Morello *et al. J Anesth Analg Crit Care* (2025) 5:25
https://doi.org/10.1186/s44158-025-00244-z

Journal of Anesthesia, Analgesia and Critical Care

CONSENSUS ARTICLE

Open Access

Golden hour management in the patient with intraparenchymal cerebral hemorrhage: an Italian intersociety document

Gianluigi Morello[1], Daniela Alampi[2], Raffaele Aspide[3*], Alessandra Beretta[4], Rita Bertuetti[4], Federico Bilotta[5], Etrusca Brogi[6], Giovanni Buscema[7], Anselmo Caricato[8,9], Davide Caruzzo[10], Carlo Alberto Castioni[3], Arturo Chieregato[6], Andrea Cortegiani[11,12], Alessandro De Cassai[13,14], Andrea Fabbri[15], Domenico Gelormini[16], Paolo Gritti[17], Lucrezia Guadrini[4], Alberto Librizzi[4], Nicola Latronico[18,19], Nicola Limbucci[20], Marina Munari[21], Edoardo Picetti[22], Giuseppina Pipitone[23], Gianluca Pucciarelli[24], Chiara Robba[25,26], Danilo Toni[27], Salvatore Sardo[28], Simone Maria Zerbi[29], Nicola Zugni[4] and Frank Rasulo[30]

Abstract

Background Spontaneous intracerebral hemorrhage (ICH) accounts for 9–27% of all strokes worldwide and is associated with high mortality and disability. The main causes include vascular malformations, small- and large-vessel angiopathies, and coagulation disorders. Mortality rates reach approximately 40% at 1 month and 54% at 1 year, largely influenced by early management decisions. Rapid intervention, particularly within the first hour, is crucial, especially for patients initially treated in peripheral hospitals. This consensus document, developed by SIAARTI with the endorsement of multiple medical societies, aims to standardize ICH management based on hospital capabilities, aligning with the "time is brain" principle and the 2022 AHA guidelines.

Methods A multidisciplinary panel of experts—including neurointensivists, neuroanesthesiologists, neurologists, neuroradiologists, emergency physicians, and neuroscience nurses—developed this consensus document. The process combined a systematic literature review with a modified Delphi method, prioritizing clinical questions using the UCLA-RAND appropriateness methodology. Literature searches were conducted on PubMed following PRISMA 2020 guidelines. Statements were formulated based on both evidence and expert consensus, and the final document underwent external peer review.

Results Computer tomography (CT) angiography, with over 90% sensitivity and specificity, is a key tool for identifying macrovascular abnormalities and detecting active bleeding, a critical factor in poor outcomes. Prognostic models, such as the ICH score, assist in clinical decision-making. Strict blood pressure control (target 130–140 mmHg) and early intubation in appropriate cases help mitigate hematoma expansion. Anticonvulsants are recommended only for patients with documented seizures. In cases of anticoagulant-related hemorrhage, prothrombin complex concentrates are effective for rapid reversal, though their long-term impact remains uncertain. Intensive care unit (ICU) admission is determined by ICH severity, with severe cases benefiting from specialized neurocritical care.

*Correspondence:
Raffaele Aspide
r.aspide@isnb.it
Full list of author information is available at the end of the article

Conclusion A multidisciplinary and inter-societal discussion provided key recommendations for the immediate management of ICH, based on the available literature. While only a few topics are supported by robust evidence, experts strongly recommend early brain angio CT, risk stratification using scoring systems, clear communication of patient data, and intubation for impaired consciousness. Blood pressure should be controlled with alpha- and beta-blockers, avoiding hypotension. Anticoagulant reversal should be appropriately managed, and eligible patients should be centralized in ICU and neurosurgical centers using dedicated scoring systems.

Keywords Intracerebral hemorrhage, Clinical questions, Computed tomography angiography, Glasgow Coma Scale, Systolic blood pressure, Tranexamic acid, Electroencephalogram

Background

Spontaneous intracerebral hemorrhages (ICH) are a significant cause of stroke, accounting for 9 to 27% of strokes worldwide. This condition arises from a variety of factors, including micro- and macroangiopathy, vascular malformations, and coagulation disorders.

ICH is associated with a high mortality rate: nearly 40% of patients die within a month, with up to 54% succumbing within a year. The decision to withhold treatment, often due to ethical considerations about the appropriateness and proportionality of care, can further impact these rates. Survivors often experience significant disabilities that negatively affect their quality of life. Thus, optimizing patient care and management strategies is essential to mitigate both mortality and morbidity in ICH cases [1].

Early intervention within the first hour of diagnosis is crucial, particularly since many patients initially receive care in hospitals without neurology or neurosurgery units. Therefore, it is imperative to swiftly diagnose and treat these patients to improve outcomes.

This document, authored by the Italian Society of Anesthesiology, Resuscitation, and Intensive Care (SIAARTI) and co-endorsed by several medical societies, outlines a standardized approach tailored to the specific capabilities of hospitals, whether they function as "hubs" or "spokes" in this context. The protocol underscores the "time is brain" concept, advocating for expedited interventions within the first 24 h following diagnosis and stabilization, in accordance with the 2022 guidelines from the American Heart Association (AHA) [2].

Methodology

The steering committee, comprising G. M. and F. R., assembled a multifaceted panel of experts renowned for their expertise in ICH and stroke management. The panel consisted of neurointensivists, neuroanesthesiologists, neurologists, neuroradiologists, emergency physicians, and neuroscience nurses. A methodologist (C. R.) was assigned to the project, and two additional experts (A. C., A. Ch.) were included in the advisory committee (A. C.). In addition to members from SIAARTI, representatives from several medical societies were invited, including the Society of Medical and Interventional Radiology (SIRM), National Association of Neuroscience Nurses (ANIN), Italian Society of Neurology (SIN), Italian Society of Emergency Medicine (SIMEU), and Italian Stroke Association-Italian Ictus Association (ISA-AII). These collaborations aimed to ensure a comprehensive and multidisciplinary approach.

The methodology employed a blend of systematic literature review complemented by a modified Delphi process, prioritizing clinical questions using the UCLA-RAND appropriateness methodology [3]. Literature searches were conducted on PubMed following PRISMA 2020 guidelines [4].

Clinical trial number

This is not applicable.

Results

The results are described as individual paragraphs related to the nine items. Table 1 summarizes the queries, with the related subcategories and the related expert panelists' answers.

Statement 1: Indications of CT angiography

Computed tomography (CT) angiography has demonstrated excellent accuracy in the detection of macrovascular anomalies, with sensitivity and specificity levels exceeding 90% [5–9]. The "DIagnostic AngioGRAphy to find vascular Malformations" (DIAGRAM) score highlighted that factors predicting intraparenchymal cerebral hemorrhage due to macrovascular disease include young age, lobar or posterior fossa hemorrhages, and the absence of small vessel disease [10]. The predictive probability of macrovascular disease was approximately 1% of patients aged 50 to 70 years with deep cerebral hemorrhage and small vessel disease. The probability increased to over 50% in patients aged between 18 and 50 with lobar or posterior fossa ICH without small vessel disease.

Table 1 This table contains the nine main statements and their sub-statements and related expert panel indications. The last column shows the percentages of agreement resulting from the votes

