Chapter 1
Prehospital and Emergency Department Management of Intracerebral Hemorrhage

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Background

Stroke is a leading cause of death and disability worldwide and a very common vascular disease prevalent globally spreading like a pandemic [1, 2]. Stroke can be ischemic or hemorrhagic in nature. Intracerebral hemorrhage (ICH) is the second most common subtype of stroke and a critical disease usually leading to severe disability or death [3]. ICH is defined as bleeding in the brain parenchyma. Incidence of ICH is 12–15 cases per 100,000 individual or about 40,000 cases per year in the United States [4]. ICH can be defined as "deep" located within the deep brain parenchyma such as the internal capsule, brain stem, or thalamus, or it can be "lobar" located in cortical–subcortical areas and follows a lobar pattern across one or multiple lobes of the brain. Deep ICH accounts for about two third of spontaneous ICH cases, and lobar ICH accounts for the remaining one third [5].

Hypertension is by far the most common risk factor. Other common risk factors are cerebral amyloid angiopathy, hematological abnormality, anticoagulation use, drug or alcohol abuse, and chronic kidney disease [6].

ICH mortality is about 40% at 30 days, making ICH one of the most deadly acute medical events. At 1 year, the mortality is 50%. Around 50% of the deaths happen in 48–72 h of ictus and are related to neurological complications (i.e., mass effect, increased intracranial pressure, and/or herniation) [7]. Many deaths also occur in the setting of withdrawal of support due to presumed poor prognosis. In the acute setting, predictors of early mortality are hematoma size, hematoma expansion, older age, coma, intraventricular hemorrhage (IVH), and infratentorial location [8].

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ICH is a medical emergency and delays in treatment result in worse outcome. Around 20% of patients will experience a decrease in the Glasgow Coma Scale of two or more points between the prehospital assessment and the initial evaluation in the emergency department [9]. Moreover, around 20% of patients demonstrate continued deterioration within the first hours after hospital arrival [10, 11]. Therefore aggressive prehospital and emergency department treatment is cornerstone for effective management of patients with ICH.

Initial management should focus on urgent stabilization of cardiorespiratory variables and treatment of intracranial complications [12]. Recent advances such as newer laboratory testing and rapid computed tomography for diagnosis, blood pressure reduction to reduce hematoma expansion, and new anticoagulant reversal agents may allow for improved outcomes. In this book chapter, we will discuss about different aspects of prehospital and emergency management of ICH.

Prehospital Stroke Care

Recent technological innovations have opened new perspectives for stroke diagnosis and treatment before the patient arrives at the hospital. These include presumed stroke diagnosis by paramedics, mobile telemedicine for remote clinical examination and imaging, mobile stroke units with integrated CT scanners, and point-of-care laboratories in ambulances [13]. Algorithms for prehospital treatment for either ischemic or hemorrhagic stroke are parallel to each other. In this section of the manuscript, we will discuss several aspects of prehospital care for patients with ICH.

Public Awareness

Time is saved if stroke symptoms are recognized early, and both the family and bystanders play a major role. Early recognition leads to early 911 call and early treatment and thus better outcomes not only for hemorrhagic but ischemic strokes as well. Multiple modalities for increasing awareness have come along including printed materials, audiovisual aids, and billboard advertisements targeting patient population, family members including children and relatives [14–16]. The effects of the campaigning were seen to be effective but for a short span only, and thus repetition and continuous promotion is the key [17]. Despite the continuous campaigning, only 53% of the population is using EMS services. The National Hospital Ambulatory Medical Care Survey (NHAMCS) reported that with use of 911 and EMS services, prehospital delays are less and patient's door to CT or MRI times are shorter as well [18]. Early alarm has been associated with female gender, higher education and socioeconomic status, presence of bystanders, family history of stroke, and acute and severe symptoms [19, 20].

Emergency Medical System Services

Emergency medical system (EMS) personal are involved since 911 activation and dispatch, response to on site, triage and stabilization in field, patient transport ground or air, and prehospital notification. The primary objective is to provide airway management if needed, provide cardiovascular support, and transport the patient to the closest facility prepared to care for patients with acute stroke [21, 22]. The secondary objective for EMS personal is to obtain a focused history regarding the symptom onset time; nature of clinical symptoms; relevant past medical and surgical history, medication, and drug use; and contact information for family. Another important role of EMS providers is the prehospital notification so that critical pathways can be initiated and consulting services alerted. Advance notice by EMS has been shown to significantly shorten time to computed tomography (CT) scanning in the ED [21, 23].

