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Prognostic Factors of Mortality and Functional Outcome for Acute Subdural Hematoma: A Review Article

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Abstract

Acute subdural hematoma (ASDH) is the most frequent intracranial traumatic lesion requiring surgery in high-income countries. To date, uncertainty remains regarding the odds of mortality or functional outcome of patients with ASDH, regardless of whether they are operated on. This review aims to shed light on the clinical and radiologic factors associated with ASDH outcome. A scoping review was conducted on Medline database from inception to 2023. This review yielded 41 patient series. In the general population, specific clinical (admission Glasgow Coma Scale [GCS], abnormal pupil exam, time to surgery, decompressive craniectomy, raised postoperative intracranial pressure) and radiologic (ASDH thickness, midline shift, thickness/midline shift ratio, uncal herniation, and brain density difference) factors were associated with mortality (grade III). Other clinical (admission GCS, decompressive craniectomy) and radiologic (ASDH volume, thickness/midline shift ratio, uncal herniation, loss of basal cisterns, petechiae, and brain density difference) factors were associated with functional outcome (grade III). In the elderly, only postoperative GCS and midline shift on brain computed tomography were associated with mortality (grade III). Comorbidities, abnormal pupil examination, postoperative GCS, intensive care unit hospitalization, and midline shift were associated with functional outcome (grade III). Based on these factors, the SHE (Subdural Hematoma in the Elderly) and the RASH (Richmond Acute Subdural Hematoma) scores could be used in daily clinical practice. This review has underlined a few supplementary factors of prognostic interest in patients with ASDH, and highlighted two predictive scores that could be used in clinical practice to guide and assist clinicians in surgical indication.

Keywords

- acute subdural hematoma
- functional prognostic
- mortality
- review
- traumatic brain injury

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Introduction

Acute subdural hematoma (ASDH) stands among the most frequent traumatic brain injuries[1] and carries a heavy morbidity and mortality burden.[2] With the current aging of the population, the tendency of the elderly to fall, and the increasing daily prescription of blood thinners, a rise of ASDH-related health care costs can only be expected in the near future.[3]

In contrast to Seelig and colleagues' pioneering work, which was focused on the reduction of ASDH-related mortality, the current objective of ASDH management is the improvement of neurological outcome.[4] Thus, decompressive craniectomy (DC) combined with neuro-resuscitation is encouraged in the young,[5,6] whereas more discernment is advocated in the elderly for whom functional prognostic is unsure.[7] Nevertheless, ASDH outcome seems to depend on a myriad of historical, clinical, and radiologic factors, which are intermingled. Besides, serious cases of ASDH can be associated with peculiar clinical presentation,[8] rendering surgical decision making and dialogue with the relatives even more difficult.

Surgical evacuation of ASDH is a standardized damage-control procedure[9] which constitutes the first step of the long way toward functional improvement. A few authors strived to provide systematic evidence[10–12] or easy-to-use clinical tools[13–18] aiming to support the neurosurgeon in the decision making for ASDH. To date though, these valuable memory aids have been drowned within the medical literature, and this review aims to shed light on these clinical tools.

Materials and Methods

Database Research

We voluntarily conducted a scoping review focused on prognostic factors of mortality and functional outcome of patients suffering from ASDH on Medline database (https://pubmed.ncbi.nlm.nih.gov/) from inception to 2023. We used the advanced search mode with the following combination of MeSH terms in the title: "acute subdural" and ("prognostic," "prognosis," "outcome," "outcomes," or "mortality").

Inclusion and Exclusion Criteria

All the English-language patient series with extractable data concerning the potential factors of interest were included. Exclusion criteria were series where ASDH and other types of intracranial hematoma were intermingled, series with prespecified exclusion criteria such as certain classes of age or certain degree of traumatic brain injury, series with unexploitable statistical data, and series that could not be found despite being indexed in Medline.

Systematic reviews concerning ASDH were also included.

Data Extraction

All the articles included in the quantitative analysis were screened in a systematic manner and the following information was extracted as baseline parameters: author and year; study type; number of patients; and mean age as baseline parameters. The following information was extracted in order to be analyzed as potential prognostic clinical factors: age; sex; medication with blood thinners; presence of comorbidities; Glasgow Coma Scale (GCS) upon admission; pupil examination; presence of extra-cranial traumatic injuries; delay from trauma to surgery; type of surgical procedure; postoperative intracranial pressure; postoperative GCS score; seizures; hospitalization in the intensive care unit. The following information was extracted in order to be analyzed as potential prognostic radiologic factors: volume and thickness of ASDH; midline shift; loss of basal cisterns; temporal brain herniation; associated traumatic brain injuries such as contusion, subarachnoid hemorrhage, or traumatic axonal injury.

Primary and Secondary Endpoints of the Study

The primary endpoint of this study was to determine the potential factors influencing the mortality and the functional outcome of patients suffering from ASDH.

The secondary endpoints were to compare these prognostic factors with the ones already identified in previous systematic reviews.

Statistical Analysis

Given that we included many different articles, each of which had already carried out their own statistical analyses, and in order to reduce measurement bias, we did not run supplementary statistical analyses. Statistical significance was retained in case of a two-sided p-value less than 0.5 regardless of the statistical test (Pearson chi-square test, Student's t-test, Mann–Whitney U test). Odds ratios were considered statistically significance if their confidence interval did not include 1.