	Statement		Percentage of agreement
1. Indications and/or criteria for performing CT angiography	1.a	The expert panel considers CT angiography appropriate in patients younger than 70 years old and spontaneous lobar intracerebral hemorrhage	100% (*IQR* 7–9)
	1.b	The expert panel considers CT angiography appropriate in patients younger than 45 years old and spontaneous deep intracerebral hemorrhage or posterior fossa hematoma	100% (*IQR* 7–9)
	1.c	The expert panel considers CT angiography appropriate in patients aged between 45 and 70 years old with no clinical history of systemic arterial hypertension, in cases of spontaneous deep intracerebral hemorrhage or posterior fossa hematoma	100% (*IQR* 7–9)
	1.2	The expert panel considers CT angiography appropriate to exclude cerebral venous thrombosis	96.15% (*IQR* 7–9)
	1.3	The expert panel considers early CT angiography appropriate to identify patients at risk of hematoma expansion	96.15% (*IQR* 7–9)
2. What is the rationale for using scores for prognostic stratification (e.g., ICH score)	2.1	Stratification of patients at admission using a severity score is indicated	100% (*IQR* 7–9)
	2.2	The use of prognostic scoring model that can predict outcome is useful; however, they cannot be used as the sole criterion for deciding the intensity of treatment and/or its withdrawn	100% (*IQR* 7–9)
3. What are the criteria for indicating orotracheal intubation?	3.1	Orotracheal intubation is indicated in the following: •In patients with a severe impairment of the level of consciousness (a score of less than 8 on the *GCS* ≤ 8) •In case of dysfunctional airway-protective mechanisms and/or inadequate gas exchange	100% (*IQR* 7–9)
4. What are the systolic BP targets to maintain?	4.1	In hemorrhagic stroke with BP 150–220 mmHg, start prompt treatment targeting 130–140 mmHg, avoiding rapid shifts, hypotension, and hypoperfusion	100% (*IQR* 7–9)
	4.2	In patients with hemorrhagic stroke and systolic *BP* > 220 mmHg, a BP reduction of approximately 90 mmHg is advisable	88.5% (*IQR* 7–9)
	4.3	In severe hemorrhagic stroke (GCS alteration or hematoma > 30 ml), BP targets should be adjusted based on *CPP* ≥ 60–70 mmHg when available	88.5% (*IQR* 7–9)
	4.4	For the hypertension, drugs with rapid onset and short half-life are preferable	100% (*IQR* 7–9)
5. The rationale for utilizing invasive and continuous blood pressure monitoring in patients with intraparenchymal cerebral hemorrhage	5.1	Invasive blood pressure monitoring is recommended as early as possible in patients with impaired consciousness	92.3% (*IQR* 7–9)
	5.2	In patients with a large intracerebral hematoma for whom continued treatment is considered beneficial, invasive blood pressure monitoring is advisable	96.15% (*IQR* 7–9)
	5.3	Invasive blood pressure monitoring is recommended in patients with atrial fibrillation and hemodynamic instability	88.5% (*IQR* 7–9)
6. What is the rationale for the use of tranexamic acid within the first hour of diagnosis?	6.1	There is no clear evidence to support the use of tranexamic acid in patients with intraparenchymal cerebral hemorrhage	96.15% (*IQR* 7–9)
7. What is the role of seizure prophylaxis in the first hour after diagnosis?	7.1	Expert panelists recommend against seizure prophylaxis in patients with ICH in the absence of epileptic seizures (observed clinically and/or with EEG)	100% (*IQR* 7–9)

Table 1 (continued)

	Statement		Percentage of agreement
8. What is the role of early use of antagonists in patients on anticoagulant or antiplatelet?	8.1.a	Expert panelists recommend early reversal of anticoagulant drugs in patients with ICH on anticoagulant therapy	100% (*IQR* 7–9)
	8.1.b	Expert panelists recommend reversal of anticoagulant drugs with specific antagonists whenever possible, or with 3–4 factors prothrombin complex concentrates, instead of fresh-frozen plasma	100% (*IQR* 7–9)
	8.2.a	Expert panelists recommend reversal of antiplatelet therapy, particularly aspirin, with platelet administration, only in ICH patients eligible for urgent neurosurgical intervention	100% (*IQR* 7–9)
	8.2.b	Expert panelists recommend against the administration of platelets or other platelet-active drugs (e.g., desmopressin) as early reversal in patients on antiplatelet therapy not undergoing urgent neurosurgical intervention	96.15% (*IQR* 7–9)
9. Admission criteria for intensive care (general or neuro, with or without neurosurgery)	9.1	As the need for intensive care relies upon the degree of vital functions' impairment, expert panelists recommend that patients with an initial GCS score < 12–13, systolic blood pressure > 160 mmHg, volume of bleeding > 15–20 ml, intraventricular hemorrhage, and subtentorial location of the hemorrhage should be admitted in an intensive care unit, making use of multidisciplinary expertise	96.15% (*IQR* 7–9)
	9.2	Expert panelists recommend that patients with intraparenchymal cerebral hemorrhage and neurological impairment, intraventricular bleeding, hydrocephalus, or subtentorial location of the hematoma should be better referred to a specialized neurointensive care unit	100% (*IQR* 7–9)
	9.3	Expert panelists recommend that in case of devastating brain injury, with poor neurological prognosis, ICU admission for organ donation purposes (DBD or DCD) is appropriate and should be pursued especially in the presence of a willingness to donate organs (expressed by the patient in life or reported by family members)	100% (*IQR* 7–9)

CT Computer tomography, *GCS* Glasgow Coma Scale, *BP* Blood pressure, *CPP* Cerebral perfusion pressure, *EEG* Electroencephalogram, *DBD* Donation after brain stem death, *DCD* Donation after circulatory death

Furthermore, Wilson et al. found that negative CT angiography (CTA) associated with small vessel disease and a positive history of arterial hypertension has a low possibility of an underlying macrovascular etiology (1.8%) [11].

Only 30% of cerebral venous thrombosis can be recognized with a non-contrast CT scan, with the visualization of a hyperdensity sign in correspondence to the venous sinuses [12]. Contrast-enhanced computed tomography can improve diagnostic accuracy. This technique has shown a sensitivity of 95% and a specificity of 91% with an overall precision between 90 and 100%, depending on the vein or venous sinus studied.

CTA allows the identification of active bleeding ("spot sign") through the visualization of the arterial extravasation of the contrast agent predicting further growth of the hematoma. The presence of spot signs is associated with a worse ICH score, lower Glasgow Coma Scale (GCS) at emergency room arrival, larger hematoma size, higher rate of expansion, and increased 90-day mortality. Furthermore, the presence of spot signs is correlated with a longer intensive care unit (ICU) stay and overall hospitalization [13–15].

Statement 2: Rationale for using prognostic scoring model

Prognostic scores such as the 'ICH score" ([16–18]) aid in assessing both the risk of death and functional outcomes for patients with ICH. Indeed, some authors believe that the predictive capacity of treating physicians is superior to the use of scores [19]. This phenomenon can be probably due to the fact that the scores are necessarily based on few covariates [20, 21] and affected by the self-fulfilling prophecy bias due to withdrawal of care, except for the maximally treated (MAX)-ICH score [22, 23].

Statement 3: Indications for orotracheal intubation

While there is a lack of trial evidence supporting superior breathing management with tracheal intubation in ICH patients [24, 25], consideration should be given to

neurological impairments such as altered cranial nerve, breathing disorders, and vomiting, all of which can lead to airway collapse and hypoxemic events impacting intensive care outcomes. Evaluations of neurological status, airway protection mechanisms, and gas exchange episodes guide the decision toward orotracheal intubation, accounting for proportionality related to patient age, preexisting conditions, and residual lifetime.

Statement 4: What are the systolic blood pressure targets to maintain?

In hemorrhagic stroke, early blood pressure (BP) management is recommended to the target value of 130–140 mmHg for ≥ 7 days to limit hematoma expansion and neurological decline, extending over 7 days if rebleeding risk persists [26, 27].

A meta-analysis published in 2021, including 16 RCTs with a total number of 5895 patients, found that the treatment of systolic blood pressure (SBP) values, in the first 7 days after the acute event, does not significantly modify the functional outcome at 3–6 months but can influence the volumetric increase of the intracerebral hematoma in patients with hemorrhagic stroke [28]. Conflicting results came from the Intensive Blood Pressure Reduction in Acute Cerebral Hemorrhage Trial (INTERACT)−2 and the Antihypertensive Treatment of Acute Cerebral Hemorrhage (ATACH)-II randomized trials [29].

It is advisable to start pressure treatment within 2 h of the onset of neurological symptoms, with the aim of reaching the BP target within 1 h of starting therapy [2]. The aim of "INTERACT-4" trial was to evaluate the efficacy of urapidil in the prehospital environment for the hyperacute treatment of hypertensive crisis [30].

Patients with hemorrhagic stroke have a higher acute kidney injury (AKI) risk [31], especially in large ICH, due to multiple factors (i.e., chronic hypertensive nephropathy, hypovolemia). In those without prior nephropathy, AKI is linked to increased mortality [32]. However, it is not yet clear whether AKI is directly responsible for this increased mortality or whether it is more a marker of the gravity of the disease from the onset [33].