Accuracy of EMS in identifying stroke (ischemic or hemorrhagic) symptoms is highly variable ranging from 30% to 83% [24, 25]. There are various scales available that can be used by EMS personal for identification of suspected stroke patients including Cincinnati prehospital stroke scale [26], Los Angeles prehospital stroke screen [27], or Face Arm Speech Test (FAST) scale assessment [28]. Certain clinical features suggest the diagnosis of ICH over ischemic stroke are vomiting, systolic blood pressure > 220 mmHg at onset, severe headache, coma or decreased level of consciousness, and symptom progression over minutes or hours. However, none of these clinical features are specific [29].

Several prehospital interventions known to influence outcomes, including administration of supplemental oxygen [30, 31], fluid resuscitation preferably with normal saline (avoiding dextrose containing solutions as it can exacerbate cerebral injury), keeping head of bed up for suspected hemorrhagic stroke, identifying hypo- or hyperglycemia with a finger stick glucose testing and treating it promptly, and insertion of angiography compatible IV lines, are routinely provided by EMS personal en route to the hospital in suspected stroke patients.

Mobile Stroke Unit

The concept of taking stroke care to the patient by deployment of mobile stroke units (MSU) is rapidly expanding. Mobile stroke units enable time-sensitive diagnosis and delivery of ultra-early stroke treatment. Walter and colleagues launched the first MSU in 2010 in Saarland, Germany, with a Mercedes-Benz Vario 815D ambulance that included conventional ambulance equipment; a small portable 8-slice CT scan; a telemedicine system for transmission of digital imaging, communication, and real-time video of patient clinical examination; and a point-of-care laboratory system [32].

Then came STEMO in Berlin with CT head and CT angiography capability, but only one CT angiography was done [33–35]. The first MSU in the United States was

launched at University of Texas, Houston, followed by Cleveland Clinic MSU and then University of Tennessee, Memphis, MSU [36–38].

The concept of MSU can be very useful for hyper-acute management of ICH. Early detection of ICH on CT head on MSU allows EMS personal to triage patient and to make sure patient is being transported to a tertiary care center with services of neurology, neurosurgery, neurocritical care, and neurointerventional specialist [13]. Hematoma expansion occurs early after ictus in ICH most commonly within 4.5–6 h from onset [21]. Whether very early aggressive reduction systolic blood pressure in the MSU could effectively improve functional outcome in ICH remains unknown, but the MSU provides a unique environment to test this hypothesis. Other than blood pressure lowering, MSUs may serve as a powerful platform for study of hemorrhage control agents as well as neuroprotective drugs in the management of ICH [39]. The BEST-MSU study reported enrolling 4 ICH cases from their first 26 patients, and aggressive BP lowering was provided within the first hour of symptom onset [40]. Use of continuous infusion antihypertensive agents by MSU teams promotes improved blood pressure control of these fragile cases while ensuring provision of close hemodynamic monitoring. Additionally, MSU teams that stock reversal agents for coagulopathic ICH are well suited to rapidly support hemostasis alongside standard management while alerting both neurosurgery and neurocritical care teams of CT/CT angiography findings and pending patient needs [40, 41]. Administration of hyperosmolar agents including mannitol or hypertonic saline, in consultation with neurocritical care team, can be carried out if clinical signs of herniation are present while en route to avoid delay and preventing complete herniation. Detailed prehospital workup with CT angiography allows the determination of vessel leak (so-called spot sign) in ICH patients. However, the cost-effectiveness of MSUs is still a concern.

Role of Mobile Telemedicine

Telemedicine-enabled ambulance-based evaluation reduces time to imaging and treatment. Non-stroke-capable hospitals are also able to get stroke expertise from stroke experts via telemedicine. Telemedicine has been shown to be safe and promotes early triaging and treatment and better clinical outcome. Telemedicine also helps in identifying severe patients which can benefit more by transferring to tertiary stroke centers [42, 43].

