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# Utilization of a Resuscitative Care Unit for Initial Triage, Management, and Disposition of Minor Intracranial Hemorrhage

Jacob R. Joseph, MD<sup>1</sup>; Nathan L. Haas, MD<sup>2,3</sup>; John R Joseph, MD<sup>2</sup>; Jason Heth, MD<sup>1</sup>;  
Nicholas J. Szerlip, MD<sup>1</sup>; Benjamin S. Bassin, MD<sup>2,3,4</sup>

**Objectives:** Management of minor intracranial hemorrhage typically involves ICU admission. ICU capacity is increasingly strained, resulting in increased emergency department boarding of critically ill patients. Our objectives were to implement a novel protocol using our emergency department–based resuscitative care unit for management of management of minor intracranial hemorrhage patients in the emergency department setting, to provide timely and appropriate critical care, and to decrease inpatient ICU utilization.

**Design:** Retrospective analysis of prospectively collected data.

**Setting:** Single large academic medical center in the United States

**Patients:** Adult patients presenting to the emergency department with management of minor intracranial hemorrhage managed via our resuscitative care unit-management of minor intracranial hemorrhage protocol from September 2017 to April 2019.

**Intervention:** Implementation of a resuscitative care unit-management of minor intracranial hemorrhage protocol.

**Measurements and Main Results:** Demographic data, need for vasoactive infusions in the emergency department, emergency department and hospital length of stay, emergency department disposition, and 30-day outcomes (readmission, mortality, need for neurosurgical procedure) were collected. Fifty-five patients were identified, with mean age  $67.1 \pm 20.0$  years. Mean Glasgow Coma Scale on presentation was  $14.8 \pm 0.5$ , and 66% had a history of trauma.

Locations of hemorrhage were subdural (42%), intraparenchymal (35%), subarachnoid (15%), intratumoral (7%), and intraventricular (2%). Nineteen patients (35%) were discharged from the emergency department, 22 (40%) were admitted to general care, and 14 (26%) were admitted to intensive care. In discharged patients, there was no mortality or neurosurgical interventions at 30 days. In a subgroup analysis of 36 patients with a traumatic mechanism, 18 (50%) were able to be discharged from the emergency department after management in the resuscitative care unit.

**Conclusions:** Initial management of emergency department patients with minor intracranial hemorrhage in a resuscitative care unit appears safe and feasible and was associated with a substantial rate of discharge from the emergency department (35%) and a low rate of admission to an inpatient ICU (26%). Use of this strategy was associated with rapid initiation of ICU-level care, which may help alleviate the challenge of increasing emergency department boarding time of critically ill patients facing many institutions.

**Key Words:** emergency department; intracranial hemorrhage; resuscitative care unit

<sup>1</sup>Department of Neurosurgery, University of Michigan, Ann Arbor, MI.

<sup>2</sup>Department of Emergency Medicine, University of Michigan, Ann Arbor, MI.

<sup>3</sup>Department of Emergency Medicine, Division of Critical Care, University of Michigan, Ann Arbor, MI.

<sup>4</sup>Michigan Center for Integrative Research in Critical Care, University of Michigan, Ann Arbor, MI.

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*Crit Care Expl* 2020; 2:e0097