In patients with moderate-severe intracerebral hemorrhage (*GCS* < 13, National Institutes of Health Score (NIHSS) ≥ 10, ICH volume ≥ 30 ml, or intraventricular hemorrhage (IVH)) and with consequent risk of intracranial hypertension, intensive BP treatment (*SBP* 110–140 mmHg) is associated with a lower frequency of hematoma expansion without reducing mortality or disabilities [34]. Indeed, a reduction in BP can lead to an increase in the cerebral blood volume and therefore according to the compliance of intracranial pressure.

Although there is no specific recommendation regarding the choice of the antihypertensive drug, rapid-onset and short-lived drugs with any possibility of continuous infusion administration allow to reduce excessive SBP fluctuations. At the same time, it is better to avoid drugs with a venodilator effect due to their unfavorable effect on the hemostasis mechanism and on the cerebral perfusion pressure (CPP). A better functional outcome has been highlighted for patients treated with alpha- and beta-blockers (i.e., urapidil and labetalol): this effect can be partially explained by the ability of these drugs to act particularly on the arteriolar compartment of peripheral resistance and mitigate the sympathetic response [35].

Statement 5: The rationale for utilizing invasive and continuous blood pressure monitoring in patients with intraparenchymal cerebral hemorrhage

BP control is crucial to limit hematoma growth. Noninvasive monitoring underestimates the SBP and overestimates diastolic blood pressure; the discrepancy between the two methods tends to increase in patients with high values of SBP [36]. In all these cases, invasive BP monitoring can be indicated. In large ICH (> 30 ml) or IVH requiring an external ventricular drain (EVD), invasive BP monitoring is essential to optimize CPP [37].

In patients with atrial fibrillation (AF), there is a high variability of pressure measurement in different points of the arterial tree [38]. In the patient with AF, the noninvasive measurement of the BP can be used for cardiac frequency values < 90 bpm or reduced variability of the heart rate (< 10 bpm difference in three subsequent beats) [39]. In the case of high values or marked variations in the time of heart rate, especially if associated with changes in BP, invasive monitoring can be recommended [40].

Statement 6: What is the rationale for the use of tranexamic acid within the first hour of diagnosis?

There are no specific trials available that clarified the effect of the use of tranexamic acid (TXA) in patients with ICH. Even if the use of TXA seems to reduce the risk of hematoma expansion, there is no evidence available showing a neurological outcome improvement and/or a reduction in mortality.

Overall, the studies examined report often contrasting results. The Tranexamic acid for hyperacute primary IntraCerebral Haemorrhage (TICH-2) trial was a controlled randomized study that included 2345 patients aimed to compare placebo versus TXA. The authors found that the reduction of hematoma expansion in patients treated with TXA was not associated with a reduction in mortality or at modified Rankin score (mRS) disability [41]. A sub-analysis of the TICH-2 trial

confirmed that TXA is able to reduce the expansion of the hematoma in the first 24 h, although this effect is only partially associated with neurological outcome [42].

A post hoc study of the "STOP-AUST" trial failed to find any significant reduction in hematoma growth after the administration of TXA in patient with IVH [43].

Statement 7: What is the role of seizure prophylaxis in the first hour after diagnosis?

In patients with ICH without evidence of detectable seizures, both clinically or instrumentally, the anticonvulsant prophylaxis has not shown any improvement in outcome, reducing the risk of early and late seizures or decreasing mortality [44–49]. Despite most published studies are predominantly uncontrolled and there remains some uncertainty regarding the definition and terminology of some electroencephalogram (EEG)-detected alterations and the choice of anti-epileptic drugs, the panel does not suggest any prophylaxis if there are no detectable seizures, clinically or instrumentally (preferably monitored with 24-h EEG continuous monitoring). Conversely, in patients with evidence of clinical or subclinical epileptic seizures, and/or detected by EEG, authors promote starting a dedicated anti-epileptic therapy.

In uncertain cases, such as an unexpected altered state of consciousness, not otherwise justifiable, in comatose patients and not clinically explorable, or in patients with lobar hemorrhagic lesions and/or near the cortex (1 cm) or in epileptogenic areas [50], a prolonged EEG (> 24 h) should be performed to check for possible epileptogenic foci or nonconvulsive disease state (NCSE).

Authors found the cortical involvement, age, hemorrhage volume, and acute symptomatic seizure (CAVE score) to be useful in identifying those patients at increased risk for late seizures [51]. Should the EEG show suggestive signs, an appropriate prophylaxis or anti-epileptic therapy can be started; any change of therapy should be based on neurophysiological control [52]. A recent trial has shown that the use of levetiracetam could be effective in reducing the risk of seizures during the early phases in patients with ICH [53].

Statement 8: What is the role of early use of antagonists in patients on anticoagulant or antiplatelet?

The administration of three- or four-factor prothrombin complex concentrates (PCC) ensures the rapid international normalized ratio (INR) reversal in a high percentage of patients on dicumarol therapy (62.9 to 80%, > 96 h) [54–58]. Nonetheless, INR reversal alone might not be enough to influence functional outcome or mortality [59].

A randomized study comparing fresh-frozen plasma, vitamin K, and PCC showed that PCC was able to improve overall survival compared to other therapies, although with similar disability scores [60]. In patients on oral anticoagulant therapy, early reduction of $INR < 1.3$ was associated with a lower expansion of the hematoma [61]. Moreover, the use of PCC 3 or 4 factors is associated with increased stability in hematoma volume stability in both patients on rivaroxaban and apixaban [62–65].

Andexanet alfa, a specific antidote, has demonstrated an excellent hemostatic response (82–90.9%) with a low incidence of thrombotic events (10%) in several studies [66–68], also confirmed by a post hoc analysis of the andexanet alfa, a novel antidote to the anticoagulation effects of factor Xa inhibitors (ANNEXA)−4 study, which showed that the hemostatic efficacy was 93.8% for apixaban and 92.6% for rivaroxaban, with 9.3% of thrombotic events in the cohort [69]. Direct comparison of andexanet alfa with four-factor PCC in non-randomized retrospective studies revealed superior [70] or at least comparable [71] results in terms of hematoma stability, functional outcome, and risk of thrombotic events.

Idarucizumab showed to be effective in preventing hematoma expansion and in improving the outcome [72] in patients who were treated with dabigatran; however, a registry study conducted in the USA did not confirm this result [73]. Other studies suggested a good hemostatic effect (79–89%) after administration of factor eight inhibitor bypassing activity (FEIBA), as highlighted by the stability of the hemorrhage volume in patients with cerebral hemorrhage treated with apixaban or rivaroxaban, whether they have undergone surgery or not [62, 74, 75].

The usefulness of platelet administration, in patients on antiplatelet therapy, has been investigated by several studies. However, only a few of them have shown efficacy in terms of reduced hematoma expansion, better outcomes, and mortality reduction [76–78]. Most of the literature available to the panel demonstrates a lack of efficacy in those outcomes [79–81]. Some studies showed a higher risk of either death or an unfavorable neurological outcome related to platelet administration [82]. The use of desmopressin alone [83] or in combination with platelet administration [80] has also not been found effective in improving the outcome of patients with intracranial hemorrhage.

Statement 9: Admission criteria for intensive care (general or neuro, with or without neurosurgery)

Independent predictive factors for intensive care admission after ICH have been identified, while predictive scores have been developed and validated. In supratentorial hemorrhage, a retrospective analysis in the Klaas study identified the variables related to the indications of

intensive care admission and developed a score to facilitate triage, the ICH triage score, which considers three variables: volume of bleeding > 30 ml, GCS score < 13, and intraventricular bleeding. The presence of one or more of these variables supports the indication for intensive care admission (sensitivity of 94.3%, $AUC = 0.88$; $p < 0.001$) [84].

The Intensive Care Triaging in Spontaneous Intracerebral Hemorrhage (INTRINSIC) score is another system of assessment with a total score of 0–9 based on four factors, such as SBP, GCS score, the volume of bleeding, and the presence of intraventricular blood at the entrance [85]. A score > / = 2 in the emergency room (ER) is predictive for ICU admission, while patients with a score of 0 or at least < 2 in the ER are more likely treated, even for the period thereafter, outside of the ICU.

Patel's work provides an easily calculable score, useful for efficient patient stratification but even to address centralization in those hospitals with the neurosurgery and for the admission to intensive care. The score includes variables such as the GCS score lower than 13 at admission, IVH, subtentorial bleeding, antiaggregant therapy, and the presence of arteriovenous malformation at CTA. The score pragmatically excludes the volume of bleeding as a predictor because its evaluation can be time-consuming in emergency conditions [86].