Emergency Department Stroke Care

All the major stroke centers are working toward the concept of "Time is brain" which holds true for both ischemic and hemorrhagic strokes [44, 45]. Timely evaluation, diagnosis, and treatment of patients with ICH should be performed expeditiously in emergency department (ED) because clinical deterioration is common in the first few hours. In addition to prehospital notification provided by EMS, there should be an

effective and quick communication between EMS transport and ED staff as soon as patient arrives in ED so that rapid clinical evaluation by adequately trained nurses and physicians can be possible [46]. The hospitals without on-site presence of stroke or neurosurgery consultants can also easily be benefited by the telemedicine which allows rapid visualization of clinical and neurological data, providing neurosurgical expertise within minutes to peripheral hospital. Telemedicine can also help to transfer such patients to tertiary care centers when necessary [42, 43].

Primary management of ICH in ED include rapid clinical evaluation, laboratory studies including blood glucose and coagulation defects, diagnostic imaging studies, management of blood pressure and early intracranial complications such as hydrocephalus or impending herniation, and admission to stroke unit or neuroscience intensive care unit (NICU).

Rapid Clinical Evaluation

Rapid clinical evaluation by trained nursing staff and physician is the most vital and earliest part of management of ICH patients in the ED. History can help to evaluate possible vascular risk factors and any triggering agents such as medicine, alcohol, illicit drugs, or other underlying pathologies such as intracranial vascular malformation, cancer, or hematological disorders. Effective physical examination should include vital sign, focused general and cardiovascular exam, and detailed neurological exam including severity scale. Different severity scales are being used for the assessment of ICH, and the most used is ICH score which provides clinical grading scale for outcome after ICH [47]. When the patient arrives to ED, it is difficult to predict that it is ischemic or hemorrhagic stroke; therefore commonly used ischemic stroke scale known as the National Health Institute Stroke Scale may be helpful in ICH as well to assess the severity of deficits. However these scales should be not be used as solo measures to grade prognosis [48, 49].

Laboratory Studies

Laboratory studies include complete blood count, complete metabolic panel, toxicology screen, coagulation profile, urine studies, and other relevant studies deemed significant by history. Early diagnosis and reversal of any triggering factors such as coagulation defects, blood glucose, etc. can play a vital role in better prognosis of patients with ICH.

Neuroimaging Evaluation

In any patients with acute stroke symptoms, it's impossible to know if stroke is ischemic or hemorrhagic based on clinical symptoms alone; therefore rapid neuroimaging evaluation is a must to make the diagnosis and elucidate the etiology of ICH. Neuroimaging usually comprises the combination of any of the following,

computerized tomography (CT) head, CT angiography, CT perfusion, magnetic resonance (MR) brain, MR angiography, and MR venography or conventional angiography. CTH without contrast is considered to be the gold standard due to its high sensitivity for diagnosing ICH, rapidity, cost-effectiveness, and easy availability [50, 51]. CT head also gives useful information about location, intraventricular extension, hydrocephalus, presence and degree of edema, and midline shift or brainstem compression secondary to the mass effect from the hematoma [51]. Both CT head and MR brain are equally sensitive to identify ICH, but CT head better visualizes intraventricular and subarachnoid bleed, and MR brain is better at identifying prior hemorrhages, hemorrhagic transformation of ischemic stroke, and underlying structural lesions (i.e., neoplasms and vascular malformations). Given the cost, duration of the examination, and poor tolerability for some patients, MR is less commonly used in the ED for workup of ICH [52].

ICH volume is a strong predictor of ICH outcome as larger hematomas have a poorer prognosis. Intracerebral hematoma volume can be rapidly estimated in the ED with the ABC/2 technique. A is the maximum ICH diameter (in cm) estimated visually; B is the maximum ICH diameter perpendicular to A (in cm), and C is the total number of CT slices with the ICH seen in the vertical plane multiplied by the CT slice thickness (typically 5 mm or 0.5 cm). A, B, and C numbers are then multiplied together and divided by 2 [53, 54]. The location of ICH on CT head, along with the patients' age and medical history, provides important information about the etiology of ICH. In general, deep ICHs are hypertensive, and lobar ICHs are caused by secondary causes, such as cerebral amyloid angiopathy, coagulopathy, vascular malformations, tumors, dural arteriovenous fistulas, and vasculitis, and warrant further investigation such as contrasted MR, CT, or MR angiography or conventional angiogram [55]. A small percentage of lobar ICH can be hypertensive as well [56].