DOI: 10.1097/CCE.000000000000097

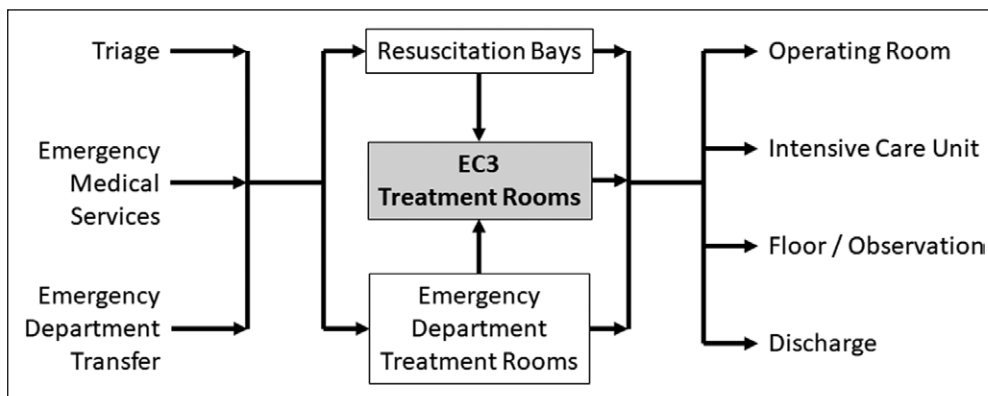
Intracranial hemorrhage (ICH) represents a heterogeneous group of diseases including subdural hemorrhage, epidural hemorrhage, intraparenchymal hemorrhage, and subarachnoid hemorrhage (SAH). ICH can result from trauma or can occur spontaneously in the case of SAH or intraparenchymal hemorrhage. The primary neurologic injury is complete at the time of presentation to the emergency department (ED). Therefore, initial focus in management is on early recognition of signs and symptoms of deterioration. Up to 23% of patients with spontaneous ICH will demonstrate continued deterioration within the first hours after arrival to the hospital (1). This risk of deterioration has resulted in the American Heart Association and American Stroke Association generating Class I recommendations that initial monitoring of patients with spontaneous ICH should take place in an ICU or dedicated stroke unit (2). In contrast, there are no published guidelines to inform disposition in ICH secondary to

trauma. Newer literature has questioned the need for ICU admission in mild traumatic brain injury, including those with ICH, as only 3.1% required an ICU-level intervention (3). Despite this, a number of studies have shown that practice patterns vary widely, and a majority of patients with minor traumatic ICH are admitted to an ICU (3, 4).

ICU capacity is under increasing strain in many healthcare systems, likely attributable to increasing patient acuity, an intensivist shortage, and decreased ICU bed availability (5). This has resulted in the need for prolonged critical care delivery in the ED in many healthcare systems, and the total annual hours of critical care delivered in U.S. EDs has recently increased by 217% (6). However, in critically ill stroke (including ICH) patients admitted to a neurologic ICU, ED length of stay greater than or equal to 5 hours was independently associated with poor outcome at hospital discharge (7). Similarly, a trend of worse outcomes associated with increasing ED boarding time has been demonstrated across multiple other disease states, and only 67% of ED to ICU admissions in the United States have an ED length of stay of less than 6 hours (6–13).

The University of Michigan Health System created the Joyce and Don Massey Family Foundation Emergency Critical Care Center (EC3) in 2015 with the goal of delivering high quality critical care in the ED (14). This ED-based ICU or resuscitative care unit (RCU) (15) is a 7,800-square-foot unit immediately adjacent to the main ED consisting of five resuscitation/trauma bays and nine patient rooms. The unit is staffed 24 hours per day by emergency medicine (EM) physicians, some of whom are boarded in critical care, as well as EM residents, critical care fellows, physician assistants, ED nurses with additional ICU training, and a nurse to patient ratio of 1:2 or 1:1. All patients presenting to the ED are initially managed by the main ED team, and patients requiring ongoing critical care can be transitioned to the EC3 team regardless of the availability of inpatient ICU beds (Fig. 1).

The RCU-minor ICH (mICH) protocol was implemented in September, 2017 as a collaborative effort between the Department of Emergency Medicine, Department of Neurosurgery, and Division of Acute Care Surgery at Michigan Medicine (University of Michigan) with the objective of providing timely and appropriate critical care and decreasing inpatient ICU utilization. We present a descriptive analysis of our initial experience with this novel strategy.