Patients with intraparenchymal cerebral hemorrhage presenting hydrocephalus, intraventricular bleeding, or infratentorial hemorrhage should be managed in facilities where a neurosurgical ICU, neuro specialist ICU, or a general ICU with neurosurgical support is available. Those conditions relate to better outcomes and reduced mortality [87, 88].

The risk of death of patients with higher GCS score, younger age, larger volume hematomas and female sex who are transferred to hub hospital, adjusted for established prognostic factors for cerebral hemorrhage, is less than half compared to those who remain in the first reference hospital [89].

Literature data [90] supports the recommendations of the European Stroke Organisation to treat patients with cerebral hemorrhage in a stroke unit or neurocritical care unit (NICU) and suggests that more critical patients may benefit further from treatment in the NICU. However, these recommendations are based on experts' opinions [1].

Discussion and up-to-date insights

ICH, a significant neurological emergency, remains associated with substantial mortality and disability rates. Effective management demands a multifaceted strategy, combining prompt diagnosis, prognostic evaluation, and targeted therapies. This report by the expert panel synthesizes consensus-based, widely accepted principles from the literature to guide clinicians in the initial treatment of patients with intraparenchymal cerebral hemorrhage where possible. It offers practical recommendations on CTA utilization, BP control, endotracheal intubation criteria, hemostatic therapy use, and intensive care monitoring practices.

Contrast neuro-imaging scoring

Rapid evaluation is critical for acute management and prognosis in patients with ICH. CTA is pivotal in the early detection of vascular anomalies and assessment of hematoma growth risk, aiding in differential diagnosis. Several research groups contribute to developing scoring systems, notably the DIAGRAM score for macrovascular cause probability prediction and the Causal CLASsification system for ICH Subtypes (CLAS-ICH) system for nuanced subtype classification [91].

Predictor score

Crucially, scoring systems like the ICH score [16] and MAX-ICH [22] enhance stratification, aiding treatment optimization. The FUNC score was also proposed with the aim of mainly evaluating the functional outcome [92]. Cai et al.'s primary brainstem haemorrhage (PBSH) score provides valuable predictive insights for brainstem hemorrhages [93]. However, these tools should not dictate sole criteria for care intensity or treatment withdrawal decisions; instead, they optimize resource allocation and personalize patient management.

Airway management and ventilation

Endotracheal intubation is warranted for patients with significantly impaired consciousness ($GCS \leq 8$) or absent airway reflexes, aiming to prevent aspiration and stabilize oxygenation and clinical stability. Nonetheless, ICH diagnosis independently correlates with reduced 1-year survival in those intubated acutely (statement 3) [25]. Beyond mortality, poor functional outcomes (measured as a mRS of 4–6) have a very high incidence (66.5%) at 1 year. This raises an important issue of proportionality in care: in patients with severe stroke requiring mechanical ventilation, discussions with caregivers, patients, and their families about post-ICU trajectories and functional outcomes are essential [94].

Blood pressure management

BP control is vital to mitigate hematoma enlargement (statement 4). Invasive monitoring benefits patients with impaired consciousness, large hematomas, at high risk of AF, or hemodynamic instability, facilitating precise pressure manipulation. The recent INTERACT-4 study from May 2024 published in the *New England Journal*

of Medicine underscores prehospital SBP reduction (to 159 mmHg) efficacy in improving neurological outcomes specifically for ICH patients, even though full target BP reduction was not met (140 mmHg) [95].

Antifibrinolytic therapy

While tranexamic acid has theoretical antifibrinolytic potential, current evidence does not robustly support its routine use in ICH ("Statement 6: What is the rationale for the use of tranexamic acid within the first hour of diagnosis?"). The tranexamic acid for hyperacute onset presentation including mobile stroke units (STOP-MSU) trial, published in the *Lancet Neurology* in June 2024, revealed no beneficial effects on outcomes when administered within 2-h poststroke onset [96].

Seizure's prophylaxis

Anticonvulsant prophylaxis is not advised for ICH patients without manifest seizures due to potential side effects and drug interactions [97]. Lekoubou's August 2024 study leveraging machine learning in predicting late seizures post-ICH highlights the potential of employing advanced analytics for enhanced risk prediction and resource allocation. Their models, applying logistic regression and Light Gradient Boosted Machine algorithms, achieved promising accuracy, with area under the receiver operating characteristic curve values of 0.7051 at 1 year and 0.694 at 5 years [98].

Patients on antiplatelet drugs

In this cohort, reversing anticoagulation early is paramount to prevent hematoma expansion, often favoring specific antagonists or concentrates over plasma ("Statement 8: What is the role of early use of antagonists in patients on anticoagulant or antiplatelet"). Platelet administration for antiplatelet-treated patients is indicated only in emergent surgical scenarios and generally not elsewhere, also based on recent systematic reviews observing worse outcomes in treated patients [99].

ICU admission

Admission to the ICU is advisable for unstable ICH patients, considering GCS scores, elevated SBP, intraventricular hemorrhage, or deep brain locations (statement 9). Loggini's systematic review suggests downgrading low-risk patients from the ICU without worsening outcomes, limiting hospital stays [100]. Moreover, the ICU serves as a resource for organ donation with patient/family consent.

Limitations

Among the main limitations of this document, it should be noted that it does not constitute formal guidelines, as no grading systems were used for literature analysis, nor was the literature extracted through a systematic review of major research databases. Moreover, it does not include specific or highly specialized elements, as this was not among the objectives of this document; for these aspects, reference should be made to publications focusing on individual treatment components. However, some new insights emerge from the literature published after the drafting of the aforementioned statements.

Conclusions

This document's expert panel synthesis offers practical guidance on managing ICH. Only a few recommendations boast strong scientific backing. Panel recommendations encompass early CTA for most ICH cases, strategic use of prognostic scores, selective intubation for consciousness impairment, judicious blood pressure regulation, appropriate anticoagulant reversal, and access to ICU for patients with severe ICH or planning a donation pathway. Expert panelists speak out against the use of tranexamic acid and anti-epileptic prophylaxis without diagnostic evidence of seizures.

Abbreviations

ICH	Intracerebral hemorrhage
SIAARTI	Society of Anesthesiology, Resuscitation and Intensive Care
AHA	American Heart Association
SIRM	Italian Society of Medical and Interventional Radiology
ANIN	National Association of Neuroscience Nurses
SIMEU	Italian Society of Emergency Medicine
SIN	Italian Society of Neurology
ISA-AII	Italian Stroke Association-Italian Ictus Association
CQs	Clinical questions
PRISMA	Preferred Reporting Items for Systematic reviews and Meta-Analyses
CT	Computer tomography
DIAGRAM	Diagnostic AngioGRAphy to find vascular Malformations
CTA	Computed tomography angiography
GCS	Glasgow Coma Scale
ICU	Intensive care unit
MAX	Maximally treated
BP	Blood pressure
SBP	Systolic blood pressure
INTERACT	Intensive Blood Pressure Reduction in Acute Cerebral Hemorrhage Trial
ATACH	Antihypertensive Treatment of Acute Cerebral Hemorrhage
AKI	Kidney injury
NIHSS	National Institutes of Health Score
IVH	Intraventricular hemorrhage
CPP	Cerebral perfusion pressure
EVD	External ventricular drain
TXA	Tranexamic acid
TICH- 2	Tranexamic acid for hyperacute primary IntraCerebral Haemorrhage
IVH	Intraventricular hemorrhage
EVD	External ventricular drain
AF	Atrial fibrillation
TXA	Tranexamic acid
mRS	Modified Rankin score

TICH	Tranexamic acid for hyperacute primary IntraCerebral Haemorrhage
EEG	Electroencephalogram
NCSE	Nonconvulsive disease state
CAVE score	Cortical involvement, age, hemorrhage volume, and acute symptomatic seizure
PCC	Prothrombin complex concentrates
INR	International normalized ratio
ANNEXA	Andexanet alfa, a novel antidote to the anticoagulation effects of factor Xa inhibitors
FEIBA	Factor eight inhibitor bypassing activity
INTRINSIC	Intensive Care Triaging in Spontaneous Intracerebral Hemorrhage
ER	Emergency room
NICU	Neurointensive care unit
CLAS-ICH	Causal CLASsification system for ICH Subtypes
PBSH	Primary brainstem haemorrhage (PBSH)
STOP-MSU	Tranexamic acid for hyperacute onset presentation including mobile stroke units

Acknowledgements
Two coordinators for the drafting of the entire document were identified (F. R. and G. M.). A methodologist (C. R.) was appointed. The panelists were selected through a public call. The reference societies were invited and appointed their representatives. Nine groups were built for the nine statements, which included members of different societies, who drafted the statements. Two external reviewers (A. C. and A. Ch.) reviewed the entire work carried out. The scientific secretariat of SIAARTI coordinated all the activities carried out.