A "spot" sign on post-contrast CT is a small enhancing foci within the hematoma, related to vascular leak at the point of enhancement; the presence of the "spot" sign seems to independently predict hematoma enlargement [53]. The ICH patients with spot sign are at risk of immediate worsening, and several ongoing studies are investigating role of ultra-intensive blood pressure control or hemostatic therapy in this subgroup of patients [53, 57–60].

Computed tomography angiography (CTA) is a useful diagnostic tool in the acute setting of ICH. It is the most widely available noninvasive technique for the detection of vascular abnormalities as secondary cause of ICH [60]. Prompt detection of these lesions is crucial and has a significant impact on patient management. Although CTA is an excellent noninvasive screening tool, digital subtraction angiography remains the gold standard investigation for diagnosis and for possible endovascular treatment of cerebral vascular malformations. The main drawback of CTA is contrast and the additional radiation exposure. Although some clinicians are concerned about the risk of contrast-induced nephropathy, there is a debate in the literature whether this entity exists. In patients with poor kidney function, contrast allergies, or other contraindications to CTA, brain vessel imaging can be achieved through MR angiography [53, 60]. Conventional digital subtraction angiography is often indicated in patients with SAH and ICH with abnormal calcifications or blood

in atypical locations or presentation or in young patients with no obvious cause for ICH. MRI is equally sensitive as is CTH to pick up ICH, but ICH evaluation on MRI depends primarily on the age of the hematoma and the type of MR sequence (i.e., T1 or T2 weighted). The signal intensity on MR depends on the specific form of Hb present, hyper-acute >24 h appear isointense on T1 and slightly hyperintense on T2; acute 1–3 days appear slightly hypointense on T1 and very hypointense on T2; early subacute >3 days appear very hyperintense on T1 and very hypointense on T2; late subacute >7 days appear very hyperintense on T1 and very hyperintense on T2; chronic center >14 days appear isointense on T1 and slightly hyperintense on T2; and chronic rim >14 days appear slightly hypointense on T1 and very hypointense on T2 [61].

After diagnosis, emergency providers should arrange for rapid admission to a stroke unit or neuroscience intensive care unit (at their own hospital if available or via transfer) and initiate early management, while the patient is awaiting this bed. The following management procedures should be initiated in the ED rather than waiting until after transfer to an intensive care unit, stroke unit, or other hospital.

Airway Protection

Generalized endotracheal intubation is indicated in patients with reduced consciousness to protect airway, bulbar dysfunctional leading to inability to handle secretions, or concomitant respiratory or cardiac problems leading to respiratory distress. In these clinical situations, induction of GETA should be done as in a rapid sequence technique with careful attention to minimize large hemodynamic fluctuations or fluctuations in intracranial pressure if monitoring is being done [62].

Blood Pressure Management

The underlying reason for high blood pressure in stroke patients is not absolutely clear. Most of patients with ICH have chronically uncontrolled hypertension and elevation of blood pressure at time of presentation to hospital is merely a reflection of the poorly controlled blood pressure. Cushing–Kocher response resulting from compression from brain stem may also play a vital role for elevated blood pressure to maintain cerebral perfusion. Acute stress response leading to abnormal neurohumoral mechanism may also cause acute high blood pressure during ICH. Blood pressure increase is associated with higher risk of hematoma expansion, neurological deterioration, poor outcome, and death. The pathophysiology behind hematoma expansion is not well understood. It is not clear whether it reflects leakage, rebleeding, or both. After vessel rupture, an initial hematoma forms, causing secondary vessel rupture due to mass effect, and also triggers an avalanche of further vessel ruptures, but the real mechanism leading to final hematoma volume remains unclear. Hematoma expansion occurs early in the course of ICH, and early CT scan repetition is warranted to detect it [63, 64].