Results

Database Research

The research yielded 112 articles and 106 after removal of duplicates. Forty-two articles were excluded after the first round, and 18 more after reading of their full contents. 46 articles were eventually retained for qualitative analysis,[19–23] and 41 for quantitative analysis (**►Fig. 1**).[2,7,16,24–61] In the 42 articles within the quantitative analysis, 34 articles included patients operated on for ASDH,[2,16,24–27,30,31,33–35,37,38,40–55,57–61] whereas seven articles included ASDH patients managed either medically or surgically.[7,28,29,32,36,39,56]

General Population

Clinical Factors Influencing Mortality

Thirty-four percent (14/41) of the studies, accounting for 2,169 patients, reported clinical factors influencing the mortality of patients suffering from ASDH.[24,26,27,31,33,34,37,38,41,42,46,47,53,55] The following factors were considered to be significantly associated with mortality: older age ($n = 1{,}559$, $p = 0.032$), medication with blood thinners ($n = 628$, $p < 0.005$), abnormal pupil examination ($n = 1{,}356$, $p < 0.05$), low admission GCS score ($n = 1{,}356$, $p < 0.05$), delay from trauma to surgery (significant $n = 1{,}002$, $p = 0.03$; nonsignificant $p = 205$), DC over craniotomy ($n = 369$, $p < 0.01$), and raised postoperative intracranial

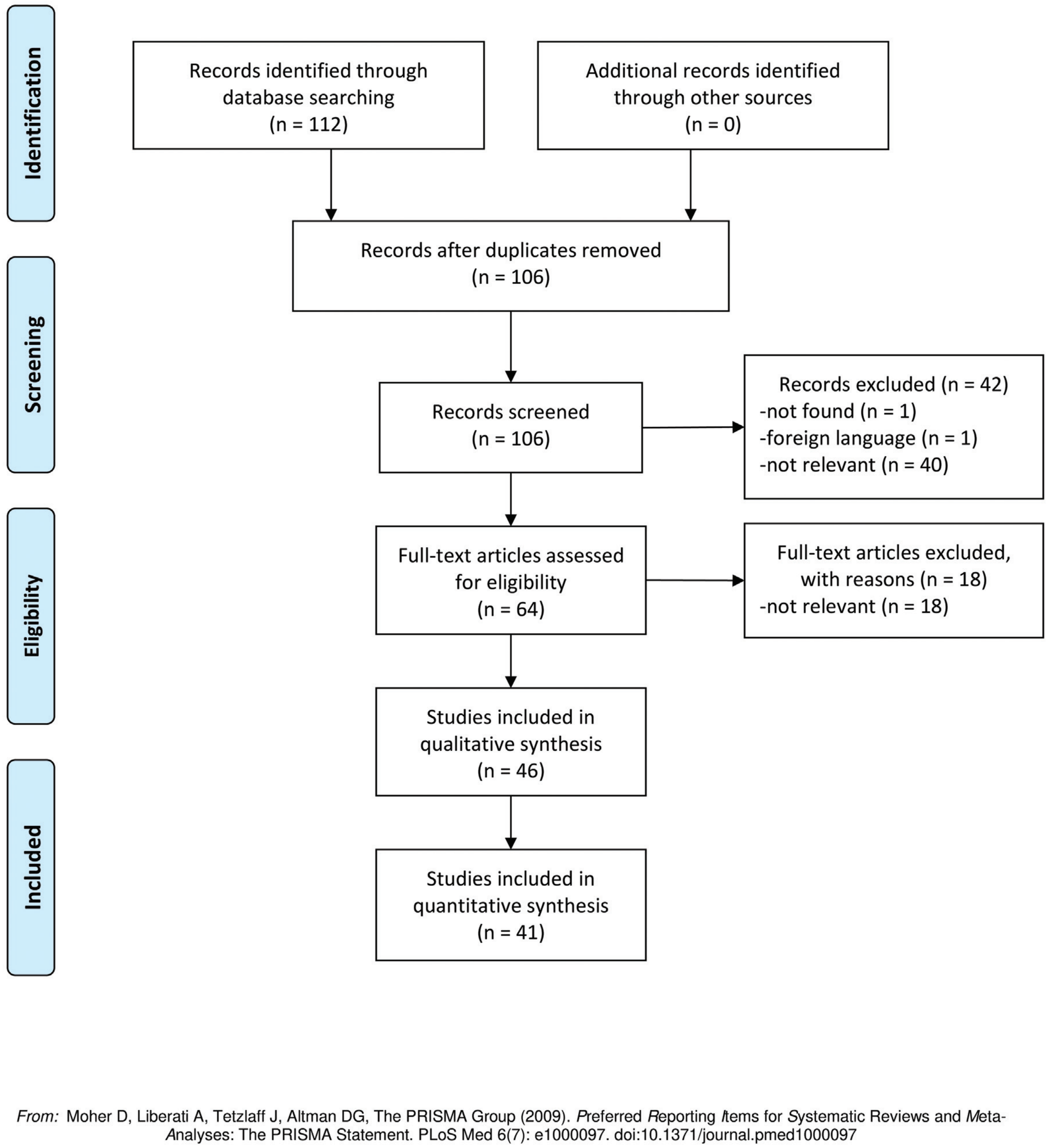

Fig. 1 Predictive factors of mortality and functional outcome for ASDH. Medline scoping review (PRISMA flowchart). ASDH, acute subdural hematoma.

pressure ($n = 183$, $p < 0.05$). Associated extra-cranial injuries ($n = 99$, $p = 0.021$, nonsignificant $n = 34$) were considered to be possibly associated with mortality. Sex (significant $n = 82$, $p < 0.006$; nonsignificant $n = 1{,}214$) was considered not to be significantly associated with mortality (►**Table 1**).