Authors' contributions
Two coordinators for the drafting of the entire document were identified (FR and GM). A methodologist (CR) was appointed. The panelists were selected through a public call. The reference societies were invited and appointed their representatives. 9 groups were built for the nine statements, which included members of different societies, who drafted the statements. Two external reviewers (AC and ACh) reviewed the entire work carried out. The scientific secretariat of SIAARTI coordinated all the activities carried out.

Funding
No funding was allocated for this study.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Competing interests
The authors declare no competing interests.

Author details
[1]ASP Catania, Anesthesia and Intensive Care, Militello Hospital, Catania, Italy. [2]Unit of Anesthesia, Department of Clinical and Surgical Translational Medicine, Intensive Care and Pain Medicine, Sant'Andrea Hospital, Sapienza University, Rome, Italy. [3]IRCCS Istituto delle Scienze Neurologiche di Bologna, Anesthesia and Intensive Care Unit, Bologna, Italy. [4]Neurocritical and Postoperative Care, Neuroanesthesia, ASST Spedali Civili Di Brescia, Brescia, Italy. [5]Department of Anesthesiology and Intensive Care Medicine, University of Rome "La Sapienza", Rome, Italy. [6]Neuroscience Intensive Care Unit, ASST Grande Ospedale Metropolitano Niguarda, Milan, Italy. [7]Department of Anesthesia and Intensive Care Unit, Azienda Ospedaliero Universitaria Policlinico"G. Rodolico — San Marco"di, Catania, Italy. [8]Terapia Intensiva Neurochirurgica, Fondazione Policlinico Universitario A.Gemelli IRCCS, Rome, Italy. [9]Università Cattolica del Sacro Cuore, Rome, Italy. [10]Azienda Sanitaria Universitaria Friuli Centrale Di Udine, Udine, Italy. [11]Department of Precision Medicine in Medical, Surgical and Critical Care (Me.Pre.C.C.), University of Palermo, Palermo, Italy. [12]Department of Anesthesia, Intensive Care and Emergency, University Hospital Policlinico Paolo Giaccone, AnalgesiaPalermo, Italy. [13]University of Padua, Padua, Italy. [14]Institute of Anesthesia and Intensive Care, University Hospital of Padua, Padua, Italy. [15]Emergency Department, Local Health Agency of Romagna, Forlì, FC, Italy. [16]Neurocritical and Postoperative Care Unit, Department of Emergency, Anesthesia and Intensive Care, Azienda Ospedaliero Universitaria Integrata Di Verona, Verona, Italy. [17]Department of Anesthesia and Intensive Care Unit, Papa Giovanni XXIII Hospital, Bergamo, Italy. [18]Department of Medical and Surgical Specialties, Radiological Sciences and Public Health, University of Brescia, Brescia, Italy. [19]Department of Emergency, Spedali Civili University Hospital, Brescia, Italy. [20]Interventional Neurovascular Unit, Careggi University Hospital, Florence, Italy. [21]Department of Anesthesia, Intensive Care and Neurointensive Care, University Hospital of Padua, Padua, Italy. [22]Department of Anesthesia and Intensive Care, Parma University Hospital, Parma, Italy. [23]Department of Neurosurgery, Parma University Hospital, Parma, Italy. [24]Department of Biomedicine and Prevention, University of Rome Tor Vergata, Rome, Italy. [25]Department of Surgical Science and Integrated Diagnostic, University of Genova, Genoa, Italy. [26]IRCCS Ospedale Policlinico San Martino, Genoa, Italy. [27]Emergency Department Stroke Unit, Department of Human Neurosciences, Sapienza University of Rome, Rome, Italy. [28]Department of Medical Sciences and Public Health, University of Cagliari, Monserrato, Italy. [29]Department of Emergency, Anesthesia and Intensive Care, Neurointensive Care, ASST Lariana Ospedale Sant'Anna, San Fermo Della Battaglia (CO), Como, Italy. [30]Dept. of Neuroanesthesia, Neurocritical and Postoperative Care, ASST Spedali Civili University Affiliated Hospital of Brescia, Brescia, Italy.

Received: 9 March 2025 Accepted: 16 April 2025
Published online: 09 May 2025

References

1. Steiner T, Salman RAS, Beer R, Christensen H, Cordonnier C, Csiba L et al (2014) European Stroke Organisation (ESO) guidelines for the management of spontaneous intracerebral hemorrhage. Int J Stroke 9(7):840–855
2. Greenberg SM, Ziai WC, Cordonnier C, Dowlatshahi D, Francis B, Goldstein JN, Hemphill JC 3rd, Johnson R, Keigher KM, Mack WJ, Mocco J, Newton EJ, Ruff IM, Sansing LH, Schulman S, Selim MH, Sheth KN, Sprigg N, Sunnerhagen KS, American Heart Association/American Stroke Association (2022) 2022 guideline for the management of patients with spontaneous intracerebral hemorrhage: a guideline from the American Heart Association/American Stroke Association. Stroke 53(7):e282–e361
3. Fitch K, Bernstein SJ, Aguilar MD, Burnand B, LaCalle JR, Lazaro P, et al (2001) The RAND/UCLA appropriateness method user's manual. Available from http://www.rand.org/pubs/monograph_reports/MR1269.html). (Accessed 22 March 2022)
4. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, Chou R, Glanville J, Grimshaw JM, Hróbjartsson A, Lalu MM, Li T, Loder EW, Mayo-Wilson E, McDonald S, McGuinness LA, Stewart LA, Thomas J, Tricco AC, Welch VA, Whiting P, Moher D (2021) The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 29(372):n71. https://doi.org/10.1136/bmj.n71.PMID:33782057;PMCID:PMC8005924
5. Sporns PB, Psychogios MN, Boulouis G, Charidimou A, Li Q, Fainardi E et al (2021) Neuroimaging of acute intracerebral hemorrhage. J Clin Med 10(5):1–13
6. Van Asch CJJ, Velthuis BK, Rinkel GJE, Algra A, De Kort GAP, Witkamp TD et al (2015) Diagnostic yield and accuracy of CT angiography, MR angiography, and digital subtraction angiography for detection of macrovascular causes of intracerebral haemorrhage: prospective, multicentre cohort study. BMJ 9:351
7. Sorimachi T, Atsumi H, Yonemochi T, Hirayama A, Shigematsu H, Srivatanakul K et al (2020) Benefits and risks of CT angiography immediately after emergency arrival for patients with intracerebral hematoma. Neurol Med Chir (Tokyo) 60(1):45–52
8. Fluss R, Rahme R (2020) How reliable is CT angiography in the etiologic workup of intracranial hemorrhage? A single surgeon's experience. Clin Neurol Neurosurg 1:188
9. Josephson CB, White PM, Krishan A, Al-Shahi Salman R (2014) Computed tomography angiography or magnetic resonance angiography for detection of intracranial vascular malformations in patients with intracerebral haemorrhage. Cochrane Database Syst Rev