**Figure 1.** Emergency critical care center (EC3) patient flow diagram.

## MATERIALS AND METHODS

A retrospective analysis of a prospectively obtained database was performed for patients who presented to the Michigan Medicine Adult ED from September 2017 to April 2019. The study size was arrived at by defining these dates. Approval of the study was provided by the University of Michigan Institutional Review Board.

Patients enrolled in the RCU-mICH protocol were identified through the use of a specific order set in the electronic medical record. All records were manually reviewed to ensure eligibility in the protocol. Inclusion criteria included neurosurgical assessment determining a relatively low-risk ICH, isolated neurologic injury, and Glasgow Coma Scale (GCS) score greater than or equal to 13. A relatively low-risk ICH included minor traumatic ICH and minor spontaneous ICH presumed secondary to hypertension. Determination of low-risk ICH was made jointly by the neurosurgical and EM team. This evaluation incorporated the clinical impression of nonconcerning features on CT (low hemorrhage volume with absence of significant mass effect or midline shift), as well as nonconcerning neurologic examination (GCS, 13–15). Exclusion criteria included active anticoagulation use, active dual antiplatelet therapy, signs of coagulopathy on laboratory values, significant polytrauma, or seizure activity. Patients with spontaneous SAH were not included.

While in the RCU, patients were comanaged by the EC3 and neurosurgery services. Patients on protocol had hourly neurologic assessments, blood pressure control as needed to maintain systolic blood pressure less than 160 mm Hg, and repeat head CT approximately 8 hours after initial CT. The decision on prophylactic antiepileptic medications was at the discretion of the neurosurgery service. ED disposition (admission to ICU, admission to floor bed, discharge from ED) was a joint decision between the EC3 and neurosurgery teams within 1 hour of repeat CT completion.

Age, gender, specific diagnosis, GCS on presentation, traumatic mechanism of injury, active anticoagulant use, active antiplatelet use, and international normalized ratio (INR) on presentation were captured. Time from presentation to the first CT, time from first CT to arrival in EC3, time between first CT and second CT, time from second CT to leaving ED, disposition, and need for vasoactive infusions in the ED were also captured. ED length of stay and hospital length of stay were recorded. Finally, 30-day outcomes including readmission at our institution, mortality, and need for neurosurgical procedure were captured.

Statistical analysis was performed using GraphPad Prism v7 (GraphPad, San Diego, CA). Descriptive statistics were performed. A comparison of subgroups based on ED disposition was performed. One-way analysis of variance was performed for continuous data, and chi-square tests were performed for categorical data. A statistical significance level of  $p$  value of less than 0.05 was set for this analysis. A separate subgroup analysis of trauma patients was performed using similar methods.

## RESULTS

A total of 101 patients were initially identified by use of the designated order set. Of these, five patients did not have evidence of ICH. Of the 96 patients with ICH, 55 met all inclusion and exclusion criteria and were included for analysis. Reasons for exclusion included coagulopathy (use of anticoagulants, dual antiplatelet therapy, or elevated coagulation variables on laboratory testing), seizure activity, and low GCS score.

Mean age was  $67.1 \pm 20.0$  years with a median age of 72.6. Thirty-five patients (63.6%) were male. Twenty-seven patients (49%) were on a single antiplatelet medication. Mean GCS on presentation was  $14.8 \pm 0.5$  with a median GCS of 15. Mean INR on presentation was  $1.02 \pm 0.1$  with a median INR of 1.0. Thirty-six patients (65.5%) had a recent history of trauma. Twenty-three patients (42%) had predominantly subdural blood, 19 (35%) had intraparenchymal blood or contusions, eight (15%) had traumatic SAH, four (7%) had intratumoral hemorrhage, and one (2%) had predominantly intraventricular hemorrhage. These data are summarized in **Table 1**.