Radiologic Factors Influencing Mortality

Nineteen point five percent (8/41) of the studies, accounting for 852 patients, reported radiologic factors influencing the mortality of patients suffering from ASDH.[24,31,34,38,42,44,46,53] The following factors were considered to be significantly associated with mortality: ASDH thickness ($n = 157$, $p = 0.00$), a midline shift of 10 mm or greater (significant $n = 314$, $p = 0.014$; nonsignificant $n = 34$), and brain herniation ($n = 183$, $p = 0.0004$). The following factors were considered to be possibly associated with mortality: associated brain contusions (significant $n = 174$, $p < 0.01$; nonsignificant $n = 207$) and associated subarachnoid hemorrhage (significant $n = 113$, $p < 0.01$; nonsignificant $n = 58$) (►**Table 2**).

Clinical Factors Influencing Functional Outcome

Forty-three point nine percent (18/41) of the studies, accounting for 2,847 patients, reported clinical factors influencing the functional outcome of patients suffering from ASDH.[2,7,16,25,28–30,32,34–36,39,43,49–52,57] Three factors were considered to be significantly associated with a poor functional

Table 1 Influence of clinical data on mortality of patients presenting with acute subdural hematoma

Study (first author and year)	Study type	Number of patients	Mean age	Prognostic factors									
				Age	Sex ♂/♀	Blood thinners	Abnormal pupil exam	Admission GCS	Extra-cranial injuries	Delay to surgery	DC		**Postop ICP**
						VKA					In favor	Against	
Seelig 1981	Mo R	82	41	NS	$p < 0.006^a$	–	$p < 0.03^a$	$p < 0.03^a$	–	$p < 0.004^a$ (> 4 h)	–	–	$p < 0.04^a$ (> 20 mmHg)
Wilberger 1991	Mo R	101	–	S (> 65)	NS	–	–	$p < 0.05$ (GCS ≤ 4)	–	S (> 12 h)	–	–	$p < 0.05$ (> 45 mmHg)
Cagetti 1992	Mo R	241	–	$p < 0.01$ (80)	–	–	–	–	–	–	–	–	–
Koç 1997	Mo R	113	31.1	NS[X]	NS[X]	–	$p < 0.01$	$p < 0.05$ (GCS ≤ 6)	–	NS	–	$p < 0.01$	–
Zhao 2009	Mo R	202	47	$p = 0.01$ (> 65)	NS	–	$p = 0.001$ (bilateral)	NS	–	$p = 0.03$	–	–	–
Kim 2009	Mo R	256	51.8	NS	NS	–	$p = 0.023^a$ OR 2.6 $(1.13–5.93)^a$	$p = 0.00^a$ OR 4.66 $(1.96–11.08)^a$	–	$p = 0.012$ (> 4 h)	–	$p = 0.00$	–
Karasu 2010	Mo R	113	32	$p = 0.0001$ (> 60)	–	–	$p < 0.006$	$p = 0.022$ (GCS ≤ 12)	–	$p < 0.0001$	–	–	–
Tien 2011	Mo R	149	44.7	$p = 0.0004$ OR 1.04 (1.02–1.07)	–	–	–	$p < 0.0001$ OR 0.78 (0.69–0.88)	–	$p = 0.0242$ OR 1.03 (1.004–1.06)	–	–	–
Baraniskin 2014	Mo R	312	70.9	$p = 0.012$ (> 65)	–	$p < 0.005$	–	–	–	–	–	–	–
Kalayci 2013	Mo R	34	37.2	$p = 0.032$ (≥ 60)	NS	–	$p = 0.002$	$p = 0.030$ (≤ 5)	NS	NS	–	–	–
Alagoz 2015	Mo R	99	46.8	$p = 0.00$	NS	–	–	$p = 0.00$	$p = 0.021$	$p = 0.013$	–	–	–
Lenzi 2017	Mo R	316	74.5	$p < 0.001^a$ OR 51.63 $(15.39–173.2)^a$	NS	$p = 0.001$	–	$p < 0.001^a$ OR 0.32 $(0.2–0.52)^a$	–	–	NS	NS	–
Yilmaz 2019	Mo R	93	59.8	$p = 0.007^a$	NS	–	–	$p = 0.009^a$ (≤ 5)	–	–		–	–
Altaf 2020	Mo R	58	44.3	–	–	–	–	–	–	NS	NS	NS	–

Abbreviations: DC, decompressive craniectomy; GCS, Glasgow Coma Scale; ICP, intracranial pressure; Mo, monocentric; Mu, multicentric OR, odds ratio; R, retrospective; VKA, vitamin K antagonist; X, chi-square test.
[a]Multivariate analysis.

outcome: older age (significant $n = 1{,}864$, $p = 0.049$; nonsignificant $n = 582$), low admission GCS score (significant $n = 2{,}300$, $p = 0.03$; nonsignificant $n = 247$), and DC (significant $n = 1{,}044$, $p < 0.01$; nonsignificant $n = 565$). Abnormal pupil examination (significant $n = 971$, $p = 0.04$; nonsignificant $n = 640$) was considered to be possibly associated with functional outcome. The following factors were considered not to be significantly associated with functional outcome: medication with blood thinners (nonsignificant $n = 362$), associate extra-cranial injuries (significant $n = 340$, $p \leq 0.05$; nonsignificant $n = 803$), delay from injury to surgery (significant $n = 387$, $p = 0.0364$; nonsignificant $n = 913$) (►**Table 3**).