2014(9):CD009372. https://doi.org/10.1002/14651858.CD009372.pub2. (**PMID:25177839; PMCID: PMC6544803**)
10. Hilkens NA, Van Asch CJJ, Werring DJ, Wilson D, Rinkel GJE, Algra A et al (2018) Predicting the presence of macrovascular causes in non-traumatic intracerebral haemorrhage: the DIAGRAM prediction score. J Neurol Neurosurg Psychiatry 89(7):674–679
11. Wilson D, Ogungbemi A, Ambler G, Jones I, Werring DJ, Jäger HR (2017) Developing an algorithm to identify patients with intracerebral haemorrhage secondary to a macrovascular cause. Eur Stroke J 2(4):369–376
12. Diagnostic value of multidetector-row CT angiography in the evaluation of thrombosis of the cerebral venous sinuses - PubMed. Available from: https://pubmed.ncbi.nlm.nih.gov/17494676/. Cited 2022 Nov 6
13. Singh SD, Pasi M, Schreuder FHBM, Morotti A, Senff JR, Warren AD et al (2021) Computed tomography angiography spot sign, hematoma expansion, and functional outcome in spontaneous cerebellar intracerebral hemorrhage. Stroke 52(9):2902–2909
14. Falcone JA, Lopez A, Stradling D, Yu W, Chen JW (2022) Blood pressure and spot sign in spontaneous supratentorial subcortical intracerebral hemorrhage. Neurocrit Care 37(1):246–254
15. Lv XN, Li Q (2020) Imaging predictors for hematoma expansion in patients with intracerebral hemorrhage: a current review. Brain Hemorrhages 1(2):133–139
16. Hemphill JC, Bonovich DC, Besmertis L, Manley GT, Johnston SC (2001) The ICH Score. Stroke 32(4):891–897
17. Cheung RTF, Zou LY (2003) Use of the original, modified, or new intracerebral hemorrhage score to predict mortality and morbidity after intracerebral hemorrhage. Stroke 34(7):1717–1722
18. Godoy DA, Piñero G, Di Napoli M (2006) Predicting mortality in spontaneous intracerebral hemorrhage. Stroke 37(4):1038–1044
19. Hwang DY, Dell CA, Sparks MJ, Watson TD, Langefeld CD, Comeau ME et al (2016) Clinician judgment vs formal scales for predicting intracerebral hemorrhage outcomes. Neurology 86(2):126–133
20. Maas MB, Francis BA, Sangha RS, Lizza BD, Liotta EM, Naidech AM (2017) Refining prognosis for intracerebral hemorrhage by early reassessment. Cerebrovasc Dis 43(3–4):110–116
21. Weimar C (2006) Development and validation of the Essen Intracerebral Haemorrhage Score. J Neurol Neurosurg Psychiatry 77(5):601–605
22. McCracken DJ, Lovasik BP, McCracken CE, Frerich JM, McDougal ME, Ratcliff JJ et al (2019) The intracerebral hemorrhage score: a self-fulfilling prophecy? Neurosurgery 84(3):741–748
23. Becker KJ, Baxter AB, Cohen WA, Bybee HM, Tirschwell DL, Newell DW et al (2001) Withdrawal of support in intracerebral hemorrhage may lead to self-fulfilling prophecies. Neurology 56(6):766–772
24. Fukuhara T, Aoi M, Namba Y (2014) Mechanical ventilation for comatose patients with inoperative acute intracerebral hemorrhage: possible futility of treatment. PLoS ONE 9(7):e103531
25. de Montmollin E, Terzi N, Dupuis C, Garrouste-Orgeas M, da Silva D, Darmon M et al (2020) One-year survival in acute stroke patients requiring mechanical ventilation: a multicenter cohort study. Ann Intensive Care 10(1):53
26. Rabinstein AA (2018) Optimal blood pressure after intracerebral hemorrhage: still a moving target. Stroke 49(2):275–276
27. Anderson CS, Heeley E, Huang Y, Wang J, Stapf C, Delcourt C et al (2013) Rapid blood-pressure lowering in patients with acute intracerebral hemorrhage. N Engl J Med 368(25):2355–2365
28. Moullaali TJ, Wang X, Sandset EC, Woodhouse LJ, Law ZK, Arima H et al (2022) Early lowering of blood pressure after acute intracerebral haemorrhage: a systematic review and meta-analysis of individual patient data. J Neurol Neurosurg Psychiatry 93(1):6–13
29. Qureshi AI, Palesch YY, Martin R, Toyoda K, Yamamoto H, Wang Y et al (2014) Interpretation and Implementation of Intensive Blood Pressure Reduction in Acute Cerebral Hemorrhage Trial (INTERACT II). J Vasc Interv Neurol 7(2):34–40 (PMID: 25132910; PMCID: PMC4132943)
30. Song L, Chen C, Chen X, Guo Y, Liu F, Lin Y et al (2021) INTensive ambulance-delivered blood pressure Reduction in hyper-ACute stroke Trial (INTERACT4): study protocol for a randomized controlled trial. Trials 22(1):1–14
31. Zheng D, Sato S, Arima H, Heeley E, Delcourt C, Cao Y et al (2016) Estimated GFR and the effect of intensive blood pressure lowering after acute intracerebral hemorrhage. Am J Kidney Dis 68(1):94–102
32. Hewgley H, Turner SC, Vandigo JE, Marler J, Snyder H, Chang JJ et al (2018) Impact of admission hypertension on rates of acute kidney injury in intracerebral hemorrhage treated with intensive blood pressure control. Neurocrit Care 28(3):344–352
33. Qureshi AI, Huang W, Lobanova I, Hanley DF, Hsu CY, Malhotra K, Steiner T, Suarez JI, Toyoda K, Yamamoto H (2020) Antihypertensive Treatment of Cerebral Hemorrhage 2 Trial Investigators. Systolic Blood Pressure Reduction and Acute Kidney Injury in Intracerebral Hemorrhage. Stroke 51(10):3030–3038. https://doi.org/10.1161/STROKEAHA.120.030272. (**Epub 2020 Aug 25 PMID: 32838673**)
34. Qureshi AI, Foster LD, Lobanova I, Huang W, Suarez JI (2020) Intensive blood pressure lowering in patients with moderate to severe grade acute cerebral hemorrhage: post hoc analysis of Antihypertensive Treatment of Acute Cerebral Hemorrhage (ATACH)-2 trial. Cerebrovasc Dis 49(3):244–252
35. Sandset EC, Anderson CS, Bath PM, Christensen H, Fischer U, Gąsecki D et al (2021) European Stroke Organisation (ESO) guidelines on blood pressure management in acute ischaemic stroke and intracerebral haemorrhage. Eur Stroke J 6(2):XLVIII–LXXXIX
36. Manios E, Vemmos K, Tsivgoulis G, Barlas G, Koroboki E, Spengos K et al (2007) Erratum: comparison of noninvasive oscillometric and intra-arterial blood pressure measurements in hyperacute stroke (blood pressure monitoring (2007) 12, (149–156)). Blood Press Monit 12(5):349
37. Tian Y, Wang Z, Jia Y, Li S, Wang B, Wang S et al (2013) Intracranial pressure variability predicts short-term outcome after intracerebral hemorrhage: a retrospective study. J Neurol Sci 330(1–2):38–44
38. Olbers J, Gille A, Ljungman P, Rosenqvist M, Östergren J, Witt N (2018) High beat-to-beat blood pressure variability in atrial fibrillation compared to sinus rhythm. Blood Press 27(5):249–255
39. Su H, Guo Z (2022) Accuracy of non-invasive blood pressure measurement in patients with atrial fibrillation. J Hum Hypertens 36(3):229–234
40. Garg RK, Ouyang B, Zwein A, Thavapalan V, Indavarapu A, Cheponis K et al (2022) Systolic blood pressure measurements are unreliable for the management of acute spontaneous intracerebral hemorrhage. J Crit Care 70:154049
41. Sprigg N, Flaherty K, Appleton JP, Salman RAS, Bereczki D, Beridze M et al (2018) Tranexamic acid for hyperacute primary IntraCerebral Haemorrhage (TICH-2): an international randomised, placebo-controlled, phase 3 superiority trial. Lancet 391(10135):2107–2115
42. Law ZK, Dineen R, England TJ, Cala L, Mistri AK, Appleton JP et al (2021) Predictors and outcomes of neurological deterioration in intracerebral hemorrhage: results from the TICH-2 randomized controlled trial. Transl Stroke Res 12(2):275–283
43. Yogendrakumar V, Wu TY, Churilov L, Tatlisumak T, Strbian D, Jeng JS et al (2022) Does tranexamic acid affect intraventricular hemorrhage growth in acute ICH? An analysis of the STOP-AUST trial. Eur Stroke J 7(1):15–19
44. Angriman F, Tirupakuzhi Vijayaraghavan BK, Dragoi L, Lopez Soto C, Chapman M, Scales DC (2019) Antiepileptic drugs to prevent seizures after spontaneous intracerebral hemorrhage. Stroke 50(5):1095–1099
45. Gigliotti MJ, Wilkinson DA, Simon SD, Cockroft KM, Church EW (2021) A systematic review and meta-analysis of antiepileptic prophylaxis in spontaneous intracerebral hemorrhage. World Neurosurg 151:218-224.e2
46. Sheth KN, Martini SR, Moomaw CJ, Koch S, Elkind MSV, Sung G et al (2015) Prophylactic antiepileptic drug use and outcome in the ethnic/racial variations of intracerebral hemorrhage study. Stroke 46(12):3532–3535
47. Spoelhof B, Sanchez-Bautista J, Zorrilla-Vaca A, Kaplan PW, Farrokh S, Mirski M et al (2019) Impact of antiepileptic drugs for seizure prophylaxis on short and long-term functional outcomes in patients with acute intracerebral hemorrhage: a meta-analysis and systematic review. Seizure 69:140–146
48. Tran QK, Bzhilyanskaya V, Afridi LZ, Ahmad M, Palmer J, Rehan MA et al (2021) Preventing seizure occurrence following spontaneous intracerebral haemorrhage: a systematic review and meta-analysis of seizure prophylaxis. Seizure 87:46–55
49. Zandieh A, Messé SR, Cucchiara B, Mullen MT, Kasner SE (2016) Prophylactic use of antiepileptic drugs in patients with spontaneous intracerebral hemorrhage. J Stroke Cerebrovasc Dis 25(9):2159–2166

