs 4 (80%)	.001

Abbreviations: GCS, Glasgow Coma Scale; ICH, intracerebral hemorrhage; LTAC, long-term acute care hospital; NICU, neurologic intensive care unit; NIHSS, National Institutes of Health Stroke Scale; SDU, neurologic step-down unit; SBP, systolic blood pressure; SNF, skilled nursing facility.

^a Age and SBP are represented as mean $\pm$ standard deviation. ICH score, ICH volume, NIHSS, GCS are reported as median (interquartile range).

discharged to home or rehabilitation versus 67 (89%) of the 75 patients not requiring NICU admission ($P = .001$; Table 2).

Next, we compared patients admitted to the SDU to a matched cohort of patients managed in an NICU at a neighboring institution. From our original cohort, we excluded 6 patients with infratentorial ICH or ICH >15 cc. Seventy-four patients admitted to the SDU were compared to 58 patients admitted to the NICU at the second institution over the same time period who met our eligibility criteria. There were no significant differences in age, gender, blood pressure, ICH volume, ICH location, NIHSS, or GCS between the 2 groups (Table 3).

Table 3. Demographics and Outcomes of Patients With Low-Risk ICH Admitted to an SDU or NICU.^a

Variable	SDU (n = 74)	NICU (n = 58)	P value
Age	69 ± 15	64 ± 15	.08
Gender (female)	34 (46%)	21 (36%)	.26
Admission SBP	168 ± 27	162 ± 30	.72
Coagulopathy	8 (11%)	7 (12%)	.79
ICH score	0 (0-1)	0 (0-0)	.35
ICH volume (mL)	1.6 (0.5-3.5)	2.1 (0.6-8.0)	.21
ICH location			
Lobar	29 (39%)	25 (43%)	.65
Basal ganglia	21 (28%)	18 (31%)	.74
Thalamus	24 (33%)	15 (26%)	.41
NIHSS	2 (1-4)	2.5 (1-5)	.90
GCS	15 (14-15)	15 (15-15)	.19
Clinical deterioration	8 (11%)	4 (7%)	.44
Hematoma expansion	3 (4%)	5 (9%)	.26
SNF/LTAC/hospice	12 (16%)	11 (19%)	.70
NICU (re-)admission	5 (7%)	1 (2%)	.17
NICU LOS in days (median)	0 (0-0)	1 (1-2)	.001
Total hospital LOS in days (median)	3 (2-4)	4 (2-5)	.05

Abbreviations: GCS, Glasgow Coma Scale; ICH, intracerebral hemorrhage; LOS, length of stay; LTAC, long-term acute care hospital; NICU, neurologic intensive care unit; SBP, systolic blood pressure; NIHSS, National Institutes of Health Stroke Scale; SDU, neurologic step-down unit; SNF, skilled nursing facility.

^a Age and SBP are represented as mean ± standard deviation. ICH score, ICH volume, NIHSS, GCS, and LOS are reported as median (interquartile range).

Rates of NICU admission (in those originally admitted to the SDU) or readmission (after NICU discharge in those admitted to the NICU) were similar between the 2 groups (7% vs 2%, $P = .17$), as was the rate of HE (4% SDU vs 9% NICU, $P = 0.26$). No patients in either group required osmotic agents, intracranial pressure (ICP) monitoring or EVD, or craniotomy. The clinical deterioration rate was similar between the 2 groups. Median ICU days were 0 in the SDU group versus 1 (IQR: 1-2) in the NICU group ($P < .001$). Total hospital LOS was shorter in patients admitted to the SDU (3 vs 4 days, $P = .05$). Discharge disposition did not differ between the groups (Table 3). No patients in either group died in the hospital.