Radiologic Factors Influencing Functional Outcome

Thirty-six point six percent (15/41) of the studies, accounting for 2,608 patients, reported radiologic factors influencing the functional outcome of patients suffering from ASDH.[2,16,25,28–30,32,34–36,39,43,49–51] Four factors were considered to significantly associated with functional outcome: ASDH volume (significant $n = 604$, $p = 0.014$), temporal uncus herniation ($n = 124$, $p = 0.03$), traumatic axonal injury ($n = 81$, $p = 0.03$), and loss of basal cisterns (significant $n = 791$, $p = 0.037$; nonsignificant $n = 205$). Four factors were considered to be possibly associated with functional outcome: ASDH thickness (significant $n = 880$, $p = 0.039$; nonsignificant $n = 788$), midline shift (significant $n = 826$, $p = 0.0473$; nonsignificant $n = 945$), brain contusion (significant $n = 841$, $p < 0.05$; nonsignificant $n = 724$), and traumatic subarachnoid hemorrhage (significant $n = 522$, $p < 0.05$; nonsignificant $n = 724$) (►**Table 4**).

Elderly

Clinical Factors Influencing mortality in the Elderly

Seven point three percent (3/41) of the studies, accounting for 242 patients, reported clinical factors influencing the mortality of patients suffering from ASDH.[45,54,60] Low postoperative GCS score was the only factor considered to be significantly associated with mortality ($n = 62$, $p = 0.0000076$). Two factors were considered to be possibly associated with mortality: abnormal pupil examination (significant $n = 62$, $p = 0.021$; nonsignificant $n = 44$), and admission GCS score (significant $n = 106$, $p = 0.014$; nonsignificant $n = 136$). Lastly, four factors were considered not to be significantly associated with mortality: sex ($n = 44$), medication with blood thinners ($n = 106$), delay from trauma to surgery ($n = 136$), and seizures ($n = 62$) (►**Table 5**).

Radiologic Factors Influencing Mortality in the Elderly

Four point nine percent (2/41) of the studies, accounting for 198 patients, reported radiologic factors influencing mortality of old patients suffering from ASDH.[54,60] Midline shift on CT (computed tomography) scan was the only factor that was considered to be significantly associated with mortality ($n = 136$, $p = 0.044$). Two factors were considered not to be significantly associated with mortality: ASDH thickness (nonsignificant $n = 136$) and brain contusion (nonsignificant, $n = 62$) (►**Table 6**).

Clinical Factors Influencing Functional Outcome in the Elderly

Fourteen point six percent (6/41) of the studies, accounting for 523 patients, reported clinical factors influencing the functional outcome of patients suffering from ASDH.[7,54,56,58–60] Four factors were considered to be significantly associated with functional outcome: comorbidities (significant $n = 95$, $p < 0.05$; nonsignificant $n = 17$), abnormal pupil examination (significant $n = 275$, $p = 0.009$; nonsignificant $n = 27$), postoperative GCS score (significant $n = 343$, $p < 0.001$), and hospitalization in intensive care unit (significant $n = 27$, $p < 0.05$). Four factors were considered to be possibly associated with functional outcome: medication with blood thinners (significant $n = 213$, $p = 0.024$; nonsignificant $n = 157$), admission GCS score (significant $n = 302$, $p < 0.05$; nonsignificant $n = 221$), delay from trauma to surgery (significant $n = 213$, $p < 0.001$; nonsignificant $n = 231$), and seizures (significant $n = 213$, $p < 0.001$; nonsignificant $n = 157$). Lastly, sex was not considered to be associated with functional outcome (nonsignificant $n = 95$) (►**Table 5**).

Radiologic Factors Influencing Functional Outcome in the Elderly

Fourteen point six percent (6/41) of the studies, accounting for 523 patients, reported radiologic factors influencing the functional outcome of patients suffering from ASDH.[7,54,56,58–60] Midline shift appeared as the sole factor considered to be significantly associated with functional outcome (significant $n = 349$, $p = 0.038$; nonsignificant $n = 112$). Brain contusion was considered to be possibly associated with functional outcome (significant $n = 62$, $p = 0.037$; nonsignificant $n = 213$). Two factors were considered not be associated with functional outcome: ASDH volume (nonsignificant, $n = 95$) and ASDH thickness (nonsignificant, $n = 349$) (►**Table 6**).

Choice of the Surgical Procedure: Craniotomy or Decompressive Craniectomy

Nine point eight percent (4/41) of the studies, accounting for 945 patients, reported differences in baseline characteristics, brain CT features, and outcomes between patients who underwent craniotomy or DC.[40,48,50,61] Compared to patients who underwent craniotomy, patients who underwent DC were more likely to be younger (significant $n = 734$, $p = 0.015$; nonsignificant $p = 46$), to suffer from extra-cerebral-associated trauma lesions (significant $n = 91$, $p = 0.001$), to have a lower admission GCS score (significant $n = 780$, $p = 0.034$), and to present abnormal pupil examination (significant $n = 46$, $p = 0.004$). Patients who underwent DC were more likely to harbor serious brain CT scan features, such as important ASDH thickness (significant $n = 808$, $p = 0.031$), important midline shift (significant $n = 808$, $p = 0.01$), traumatic subarachnoid hemorrhage (significant $n = 46$, $p = 0.003$), and loss of basal cisterns (significant $n = 256$, $p = 0.02$). Although the mean discharge Glasgow Outcome Scale (GOS) score of patients who underwent DC was lower (significant $n = 643$, $p < 0.001$), the long-term functional