50. Law ZK, England TJ, Mistri AK, Woodhouse LJ, Cala L, Dineen R et al (2020) Incidence and predictors of early seizures in intracerebral haemorrhage and the effect of tranexamic acid. Eur Stroke J 5(2):123–129
51. Kwon SY, Obeidat AZ, Sekar P, Moomaw CJ, Osborne J, Testai FD et al (2020) Risk factors for seizures after intracerebral hemorrhage: ethnic/racial variations of intracerebral hemorrhage (ERICH) study. Clin Neurol Neurosurg 192:105731
52. Wong YS, Wu CS, Ong CT (2021) Discontinuation of preventive antiepileptic drugs in patients with intracerebral hemorrhage. BMC Neurol 21(1):150
53. Peter-Derex L, Philippeau F, Garnier P, André-Obadia N, Boulogne S, Catenoix H et al (2022) Safety and efficacy of prophylactic levetiracetam for prevention of epileptic seizures in the acute phase of intracerebral haemorrhage (PEACH): a randomised, double-blind, placebo-controlled, phase 3 trial. Lancet Neurol 21(9):781–791
54. Switzer JA, Rocker J, Mohorn P, Waller JL, Hughes D, Bruno A, et al (2012) Clinical experience with three-factor prothrombin complex concentrate to reverse warfarin anticoagulation in intracranial hemorrhage. Available from: https://doi.org/10.1161/STROKEAHA.112.661454
55. Dowlatshahi D, Butcher KS, Asdaghi N, Nahirniak S, Bernbaum ML, Giulivi A et al (2012) Poor prognosis in warfarin-associated intracranial hemorrhage despite anticoagulation reversal. Stroke 43(7):1812–1817
56. Cruz JL, Moss MC, Chen SL, Hansen KM, Amerine LB (2015) Retrospective evaluation of the clinical use of prothrombin complex concentrate for the reversal of anticoagulation with vitamin K antagonists. Blood Coag Fibrinol 26(4):378–382
57. Imberti D, Barillari G, Biasioli C, Bianchi M, Contino L, Duce R et al (2011) Emergency reversal of anticoagulation with a three-factor prothrombin complex concentrate in patients with intracranial haemorrhage. Blood Transfus 9(2):148–155
58. Imberti D, Barillari G, Biasioli C, Bianchi M, Contino L, Duce R et al (2008) Prothrombin complex concentrates for urgent anticoagulation reversal in patients with intracranial haemorrhage. Pathophysiol Haemost Thromb 36(5):259–265
59. Stead LG, Jain A, Bellolio MF, Odufuye AO, Dhillon RK, Manivannan V et al (2010) Effect of anticoagulant and antiplatelettherapy in patients with spontaneous intra-cerebral hemorrhage: does medication use predict worse outcome? Clin Neurol Neurosurg 112(4):275–281
60. Hanger HC, Geddes JAA, Wilkinson TJ, Lee M, Baker AE (2013) Warfarin-related intracerebral haemorrhage: better outcomes when reversal includes prothrombin complex concentrates. Intern Med J 43(3):308–316
61. Kuramatsu JB, Gerner ST, Schellinger PD, Glahn J, Endres M, Sobesky J et al (2015) Anticoagulant reversal, blood pressure levels, and anticoagulant resumption in patients with anticoagulation-related intracerebral hemorrhage. JAMA - Journal of the American Medical Association 313(8):824–836
62. Castillo R, Chan A, Atallah S, Derry K, Baje M, Zimmermann LL et al (2021) Treatment of adults with intracranial hemorrhage on apixaban or rivaroxaban with prothrombin complex concentrate products. J Thromb Thrombolysis 51(1):151–158
63. Bobby L, Westlake E, Esplin N, Young S (2021) Activated prothrombin complex concentrate for reversal of oral factor Xa inhibitors at a level 1 trauma center. Thromb Res 1(206):33–35
64. Sheikh-Taha M (2019) Treatment of apixaban- and rivaroxaban-associated major bleeding using 4-factor prothrombin complex concentrate. Intern Emerg Med 14(2):265–269
65. Panos NG, Cook AM, John S, Jones GM (2020) Factor Xa inhibitor-related intracranial hemorrhage: results from a multicenter, observational cohort receiving prothrombin complex concentrates. Circulation 141(21):1681–1689
66. Connolly SJ, Crowther M, Eikelboom JW, Gibson CM, Curnutte JT, Lawrence JH et al (2019) Full study report of andexanet alfa for bleeding associated with factor Xa inhibitors. N Engl J Med 380(14):1326–1335
67. Giovino A, Shomo E, Busey KV, Case D, Brockhurst A, Concha M (2020) An 18-month single-center observational study of real-world use of andexanet alfa in patients with factor Xa inhibitor associated intracranial hemorrhage. Clin Neurol Neurosurg 1:195
68. Brown CS, Scott RA, Sridharan M, Rabinstein AA (2020) Real-world utilization of andexanet alfa. Am J Emerg Med 38(4):810–814
69. Demchuk AM, Yue P, Zotova E, Nakamya J, Xu L, Milling TJ et al (2021) Hemostatic efficacy and anti-FXa (factor Xa) reversal with andexanet alfa in intracranial hemorrhage: ANNEXA-4 substudy. Stroke 52(6):2096–2105
70. Barra ME, Das AS, Hayes BD, Rosenthal ES, Rosovsky RP, Fuh L et al (2020) Evaluation of andexanet alfa and four-factor prothrombin complex concentrate (4F-PCC) for reversal of rivaroxaban- and apixaban-associated intracranial hemorrhages. J Thromb Haemost 18(7):1637–1647
71. Ammar AA, Ammar MA, Owusu KA, Brown SC, Kaddouh F, Elsamadicy AA et al (2021) Andexanet alfa versus 4-factor prothrombin complex concentrate for reversal of factor Xa inhibitors in intracranial hemorrhage. Neurocrit Care 35(1):255–261
72. Kermer P, Eschenfelder CC, Diener HC, Grond M, Abdalla Y, Abraham A et al (2020) Antagonizing dabigatran by idarucizumab in cases of ischemic stroke or intracranial hemorrhage in Germany—updated series of 120 cases. Int J Stroke 15(6):609–618
73. Singh S, Nautiyal A, Belk KW (2020) Real world outcomes associated with idarucizumab: population-based retrospective cohort study. Am J Cardiovasc Drugs 20(2):161–168
74. Engelbart JM, Zepeski A, Galet C, Policeni B, Skeete DA, Faine BA (2019) Safety and effectiveness of factor eight inhibitor bypassing activity for direct oral anticoagulant-related hemorrhage reversal. Am J Emerg Med 37(2):214–219
75. Hunt AR, Coffeen SN, Shiltz DL, Ice C, Parker J (2021) Factor VIII inhibitor bypassing activity (FEIBA) reversal for apixaban and rivaroxaban in patients with acute intracranial and nonintracranial hemorrhage. Ann Pharmacother 55(12):1455–1466
76. Li X, Sun Z, Zhao W, Zhang J, Chen J, Li Y et al (2013) Effect of acetylsalicylic acid usage and platelet transfusion on postoperative hemorrhage and activities of daily living in patients with acute intracerebral hemorrhage: clinical article. J Neurosurg 118(1):94–103
77. Naidech AM, Liebling SM, Rosenberg NF, Lindholm PF, Bernstein RA, Batjer HH et al (2012) Early platelet transfusion improves platelet activity and may improve outcomes after intracerebral hemorrhage. Neurocrit Care 16(1):82–87
78. Suzuki Y, Kitahara T, Soma K, Konno S, Sato K, Suzuki S, Oka H, Yamada M, Fujii K, Kitahara Y, Yamamoto Y, Otsuka T, Sugiura Y, Kanoh Y, Tamai Y, Ohto H (2014) Impact of platelet transfusion on survival of patients with intracerebral hemorrhage after administration of anti-platelet agents at a tertiary emergency center. PLoS One 9(5):e97328. https://doi.org/10.1371/journal.pone.0097328. (**PMID: 24869669; PMCID: PMC4037183**)
79. Engel-Haber E, Horev A, Chablani P, Bornstein NM, Jadhav A, Jovin TG et al (2015) Aspirin response test role in platelet transfusion following intracerebral hemorrhage. Clin Neurol Neurosurg 137:12–14
80. Mengel A, Stefanou MI, Hadaschik KA, Wolf M, Stadler V, Poli K, Lindig T, Ernemann U, Grimm F, Tatagiba M, Ziemann U, Poli S (2020) Early Administration of Desmopressin and Platelet Transfusion for Reducing Hematoma Expansion in Patients With Acute Antiplatelet Therapy Associated Intracerebral Hemorrhage. Crit Care Med 48(7):1009–1017. https://doi.org/10.1097/CCM.0000000000004348. (**PMID: 32304415**)
81. Creutzfeldt CJ, Weinstein JR, Longstreth WT, Becker KJ, McPharlin TO, Tirschwell DL (2009) Prior antiplatelet therapy, platelet infusion therapy, and outcome after intracerebral hemorrhage. J Stroke Cerebrovasc Dis 18(3):221–228
82. Baharoglu MI, Cordonnier C, Salman RAS, de Gans K, Koopman MM, Brand A et al (2016) Platelet transfusion versus standard care after acute stroke due to spontaneous cerebral haemorrhage associated with antiplatelet therapy (PATCH): a randomised, open-label, phase 3 trial. The Lancet 387(10038):2605–2613
83. Schmidt KJ, Sager B, Zachariah J, Raad BF, James EG, Fletcher JJ (2019) Cohort analysis of desmopressin effect on hematoma expansion in patients with spontaneous intracerebral hemorrhage and documented pre-ictus antiplatelet use. J Clin Neurosci 1(66):33–37
84. Klaas JP, Braksick S, Mandrekar J, Sedova P, Bellolio MF, Rabinstein AA et al (2017) Factors associated with the need for intensive care unit admission following supratentorial intracerebral hemorrhage: the triage ICH model. Neurocrit Care 27(1):75–81