Discussion

At our institution, select patients with ICH may be admitted to an SDU in lieu of an NICU. We show that this practice is safe and does not adversely affect patient outcomes or discharge disposition. This is consistent with 2 small studies that have analyzed some outcome measures of patients with ICH admitted to an SDU.^{12,15} One study evaluated 20 patients admitted to an SDU but did not have an NICU control for comparison.¹² The other study focused on the outcome at discharge between patients admitted to an SDU versus an ICU but did not evaluate instances of significant deterioration, including HE, that

required transfer to a higher level of care.^{12,15} We analyzed the admission rate to the NICU of patients originally admitted to the SDU as our primary end point and found only 2 (3%) of 80 patients required transfer to the NICU for complications directly related to ICH and only 1 for HE. Neither of these patients required intensive interventions such as osmotic agents, ICP monitoring, or craniotomy. In our opinion, admission to an SDU did not adversely affect the outcome, as these patients were rapidly transferred to the NICU when higher level monitoring was indicated.

By comparing similar cohorts of patients with ICH admitted to an SDU and an NICU, we corroborate previously published results¹⁵ that, admission to an SDU significantly decreases total hospital LOS. We also confirmed that there was no difference in outcome measures including total complications, HE, and discharge to skilled-nursing facility or hospice between patients admitted to the SDU and a matched cohort admitted to an NICU. Unlike the prior study, all patients in our cohorts were managed in a neurological unit under the care of a neurointensivist or stroke specialist. No patients were in a medical ICU or managed by a neurology consult team.

Additionally, while prior studies have only included patients with supratentorial ICH,¹²⁻¹⁵ 2 patients in our initial SDU cohort had cerebellar ICH. Both patients presented within 24 hours of symptom onset and had ICH volumes <5 mL. Neither of these patients had clinical deterioration or HE. Recent data suggest that small cerebellar (<5 mL) and brainstem ICH (<3 mL) without other concerning findings are unlikely to expand or lead to other significant complications.¹¹ This raises the possibility that patients with small, infratentorial ICH without active bleeding, significant edema, or other malignant features may also be candidates for SDU admission. However, since HE and edema from these ICHs portend worse outcomes and patients are more likely to need surgical interventions,² larger, prospective studies are needed to determine if it is safe to admit some patients with infratentorial ICH to an SDU.

Ultimately, with rising critical care costs and increased need for critical care beds, admitting certain patients with smaller ICH to an SDU could improve the availability of ICU resources for patients who actively require neurocritical care interventions and decrease hospital costs. Not surprisingly, we demonstrate that admitting patients to an SDU decreases NICU days for patients with low-risk ICH. Another study noted a trend in cost reduction between patients with ICH admitted to an SDU and to an ICU, although this was not significant (Table 3).¹⁵ There have been 3 studies to date, including ours, that analyze data from patients with ICH admitted to an SDU and 3 additional studies that identify characteristics of patients with ICH who are unlikely to require ICU-level care.^{11,12,14,15} Criteria proposed in these studies are summarized in supplementary Table 1.

Based on our data and prior studies, patients with the following ICH characteristics can likely be safely admitted to an SDU even if they present within 24 hours of symptom onset:

1. Supratentorial ICH ≤ 15 cc^{11,13-15};
2. No SAH and no to minimal IVH (Graeb score ≤ 2)^{12,15};
3. GCS ≥ 13 ^{13,14};
4. NIHSS ≤ 10 ¹²;
5. No coagulopathy^{11,15};
6. No evidence of active extravasation on imaging (ie, spot sign or swirl sign)¹¹; and
7. No other ICU indication.

We recommend that the SDU be able to provide monitoring of neurologic status and vital signs at least every 2 hours,^{12,15} be staffed by stroke, critical care or neurohospitalist-trained neurologists,^{6,8} and provide prompt transfer of patients to an NICU, when indicated. These recommendations are more rigorous than previously proposed but are based on the data from patients admitted to SDUs.

Despite our findings, this study has several limitations. It is retrospective, so, we are limited in our ability to rigorously analyze some outcome measures including cost data. We also utilized another institution for our control group, which introduces possible variability in the management practices. Additionally, our study was relatively small and conducted at 2 tertiary care centers in the same city which may limit the generalizability of our results to other geographic regions and centers.

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Supplemental Material

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