Table 2 Influence of brain CT features on mortality of patients presenting with acute subdural hematoma

Study (first author and year)	Study type	Number of patients	Mean age	Prognostic factors						
				Hematoma			Associated TBI		Loss basal cisterns	Brain herniation
				Volume (mL)	Thickness (mm)	Midline shift (mm)	Contusion	SAH		
Seelig 1981	Mo R	82	41	–	–	–	NS	–	–	–
Koç 1997	Mo R	113	31.1	–	–	–	$p < 0.01$	$p < 0.01$	–	–
Kim 2009	Mo R	256	51.8	NS	NS	$p = 0.008$ (≥ 10)	–	–	–	–
Tien 2011	Mo R	149	44.7	–	–	–	NS	–	–	$p = 0.0004$ OR 5.06 (2.06–12.45)
Kalayci 2013	Mo R	34	37.2	–	–	NS	–	–	–	–
Inamasu 2014	Mo R	61	65.3	–	–	–	$p = 0.009$ (left hemisphere)	–	–	–
Alagoz 2015	Mo R	99	46.8	–	$p = 0.00$	–	–	–	–	–
Yilmaz 2019	Mo R	58	59.8	–	$p = 0.039$ (≥ 15)	$p = 0.014$ (≥ 10)	NS	NS	–	–

Abbreviations: CT, computed tomography; Mo, monocentric; SAH, subarachnoid hemorrhage; TBI, traumatic brain injury.

prognosis was somewhat comparable between the DC and the craniotomy group (significant $n = 46$, $p = 0.004$; nonsignificant $n = 256$) (►**Table 7**).

Discussion

Guidelines

The potential prognostic factors underlined previously echoes Bullock guidelines (2006), which proposed standardized clinical parameters (loss of $\geq$ 2 GCS points in a comatose patient, abnormal pupil examination, raised intracranial pressure > 20 mmHg) and radiologic parameters (ASDH thickness > 10 mm, midline shift > 5 mm) for surgical indication.[62] This being said, these guidelines do not help predict the patient postoperative awakening nor their long-term functional outcome. Hence, this review highlighted supplementary prognostic factors which merit discussion.

Radiologic Factors

Although the clinical factors influencing the mortality and the functional outcome identified in this review were quite comparable, the same cannot be said for radiologic factors. Notably, ASDH volume, temporal uncus herniation, loss of basal cisterns, and associated traumatic axonal injury were associated with functional outcome in this work.

Blood Thinners

In this review, medication with blood thinners was associated with increased mortality but had no impact on functional outcome. What is more, a series of 300 patients (2011) did not find any correlation between prior medication with oral antithrombotic therapy and morbidity or mortality in patients operated on for ASDH. Besides, a recent systematic review[12] concerning patients that are 65 years or older found that blood thinners had no independent influence neither on the importance or the recurrence of ASDH, nor on the outcome.[12]

Associated Extra-cranial Injuries

In this review, associated extra-cranial injuries were possibly associated with mortality but not with functional outcome. To date though, the impact of extra-cranial injury on functional outcome of patients with severe traumatic brain injury still remains open to debate.[63] This being said, damage-control surgery may be carried out in patients with severe traumatic brain injury under close monitoring with invasive intracranial pressure monitor.[63] Moreover, combined cranial and extra-cranial surgery or invasive procedure can be carried out simultaneously in case of multiple life-threatening lesions in severe trauma patients, if necessary.[64]

Choice of the Surgical Procedure

This review underlined that DC was preferred over craniotomy in younger patients with worst neurological status, multiple extra-cranial injuries, and more serious radiologic parameters on brain CT scan. Indeed, DC has become the damage-control procedure of choice in case of severe traumatic brain injury in the young.[5,6] This corroborates Bullock

Table 3 Influence of clinical data on functional outcome (GOS) of patients presenting with acute subdural hematoma