The timeline for patients in the ED is shown in **Figure 2**. Patients had an initial CT  $86.6 \pm 72.3$  minutes (median 74.0 min)

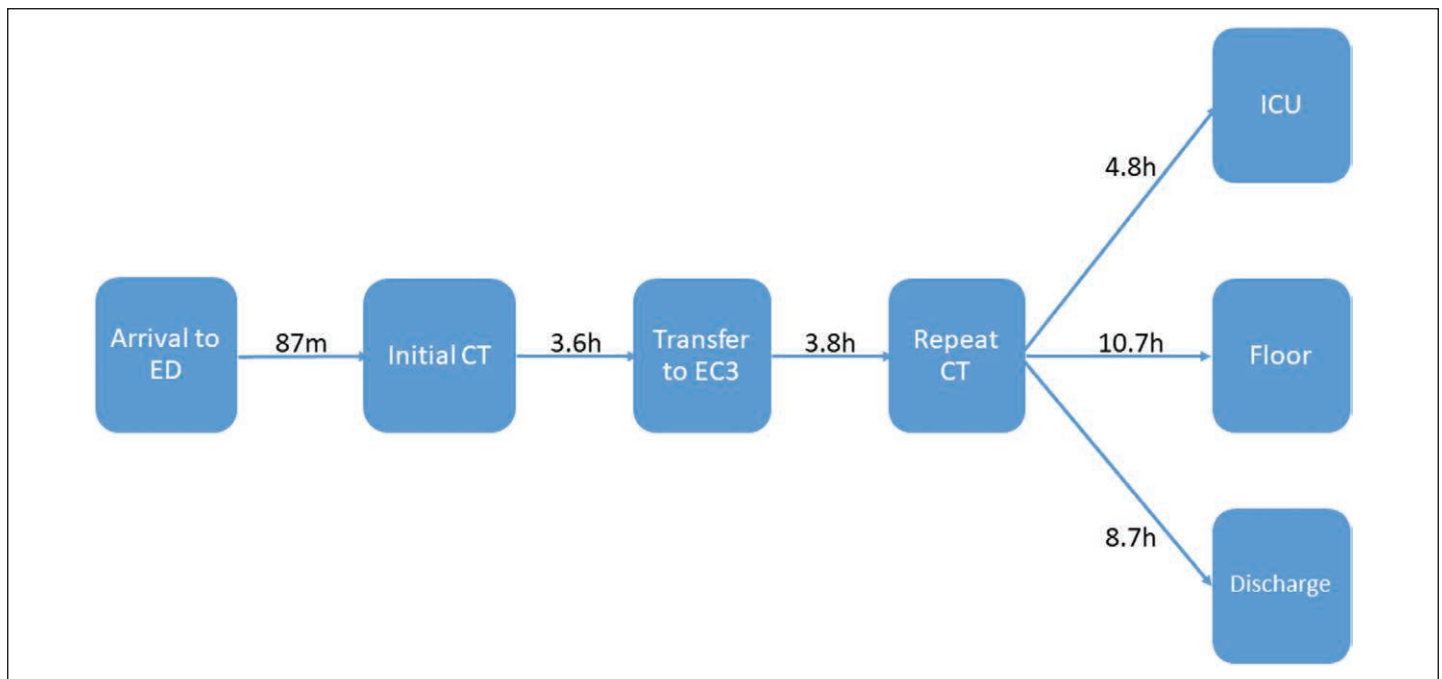
after arrival to the ED and  $3.6 \pm 2.0$  hours (median 3.3 hr) elapsed between initial CT and transfer to the RCU. Time between the initial CT and repeat CT was  $7.3 \pm 3.3$  hours (median 6.6 hr). Mean time in the RCU was  $12.6 \pm 6.1$  hours (median 12.0 hr), with total ED/RCU time of  $17.6 \pm 6.6$  hours (median 15.7 hr).