85. Faigle R, Chen BJ, Krieger R, Marsh EB, Alkhachroum A, Xiong W et al (2021) Novel score for stratifying risk of critical care needs in patients with intracerebral hemorrhage. Neurology 96(20):E2458–E2468
86. Patel NM, Tran QK, Capobianco P, Traynor T, Armahizer MJ, Motta M et al (2021) Triage of patients with intracerebral hemorrhage to comprehensive versus primary stroke centers. J Stroke Cerebrovasc Dis 30(5):105672. https://doi.org/10.1016/j.jstrokecerebrovasdis.2021.105672. (Epub 2021 Mar 14. PMID: 33730599)
87. Knopf L, Staff I, Gomes J, McCullough L (2012) Impact of a neurointensivist on outcomes in critically ill stroke patients. Neurocrit Care 16(1):63–71
88. Diringer MN, Edwards DF (2001) Admission to a neurologic/neurosurgical intensive care unit is associated with reduced mortality rate after intracerebral hemorrhage. Crit Care Med 29(3):635–640
89. Abid KA, Vail A, Patel HC, King AT, Tyrrell PJ, Parry-Jones AR (2013) Which factors influence decisions to transfer and treat patients with acute intracerebral haemorrhage and which are associated with prognosis? A retrospective cohort study. BMJ Open 3(12):e003684. https://doi.org/10.1136/bmjopen-2013-003684. (**PMID: 24345898; PMCID:PMC3884585**)
90. Ungerer MN, Ringleb P, Reuter B, Stock C, Ippen F, Hyrenbach S et al (2020) Stroke unit admission is associated with better outcome and lower mortality in patients with intracerebral hemorrhage. Eur J Neurol 27(5):825–832
91. Raposo N, Zanon Zotin MC, Seiffge DJ, Li Q, Goeldlin MB, Charidimou A et al (2023) A causal classification system for intracerebral hemorrhage subtypes. Ann Neurol 93(1):16–28. https://doi.org/10.1002/ana.26519. (Epub 2022 Nov 16. PMID: 36197294; PMCID: PMC9839566)
92. Rost NS, Smith EE, Chang Y, Snider RW, Chanderraj R, Schwab K et al (2008) Prediction of functional outcome in patients with primary intracerebral hemorrhage. Stroke 39(8):2304–2309
93. Cai C, Yan C, Chen S, Yang W, Huang Y, Ma J, Xu H (2024) Development and validation of a prediction model for 30-day mortality and functional outcome in patients with primary brainstem hemorrhage. Cerebrovasc Dis 53(1):79–87. https://doi.org/10.1159/000530348. (Epub 2023 May 25 PMID: 37231825)
94. Sonneville R, Mazighi M, Collet M, Gayat E, Degos V, Duranteau J, SPICE Investigators et al (2023) One-year outcomes in patients with acute stroke requiring mechanical ventilation. Stroke 54(9):2328–2337. https://doi.org/10.1161/STROKEAHA.123.042910. (Epub 2023 Jul 27. PMID: 37497675)
95. Li G, Lin Y, Yang J, Anderson CS, Chen C, Liu F, INTERACT4 Investigators et al (2024) Intensive ambulance-delivered blood-pressure reduction in hyperacute stroke. N Engl J Med 390(20):1862–1872. https://doi.org/10.1056/NEJMoa2314741. (Epub 2024 May 16. PMID: 38752650)
96. Yassi N, Zhao H, Churilov L, Wu TY, Ma H, Nguyen HT, STOP-MSU Trial Investigators et al (2024) Tranexamic acid versus placebo in individuals with intracerebral haemorrhage treated within 2 h of symptom onset (STOP-MSU): an international, double-blind, randomised, phase 2 trial. Lancet Neurol 23(6):577–587. https://doi.org/10.1016/S1474-4422(24)00128-5. (Epub 2024 Apr 20. PMID: 38648814)
97. Frontera JA, Rayi A, Tesoro E, Gilmore EJ, Johnson EL, Olson D et al (2025) Guidelines for seizure prophylaxis in patients hospitalized with nontraumatic intracerebral hemorrhage: a clinical practice guideline for health care professionals from the Neurocritical Care Society. Neurocrit Care 42(1):1–21. https://doi.org/10.1007/s12028-024-02183-z. (Epub 2024 Dec 21. PMID: 39707127)
98. Lekoubou A, Petucci J, Femi Ajala T, Katoch A, Hong J, Sen S et al (2024) Can machine learning predict late seizures after intracerebral hemorrhages? Evidence from real-world data. Epilepsy Behav 157:109835. https://doi.org/10.1016/j.yebeh.2024.109835. (Epub 2024 May 30. PMID: 38820686)
99. Shahzad F, Ahmed U, Muhammad A, Shahzad F, Naufil SI, Sukkari MW et al (2024) Safety and efficacy of desmopressin (DDAVP) in preventing hematoma expansion in intracranial hemorrhage associated with antiplatelet drugs use: a systematic review and metaanalysis. Brain Behav 14(5):e3540. https://doi.org/10.1002/brb3.3540. (PMID: 38778788; PMCID: PMC11112402)
100. Loggini A, Hornik J, Hornik A, Braksick SA, Klaas JP (2024) Safety and outcome of admission to step-down level of care in patients with low-risk spontaneous intracerebral hemorrhage: a systematic review and meta-analysis. Neurocrit Care 41(3):1073–1080. https://doi.org/10.1007/s12028-024-02044-9. (Epub 2024 Jul 2 PMID: 38955932)

Publisher's Note