Study (first author and year)	Study type	Number of patients	Mean age	Prognostic factors									
				Age	Sex ♂/♀	Blood thinners	Abnormal pupil exam	Admission GCS extra-cranial injuries		Delay to surgery (h)	DC		Postop ICP
						VKA					Good outcome	Poor outcome	
Haselsberger 1988	Mo R	111	–	–	–	–	–	$p < 0.001$	–	$p < 0.001$	–	–	–
Yanaka 1993	Mu R	224	48.1	$p < 0.01$	NS	–	$p < 0.01$	$p < 0.01$	$p < 0.05$	–	NS	–	$p < 0.01$
Cook 1996	Mo P	103	37.0	–	–	–	NS	–	–	NS	–	–	NS
Massaro 1996	Mo R	127	47.0	NS	NS	–	–	$p < 0.0001$	–	NS	–	–	–
Servadei 2000	Mo R	223	–	OR 0.27 (0.09–0.83) (> 50 yo)	NS	–	OR 0.11 (0.05–0.26)	OR 0.14 (0.06–0.30) (≤ 8)	NS	NS	–	–	–
Chieregato 2009	Mo R	20	43.5	NS	NS	–	NS	NS (motor)	–	$P = 0.0364$	–	–	NS
Kim 2009	Mo R	256	51.8	OR 4.91 (1.8–13.4)[a]	NS	–	$p = 0.003$[a] OR 3.73 (1.56–8.92)[a]	$p = 0.00$[a] OR 5.64 (2.61–12.2)[a]	–	$p = 0.006$ (≥ 4)	–	$p = 0.00$	–
Wong 2010	Mo R	34	60.0	$p < 0.001$ OR 0.94 (0.92–0.97)[a]	$p = 0.011$	–	OR 2.15 (1.2–114.5)[a]	$p < 0.001$ OR 2.15 (1.44–3.21)[a] (motor)	$p = 0.368$	–	NS	NS	–
Leitgeb 2012	Mu P	360	56.8	$p = 0.0002$[a]	NS[a]	–	NS[a]	$p = 0.0075$[a]	NS	–	NS	NS	–
Yamaguchi 2013	Mo R	81	61.8	–	–	–	–	–	–	–	–	–	–
Lee 2017	Mo R	75	–	NS	NS	NS	NS[a]	$p = 0.03$[a] OR 9.2 (1.24–68.3)[a]	NS	$p = 0.042$ NS[a]	–	–	–
Vilcinis 2017	Mo R	643	58.1	$p < 0.001$[a] OR 1.06 (1.04–1.08)[a]	–	–	–	$p < 0.001$[a] OR 0.76 (0.71–0.81)[a]	–	–	–	$p < 0.001$[a] OR 5.3 (3–9.2)[a]	–
Won 2017	Mo R	116	72.9	–	–	$p = 0.05$ OR 2.3 (1–5.2) NS[a]	–	–	–	–	–	–	–
Karnjanasavitree 2018	Mo R	145	49.8	NS	NS	–	$p = 0.04$[a] OR 2.5 (1.03–6.2)[a]	NS	NS	NS[a] (ED to surgery)	–	$p < 0.01$	–
Lavrador 2018	Mo R	89	70	NS[a]	NS[a]	NS[a]	$p = 0.03$[a]	$p = 0.023$ NS[a]	–	–	NS[a]	NS[a]	–
Baucher 2019	Mo R	82	54	NS[a]	NS	NS	NS[a]	NS[a]	$p = 0.03$[a] OR 6.73 (1.15–40)[a]	NS	NS	NS	–
Jin 2018	Mo P	124		$p = 0.049$[a] OR 5.7 (1.1–31.8)[a] (> 45 yo)	NS	–	–	$p = 0.024$[a] OR 8.9 (1.3–58.7)[a] (≤ 12)	–	NS	–	–	–
Igbokwe 2021	Mo R	34	36.3	NS	NS	–	–	$p = 0.029$	–	NS	–	–	–

Abbreviations: DC, decompressive craniectomy; GCS, Glasgow Coma Scale; ICP, intracranial pressure; Mo, monocentric; Mu, multicentric; OR, odds ratio; R, retrospective; VKA, vitamin K antagonist.
[a]Multivariate analysis.

Table 4 Influence of brain CT features on functional outcome (GOS) of patients presenting with acute subdural hematoma

Study (first author and year)	Study type	Number of patients	Mean age	Prognostic factors								
				Hematoma					Associated TBI			Loss basal cisterns
				Volume (mL)	Thickness (mm)	Midline shift (mm)	Brain herniation	Thickness/ midline shift	Contusion		SAH	TAI
Haselsberger 1988	Mo R	111	–	–	–	–	–	–	$p < 0.01$	–	–	–
Yanaka 1993	Mu R	224	48.1	$p < 0.01$	$p < 0.01$	$p < 0.01$	–	–	$p < 0.01$	$p < 0.01$	–	$p < 0.01$
Cook 1996	Mo P	103	37.0	–	–	$p < 0.013$	–	–	NS	NS	–	NS
Massaro 1996	Mo R	127	47.0	–	–	–	–	–	$p = 0.0335$	–	–	–
Servadei 2000	Mo R	223	–	–	OR 0.25 (0.10–0.64) (≥ 16)	OR 0.25 (0.12–0.5) (≥ 11)	–	–	OR 0.25 (0.09–0.72)	OR 0.41 (0.22–0.74)	–	OR 0.06 (0.02–0.17)
Chieregato 2009	Mo R	20	43.5	–	$p = 0.0144$	$p = 0.0473$	–	–	–	–	–	NS
Kim 2009	Mo P	256	51.8	$p = 0.008$ (≥ 50)	$p = 0.00$ (≥ 15)	$p = 0.00$ (≥ 10)	–	–	–	–	–	–
Wong 2010	Mo R	34	60.0	–	–	–	–	–	NS	NS	–	–
Leitgeb 2012	Mu P	360	56.8	–	–	–	–	–	NS	NS	–	–
Yamaguchi 2013	Mo R	81	61.8	–	–	–	–	–	$p = 0.04$ (+ TAI)	–	$p = 0.03$ (< 60 yo)	–
Lee 2017	Mo R	75	–	–	$p = 0.039$[a] OR 6.31 (1.12–35.66)[a]	NS	–	–	$p < 0.05$[a]	$p < 0.05$[a]	–	$p = 0.018$[a]
Vilcinis 2017	Mo R	643	58.1	–	NS[a]	NS[a]	–	–	–	–	–	–
Karnjanasavitree 2018	Mo R	145	49.8	–	NS	NS	–	–	NS	NS	–	$p = 0.007$[a] OR 3.2 (1.3–7.8)[a]
Baucher 2019	Mo R	82	54	–	$p = 0.02$[a] OR 9.87 (1.54–63.4)[a] (≥ 20)	NS[a]	–	–	NS[a]	NS[a]	–	NS
Jin 2018	Mo P	124	–	$p = 0.014$[a] OR 9.4 (1.6–56.7)[a] (> 80)	–	–	$p = 0.03$[a] OR 6 (1.2–29.9)[a]	$p = 0.009$[a] OR 9.15 (1.8–47.7)[a]	–	–	–	$p = 0.037$[a] OR 8.06 (1.1–57.4)[a]

Abbreviations: GOS, Glasgow Outcome Scale; Mo, monocentric; OR, odds ratio; R, retrospective; SAH, subarachnoid hemorrhage; TAI, traumatic axonal injury; TBI, traumatic brain injury.
[a]Multivariate analysis.