Nineteen patients (35%) were discharged from the ED, 22 (40%) were admitted to general care, and 14 (26%) were admitted to intensive care. The differences between these groups are summarized in **Table 1**. Discharged patients were more likely to have a traumatic mechanism (95%) as compared to those with general care dispositions (64%) and intensive care dispositions (29%) ( $p < 0.001$ ). Inpatient length of stay was significantly longer in patients admitted to intensive care as compared to general care (10.8 vs 3.3 d;  $p = 0.003$ ). In discharged patients, there was no mortality or neurosurgical interventions at 30 days, whereas three patients (16%) required readmission. Of general care patients, three patients (14%) died within 30 days, two patients (9%) required neurosurgical intervention, and four patients (18%) required readmission. Of patients admitted to intensive care, one patient (7%) died, five (36%) required neurosurgical intervention, and two (14%) required readmission.

**TABLE 1. Patient Characteristics and Outcomes by Emergency Department Disposition**

Characteristic	All Patients	Discharges From ED	Floor Admissions	ICU Admissions	Significance (p)
Patients, n (%)	55	19 (34.5)	22 (40)	14 (25.5)	
Mean age, yr	67.1	64.7	67.4	69.8	0.8
Male sex, n (%)	35 (63.6)	11 (57.9)	14 (63.6)	10 (71.4)	0.9
Initial Glasgow Coma Scale, mean	14.8	14.9	14.9	14.6	0.3
Traumatic mechanism, n (%)	36 (65.5)	18 (94.7)	14 (63.6)	4 (28.6)	<0.001
Antiplatelet use, n (%)	27 (49.1)	6 (31.5)	12 (54.5)	9 (64.2)	0.1
International normalized ratio on presentation, mean	1.02	1.03	1.00	1.05	0.6
Predominant intracranial hemorrhage, n (%)					
Subdural hemorrhage	23 (42)	10	10	3	
Intraparenchymal hemorrhage/contusion	19 (35)	5	6	8	
Subarachnoid hemorrhage	8 (15)	2	4	2	
Intraventricular hemorrhage	1 (2)	1	0	0	
Intratumoral hemorrhage	4 (7)	1	2	1	
Vasoactive infusion, n (%)	16 (29.1)	3 (15.8)	6 (27.3)	7 (50)	0.1
Mean ED length of stay, hr (SD)	17.6 (6.6)	17.1 (4.9)	20.6 (7.5)	13.7 (4.9)	0.01
Median ED length of stay, hr	15.7	17.5	21.0	12.9	
Mean inpatient length of stay (if admitted), d (SD)	6.2 (7.6)	N/A	3.3 (3.7)	10.8 (9.9)	0.003
Median inpatient length of stay (if admitted), d	4.0	N/A	2.2	6.2	
Readmission within 30 d, n (%)	9 (16.4)	3 (15.8)	4 (18.2)	2 (14.3)	1.0
30-d mortality, n (%)	4 (7.3)	0 (0)	3 (13.6)	1 (7.1)	0.2
30-d neurosurgical intervention, n (%)	7 (12.7)	0 (0)	2 (9.1)	5 (35.7)	0.01

ED = emergency department.



**Figure 2.** Emergency department (ED) timeline for patients managed via the resuscitative care unit minor intracranial hemorrhage protocol. EC3 = Emergency Critical Care Center.

In a subgroup analysis of 36 patients with a traumatic mechanism, 18 (50%) were able to be discharged from the ED. Fourteen (39%) were admitted to general care, and four (11%) were admitted to intensive care. In total, there were nine patients (25%) who required readmission, three patients (8.3%) who underwent neurosurgical intervention, and two patients (5.6%) who died within 30 days of presentation.

## DISCUSSION

The management of patients with mICH can represent a treatment dilemma for physicians. Although mICH is generally regarded as a condition with a low-risk for decline, patients are typically admitted to an ICU for close observation. Many attempts have been made to stratify risk of ongoing bleeding or clinical deterioration in order to minimize “over-triage,” but none have been translated into widespread clinical practice (3). This dilemma has resulted in a wide variability in practice patterns and disposition from the ED for mICH. Prior to development of our RCU, typical practice at our institution consisted of all patients with mICH being admitted to the hospital, with most admitted to an ICU. This mirrors previous data by Nishijima et al (3), in which rates of discharge from the ED ranged from 0% to 7.3% across eight institutions. A study by the Transforming Research and Clinical Knowledge (TRACK)-traumatic brain injury group found the rate of discharge from the ED for mild traumatic brain injury with ICH was similarly low at only 11.1% (16).