ATACH-I trial failed to find any significant relationship between SBP reduction and hematoma expansion, perihematomal edema, and 3-month outcome among patients with ICH [65]. INTERACT1 (intensive blood pressure reduction in acute cerebral hemorrhage trial-1) showed that patients within 6 h of ICH with rapid reduction of SBP to <140 mmHg to be safe [66]; but INTERACT 2 (intensive blood pressure reduction in acute cerebral hemorrhage trial-2) failed to meet its primary end point, and did not definitively show improved outcome with intensive BP treatment (SBP target <140 mmHg) [67–69]. The most robust and latest data on BP management come from the ATACH-2 trial (antihypertensive treatment of acute cerebral hemorrhage II), a large clinical trial randomizing patients to one of two different systolic blood pressure (SBP) control strategies, SBP 110–139 mmHg vs SBP 140–179 mmHg, which showed that patients with ICH and tight SBP control of 110–139 mmHg did not result in a lower rate of death or disability than standard reduction to a target of 140–179 mmHg [70]. The main limitation in ATACH-2 trial is that patient randomized to have intensive treatment had ultra-intensive control of blood pressure, i.e., the mean minimum systolic blood pressure during the first 2 h was 128.9 ± 16 mmHg versus 141.1 ± 14.8 mmHg in the standard-treatment group. Such intense systolic blood pressure control led to higher percentage of patients with any serious adverse events (25.6% vs. 20.0%).

The current American Heart Association guidelines suggest that the early lowering of BP to 140 mmHg is safe and can be effective for patients with ICH presenting with a 150–220 mmHg systolic blood pressure [21].

To avoid hypotension, short half-life antihypertensive, such as labetalol or nicardipine, is recommended to control blood pressure in patients with ICH [21, 64]. Clevidipine monotherapy has recently shown promising effects in terms of safe rapid blood pressure reduction in ICH patients leading to decreased hematoma expansion [71].

Thromboprophylaxis in ICH Patients

Deep vein thrombosis (DVT) prophylaxis is tricky in patients with ICH as they have tendency to bleed more with conventional medications used for DVT prophylaxis; therefore intermittent pneumatic sequential compression devices (SCDs) are indicated in such patients beginning the day of hospital admission. DVT prophylaxis can be started with conventional low-dose molecular weight heparin or unfractionated heparin once intracranial bleed has been stopped after 3–4 days of onset of the ICH [72–74]. ICH patients with symptomatic DVT or PE can be given one of the following two options, systemic anticoagulation or IVC filter placement, depending on various factors such as comorbidities including prothrombotic conditions, cause of hemorrhage, time from hemorrhage onset, and hematoma stability.

Hemostatic Treatment

(a) Platelet function
Limited data is available to support the reversal strategy to improve platelet function in patients with ICH who are taking antiplatelet medications. PATCH trial failed to show beneficial effect of platelet transfusion over standard care for people taking antiplatelet therapy before intracerebral hemorrhage [75]. However, patients with severe thrombocytopenia, 50,000–100,000, should receive replacement therapy with platelet transfusion [72].

(b) Anticoagulant-Associated Coagulopathy
Anticoagulants and coagulation defect may lead to intracranial hematoma expansion and subsequently clinical deterioration and death. In case of warfarin coagulopathy, recommendations are to discontinue warfarin, administer intravenous vitamin K, and factor repletion [72–74]. INCH trial [76] showed that in patients with vitamin K antagonist-related intracranial hemorrhage, prothrombin complex concentrates (PCC) may be preferred over fresh frozen plasma (FFP) due to rapid action causing INR normalization in short period of time and leading to smaller hematoma expansion [67, 68]. The optimal INR target is still debated, and proposed target value range less than 1.5. rFVIIa is not recommended for reversal in ICH [77]. FAST trial failed to prove the beneficial effects of hemostatic therapy with rFVIIa in terms of survival or functional outcome after ICH, but it significantly reduced growth of the hematoma [78].

Protamine sulfate may be considered to reverse heparin in patients with acute ICH at the dose of 1 mg per 100 units of heparin (maximum dose up to 50 mg).

Novel oral anticoagulants (NOACs) or direct oral anticoagulants (DOACs) are increasingly being used as an alternative to warfarin. The most commonly used are the factor Xa inhibitors apixaban, rivaroxaban, and edoxaban and the direct thrombin inhibitor dabigatran. Functions of these agents do not need to be monitored by laboratory studies such as INR. Limited data is available on reversal of these newer agents by antagonists. Administration of vit K for reversal of these newer agents is futile; however charcoal (<2 h intake of NOACs) PCC, FEIBA, and rFVIIa have showed some promising effects which needed to be further investigated [79, 80]. Idarucizumab has been recently licensed and proved effective for reversal of dabigatran [81]. Andexanet alfa has also shown promising effect in reversal of rivaroxaban, apixaban, and edoxaban and is likely to be soon licensed for use in patients with ICH [82–84].