Table 5 Influence of clinical data mortality and functional outcome (GOS) of elderly patients presenting with acute subdural hematoma

Study (first author and year)	Study type	Number of patients	Inclusion age	Mean age	Outcome criteria	Prognostic factors								
						Sex ♂/♀	Blood thinners **VKA**	Comorbidities	Abnormal pupil exam	Admission GCS	Delay to surgery	Seizures	Postop GCS	ICU treatment
Raj 2016	Mo R	44	≥ 75	81	Mortality	NS	NS	–	NS	$p < 0.002$ (≤ 8)	–	–	–	–
Won 2017	Mo R	68	≥ 80	85.2	GOS	NS	NS	$p < 0.05$[a] OR 9.7 (1–100.5)[a] (≥ 5)	–	$p = 0.02$ (≤ 8) NS[a]	NS	$p = 0.04$ NS[a]	$p < 0.001$[a] OR 15.4 (2.9–80.8)[a] (GCS ≤ 8)	–
Akbik 2019	Mo R	62	≥ 65	78	Mortality	–	NS	–	$p = 0.021$	$p = 0.014$	–	NS	$p = 0.0000076$	–
					GOS	–	NS	–	$p = 0.009$	$p = 0.016$	–	NS	$p = 0.000006$	–
Trevisi 2020	Mu R	213	≥ 70	80	GOS	–	$p = 0.024$[a] OR 0.32 (0.012–0.86)	–	$p < 0.001$ NS[a]	$p < 0.001$[a]	$p < 0.001$	$p < 0.001$	$p < 0.001$	–
Younsi 2021	Mo R	27	≥ 80	84	GOS	NS	NS	$p < 0.05$ OR 9.5 (1.3–63.3) (≤ 1)	NS	$p < 0.05$ OR 0 (0–0.7) (< 8)	NS	NS	–	$p < 0.05$ OR 0.1 (0.01–0.8)
Krueger 2023	Mo R	17	≥ 80	82.5	GOS	–	–	NS (Charlson index)[a]	–	$p = 0.02$ NS[a]	–	–	–	–
Trevisi 2022	Mu R	136	≥ 70	78.5	Mortality	–	–	–	–	NS[a]	NS[a]	–	–	–
					GOS	–	–	–	–	NS[a]	NS[a]	–	–	–

Abbreviations: GCS, Glasgow Coma Scale; ICU, intensive care unit; GOS, Glasgow Outcome Scale; Mo, monocentric; OR, odds ratio; R, retrospective; VKA, vitamin K antagonist.
[a]Multivariate analysis.

Table 6 Influence of brain CT features on mortality and functional outcome (GOS) of elderly patients presenting with acute subdural hematoma

Study (first author and year)	Study type	Number of patients	Inclusion age	Mean age	Outcome criteria	Prognostic factors			
						Hematoma			Associated TBI
						Volume	Thickness (mm)	Midline shift (mm)	Contusion
Won 2017	Mo R	68	≥ 80	85.2	GOS	NS	–	NS	–
Akbik 2019	Mo R	62	≥ 65	78	Mortality	–	–	–	NS
					GOS	–	–	–	$p = 0.037$
Trevisi 2020	Mu R	213	≥ 70	80	GOS	–	$p < 0.001$ NS[a]	$p = 0.001$ OR 1.2 (1.07–1.33)[a]	NS
Younsi 2021	Mo R	27	≥ 80	84	GOS	NS	–	NS	–
Krueger 2023	Mo R	17	≥ 80	82.5	GOS	–	–	NS[a]	–
Trevisi 2022	Mu R	136	≥ 70	78.5	Mortality	–	NS[a]	$p = 0.044$[a] OR 1.23[a]	–
					GOS	–	NS[a]	$p = 0.038$[a] OR 1.28[a]	–

Abbreviations: GOS, Glasgow Outcome Scale; Mo, monocentric; OR, odds ratio; R, retrospective; TBI, traumatic brain injury.
[a]Multivariate analysis.

Table 7 Differences in baseline characteristics, operative details, and outcome between patients undergoing craniotomy or decompressive craniectomy for acute subdural hematoma