The hesitation for ED discharge largely stems from inadequate data on the individual patient. Decisions on management must be based on initial CT and initial examination, and there is typically no sense of the “trend” of the patient. In this study, we evaluated the use of the RCU-mICH protocol at our institution to combat this issue. This protocol allows for expedited access to critical care

nursing with neurologic checks performed every hour and tight blood pressure control. The protocol also provided a follow-up CT which was performed 8 hours after the initial scan. In total, the RCU-mICH protocol delayed the decision of ED disposition while providing ICU-level care and provided additional data on clinical and radiographic trends.

With use of the RCU-mICH protocol, 35% of patients were able to be discharged from the ED safely, representing a notable increase when compared with previous studies in which ED discharge rates ranged from 0% to 11.1% (3, 16). Only three of the discharged patients required readmission within 30 days. A further 40% of patients were admitted to a general care floor, with only the remaining 26% of patients requiring an inpatient ICU admission, lower than previously published rates of inpatient ICU utilization of 50%–97% (3). In addition, only one patient admitted to the ICU (7%) had a total inpatient length of stay less than 2 days. When used as a criterion for “over-triage,” this represented an improvement compared with data from the National Trauma Data Bank (4). Avoidance of “short-stay” ICU admissions may allow more appropriate resource utilization of inpatient ICU beds for patients with more substantial critical care requirements.

The average time to RCU from initial triage was 5 hours, with average total ED length of stay of 17.6 hours. This allowed patients to receive ICU-level care during the important initial stages of ICH. Previous studies have shown management of systolic blood pressure during these “golden hours” of treatment is critical (17), and improved outcomes have been observed with time-to-ICU of less than 5–6 hours (7, 8). It is feasible that this model of early critical care delivery to patients with mICH in an RCU may prevent detrimental outcomes previously observed for patients with prolonged ED boarding times (7).

Several important limitations of this study are recognized. This was an observational study conducted at a single quaternary referral center in the United States, and further research is needed to determine the external generalizability of results. The observational nature of this study can suggest association but cannot prove causation. Patients were excluded if anticoagulated, on dual antiplatelet therapy, significant polytrauma, seizure activity, additional critical care requirements (i.e., mechanical ventilator management), or clinician discretion, and thus applicability of results to additional patient populations is limited.

## CONCLUSIONS

Initial management of ED patients with minor ICH in a RCU (ED-based ICU) appears feasible. Use of this strategy was associated with a substantial rate of discharge from the ED (35%) with no mortality or subsequent neurosurgical interventions within 30 days and a low rate of admission to an inpatient ICU (26%). Although prolonged ED length of stay has been associated with worse outcomes for patients with ICH, use of this strategy was associated with rapid initiation of ICU-level care, which may help alleviate the challenge of increasing ED boarding time of critically ill patients facing many institutions. Additional research is warranted to explore the value of this care delivery model in other systems.

## ACKNOWLEDGMENTS

We would like to acknowledge the support from the Department of Emergency Medicine, Department of Neurosurgery, and Division of Acute Care Surgery at Michigan Medicine (University of Michigan) in development and implementation of the RCU-mICH protocol.

This work was performed at the University of Michigan in Ann Arbor, MI. Results of this work were presented at the Society of Critical Care Medicine's 49th Critical Care Congress in Orlando, FL, February 16–19, 2020.

The authors have disclosed that they do not have any potential conflicts of interest.

For information regarding this article, E-mail: haasn@med.umich.edu

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