(c) Recombinant tissue plasminogen activator (rtPA)-associated coagulopathy may lead to hemorrhagic conversion of ischemic stroke, symptomatic ICH being the most dangerous complication. To prevent the hemorrhagic conversion of ischemic stroke, it is recommended to strictly control blood pressure and avoid antithrombotic medication in the first 24 h following the infusion of rtPA. Limited data is available to standardize the treatment of post rtPA ICH. It is recom-

mended to immediately discontinue rtPA and administer any of the following compounds: cryoprecipitate, antifibrinolytic, aminocaproic acid, vitamin K, FFP, PCC, platelet transfusion, or recombinant activated factor VII A [85].

Intracranial Pressure Management

Current AHA/ASA guidelines suggest ICP monitoring with parenchymal or ventricular devices in patients with coma, significant IVH with hydrocephalus, and evidence of transtentorial herniation, with a cerebral perfusion pressure target of 50–70 mmHg. ICP increase can be avoided or treated by elevation of the head to 30, adequate sedation, or avoidance of hyponatremia [21]. ICH who are at risk of transtentorial herniation may also benefit from hyperosmolar therapy with mannitol or hypertonic saline.

Surgical Management of ICH

Surgery in patients with neurologically asymptomatic ICH is not clearly beneficial. Supratentorial hematoma evacuation in deteriorating patients might be considered as a life-saving measure. STICH and STICH II were undertaken to determine whether early surgery reduces mortality and improve neurological outcome compared with conservative management for supratentorial ICH [86, 87]. Both STICH and STICH II failed to clearly identify the beneficial role of surgery in patients supratentorial hemorrhages, but subgroup analysis of STICH [86] suggested that patients with lobar hemorrhages within 1 cm of the cortical surface might benefit from surgery which led to STICH II trial that specifically included the ICH patients with superficial lobar hemorrhage.

Supratentorial ICH patients who are in a coma, have large hematomas with midline shift, or have elevated ICP refractory to medical management may also have mortality benefit from decompressive craniectomy with or without hematoma evacuation [86, 87].

The role of minimally invasive clot also is uncertain [88, 89]. The Minimally Invasive Surgery Plus Recombinant Tissue-Type Plasminogen Activator for ICH Evacuation Trial II (MISTIE II) showed a significant reduction in perihematomal edema in the hematoma evacuation group. Such a promising effect in MISTIE II led researchers to continue a randomized phase 3 clinical trial of minimally invasive hematoma evacuation (MISTIE III) which is currently in progress [90]. Apollo devices have also been studied for minimally invasive evacuation of ICH and intraventricular hemorrhage, but further studies are required to prove benefit from this promising technology [91].

Emergent surgical removal of the hemorrhage is also recommended in patient with cerebellar hemorrhage who have neurological deterioration, brain stem compression, or neurologically or hydrocephalus from ventricular obstruction [88, 89].

Intraventricular administrations of thrombolytics or any other endoscopic treatment of IVH are clinically unproven in terms of efficacy [92].

Blood Glucose Management

No specific blood glucose target level is recommended, but tight glycemic control has been shown to be associated with better outcome [93]. The AHA/ASA guidelines suggest to avoid both hyperglycemia and hypoglycemia [21].

Temperature Management

Optimal temperature management is still unclear, but it is recommended to treat fever as it has been associated with poor outcome. The presence of fever is a common finding in patients with ICH, especially in those with extensive IVH [93]. More studies are needed to investigate the role of normothermia or hypothermia and their effect on outcome in patients with ICH.

Seizures and Antiseizure Drugs

The prophylactic administration of antiseizure drug therapy is not recommended, and even some data suggest that phenytoin may worsen outcomes in patients with ICH. Antiseizure medications are administered in the patients with clinical or electroencephalography (EEG) evidence of seizures [94]. The patients with ICH who have impaired mental status that is disproportionate to the degree of brain damage should be considered for continuous EEG monitoring to rule out nonconvulsive seizures.

Transfer to an Intensive Care Unit, Stroke Unit, or Other Hospital

There should be no delay in transfer of patients with ICH to a facility which is better equipped to manage this devastating condition. Furthermore, studies have shown better morbidity and mortality rates in patients who are admitted to dedicated stroke unit.

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