Study (first author and year)	Study type	Number of patients	Variables	Craniotomy	Decompressive craniectomy	
Li 2012	Mo R	91	Number of patients	40 (44%)	51 (56%)	
			Age	59	45	$p = 0.015$
			Mean GCS	9.5	5	$p = 0.001$
			Extracranial injuries	1 (2.5%)	16 (31.4%)	$p = 0.001$
			CT: loss basal cisterns	7 (17.5%)	28 (54.9%)	$p = 0.001$
			6 months mRS ≥ 4	17 (42.5%)	21 (41.2%)	NS
Kwon 2016	Mo R	46	Number of patients	20 (43.5%)	26 (56.5%)	
			Age	63.4	65.5	NS
			GCS < 8	7 (35%)	16 (61.5%)	$p = 0.034$
			Abnormal pupil exam	8 (40%)	20 (76.9%)	$p = 0.004$
			CT: SAH	5 (25%)	18 (69.2%)	$p = 0.003$
			6 months mRS ≥ 4	8 (40%)	20 (76.9%)	$p = 0.004$
Vilcinis 2017	Mo R	643	Number of patients	394	249	
			Age	60.3	54.2	$p < 0.001$
			♂/♀ ratio	(202/192) 1.05	(201/48) 4.19	$p < 0.001$
			Mean GCS	9.3 ± 4.1	5.3 ± 3	$p < 0.001$
			CT: hematoma thickness (mm)	1.63 ± 0.6	1.75 ± 0.8	$p = 0.031$
			CT: midline shift (mm)	0.99 ± 0.7	1.42 ± 0.7	$p < 0.001$
			Discharge mean GOS	3.4 ± 1.5	1.98 ± 1.3	$p < 0.001$
Anis 2022	Mo R	165	Number of patients	87 (52.7%)	78 (47.3%)	
			CT: hematoma thickness (mm)	11.3 ± 8.2	23.8 ± 24.6	$p = 0.001$
			CT: midline shift (mm)	6.2 ± 6.8	9.9 ± 10.8	$p = 0.01$
			CT: loss basal cisterns	49 (56.3%)	54 (69.2%)	$p = 0.02$
			ER to OR delay (min)	231	556	$p = 0.01$
			Tracheostomy	26 (29.9%)	36 (46.2%)	$p = 0.03$
			GOS	4.3 ± 1	4.3 ± 1	NS

Abbreviations: CT, computed tomography; GCS, Glasgow Coma Scale; GOS, Glasgow Outcome Scale; mRS, modified Rankin Scale.

guidelines stating that patients with an intracranial pressure higher than 20 mmHg require surgical treatment of ASDH,[62] and that a raised postoperative intracranial pressure was associated with mortality in this review.

In case of surgical indication for old patients suffering from ASDH, craniotomy might be preferred given the dismal prognostic of ASDH and the slim odds for postoperative massive brain swelling in this age group.[11]

Elderly

This review underlined that the postoperative GCS score was the sole factor associated with mortality, while the preoperative GCS score and abnormal pupil examination were uncertain factors. Apart from these, comorbidities and hospitalization in the intensive care unit were associated with functional outcome. Midline shift was the only radiologic factor associated with mortality or functional outcome. These findings mostly concur with a recent systematic review stating that severe head trauma (preoperative GCS ≤ 8) was the sole independent prognostic factor.[10]

Scoring Systems

Three reliable scoring systems have been developed in order to predict the middle-term or long-term functional outcome or mortality.

Jin et al presented a nomogram score based on a series of 124 patients operated on for ASDH, aiming to predict 3-month functional outcome (GOS).[16]

RASH score (ASDH operated on)	
Age (years)	
≤59	0
60-79	1
≥80	2
GCS	
≥14	0
9-13	1
≤8	2
Pupil exam	
Fixed unilateral	1
Fixed bilateral	2
Midline shift >5mm	1
Loss consciousness	2
Total	0-8

RASH score for 2016 series	
RASH	**Mortality (%)**
0	0 (0.0)
1	13 (8.3%)
2	62 (17.4%)
3	134 (27.2%)
4	184 (32.5%)
5	176 (44.6%)
6	222 (60.0%)
7	102 (78.5%)
8	22 (88.0%)

Fig. 2 Richmond Acute Subdural Hematoma (RASH) score.

SHE score (patients >65yo)	
Age	
<80	0
≥80	1
Admission GCS score	
3-4	2
5-12	1
13-15	0
ASDH volume (mL)	
<50	0
≥50	1
Total	0-4

SHE score for 2019 series	
Score	**30-day mortality (%)**
0	3/94 (3.2%)
1	13/99 (13.1%)
2	16/49 (32.7%)
3	22/23 (95.7%)
4	12/12 (100%)

Fig. 3 Subdural Hematoma in the Elderly (SHE) score.

Dincer et al introduced the Richmond Acute Subdural Hematoma score (RASH) based on a series of 2,516 patients operated on for ASDH within 4 hours following admission, aiming to predict mortality (►**Fig. 2**).[17]

Alford et al presented the "Subdural Hematoma in the Elderly" (SHE) score based on a series of 469 patients more than 65 years old suffering from subdural hematoma, and aiming to predict the 1-month mortality (►**Fig. 3**).[15] This score was based on the patient's age, the GCS score, and the ASDH volume, which were all associated with 1-month mortality and functional outcome on multivariate analysis.

From the author's point of view, the RASH and the SHE scores could both be used in daily clinical practice, thanks to their simplicity.

Ratio between ASDH Thickness and Midline Shift: Looking toward the Future

Zumkeller[65] introduced the ASDH thickness to middle shift ratio on brain CT scan as a marker of mortality and poor functional outcome: the mortality reached 50% when the midline shift exceeded the ASDH thickness by 3 mm, and 25% for 5 mm. The usefulness of a Zumkeller index more than 3 mm for predicting mortality was further confirmed in univariate and multivariate analysis.[19,66]

Conclusion

This scoping review has underlined factors predictive of mortality and poor functional outcome in patients suffering from ASDH, some of which had already been previously identified. Nonetheless, delay from trauma to surgery and also possibly associated extra-cranial injuries were confirmed as factors associated with mortality. Regarding radiologic factors, the presence of petechiae (traumatic axonal injury) was associated with poor functional outcome, while the presence of contusions and traumatic subarachnoid hemorrhage were potential aggravating factors. In the elderly, comorbidities, abnormal pupil examination, postoperative GCS score, and hospitalization in intensive care unit were associated with functional prognostic.

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Conflict of Interest
None declared.

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