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Article

Has the Timing of the Surgery a Major Role in Influencing Outcome in Elderly Patients with Acute Subdural Hematomas?

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Abstract: Background: The incidence of traumatic acute subdural hematomas (ASDH) in elderly is increasing. Despite surgical evacuation, these patients have poor survival and low rate of functional outcome, and surgical timing plays a no clear role as predictor. We investigated if the timing of surgery has a major role in influencing outcome in these patients.Methods: We retrospectively retrieved clinical and radiological data of all patients ≥70 years operated on for post-traumatic ASDH in a 3 years period in 5 Italian Hospitals. Patients were divided in 3 surgical timing groups from hospital arrival: ultra-early (within 6h); early (6-24h); delayed (after 24h). Outcome was measured at discharge using two endpoints: survival (alive/dead) and functional outcome at Glasgow Outcome Scale (GOS). Univariate and multivariate predictor models were constructed.Results: We included 136 patients. About 33% died for consequences of ASDH and among the survivors only 24% were in good functional outcome at discharge. Surgical timing groups appeared different according to presenting GCS, which was on average lower in ultra-early surgery group, and radiological findings, which appeared worse in the same group. Delayed surgery was more frequent in patients with subacute clinical deterioration. Surgical timing appeared associated neither with survival nor with functional outcome also after stratification for preoperative GCS. Preoperative midline shift was the strongest outcome predictor. Conclusions: An earlier surgery was offered to patients with worse clinical-radiological findings. Also after stratification for GCS it was not associated with better outcome. Among the radiological markers, preoperative midline shift was the strongest outcome predictor.

Keywords: acute subdural hematoma; comorbidity; elderly; outcome; surgery; timing of surgery; traumatic brain injury

1. Introduction

With the increase in mean age of the world population, the incidence of head injury and acute subdural hematoma (ASDH) in the elderly is simultaneously raising [1]. Traumatic ASDH represents a severe medical condition generally associated with a poor outcome in elderly patients [2,3]. Current guidelines on optimal treatment of these patients are based on weak evidences and, despite being considered a life-saving

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procedure, the role of surgery remains debated [4–8]. Thus, in these patients it is quite common among clinicians preferring at first glance a conservative treatment and shifting towards surgery only in case of deterioration of the state of consciousness.

Controversial appears in fact the role of surgical timing in influencing outcome. Indeed, despite in general a prompt surgical evacuation is regarded as an important variable associated with outcome in the natural history of ASDH [9–11], this was not confirmed by the few studies focusing on elderly patients [12,13] as the advantages of hematoma evacuation have to be balanced with the increased risk of surgery in this age range.

Aim of this study is to investigate if timing of surgery had a major role in influencing outcome in a multicentric series of patients ≥70 years-old operated for a post-traumatic ASDH.

2. Materials and Methods

Population and treatment

We selected from retrospective databases of 5 Italian tertiary referral hospitals all patients ≥70 years operated on for a post-traumatic ASDH between January 1st 2017 and December 31st 2019. Non-traumatic or acute on chronic subdural hematomas were excluded, as well as patients operated after hematoma chronicization. Patients with fixed and dilated pupils were also excluded since they would have invariably presented a poor outcome [8]. Presence of other intracranial post-traumatic lesions associated to ASDH was instead not an exclusion criteria, unless their role was deemed as decisive for patient neurological status, overwhelming the role of the subdural collection.

In general, indications for ASDH evacuation were based on impaired consciousness, focal neurological symptoms, hematoma thickness >1cm, and midline shift >5mm. As no guidelines are yet available on the appropriate treatment in the elderly, decision making and timing of the correct management were based on a case by case evaluation of clinical status, radiological features, and family consultation.

Clinical and radiological data collection

For each patient, we retrieved age, sex, Charlson Comorbidity Index (CCI), history of arterial hypertension, use of antithrombotic drugs, the need for an urgent coagulopathy correction at A&E admission, mechanism of injury, neurological status measured by Glasgow Coma Scale (GCS) at admission and during the entire preoperative period, pupillary size and light reaction, neurological deficits, and seizures. Patients were divided in three GCS level groups, both at arrival and soon before surgery: mild (13-15), moderate (9-12) and severe (3-8).

Radiological parameters were retrieved by local PACS. For each patients we collected ASDH thickness, midline shift and presence of other post-traumatic lesions at first CT-scan, at any CT-scan performed in the preoperative period and at the first post-operative CT-scan (within 24 hours from surgery). ASDH thickness/midline shift ratio was computed in all cases.

Timing of surgery groups

Timing of surgery was calculated from A&E arrival to the starting time of the surgical procedure as recorded on surgical reports. Patients were divided in three groups according to the timing of surgery:

1) ultra-early, within 6 hours from A&E arrival;
2) early, between 6 hours and 24 hours form arrival;
3) delayed, after 24 hours.

Timing was chosen by the surgical team in a case-by-case fashion according to clinical status, radiological evidence, presence of comorbidities, need for coagulopathy reversal, patients and families wills, etc.

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Outcome Measures

Outcome was measured at discharge. We used two main endpoints: 1) survival (alive or dead); 2) functional outcome (good or poor).

The functional outcome was measured according to the Glasgow Outcome Scale (GOS) as death (D), vegetative status (VS), severe disability (SD), moderate disability (MD), good recovery (GR). GOS 1-3 (D, VS, SD) were considered as a poor outcome and 4-5 (MD, GR) as a good outcome.

Statistical Analysis

ANOVA test (for quantitative variables), Chi-Squared test (for qualitative variables), and their respective post-hoc tests with Bonferroni's correction were used to compare the differences in clinical-radiological characteristics, survival, and survival among the 3 groups with different surgical timing. Outcomes were also stratified by preoperative GCS level.

Logistic regression models were used to assess the association of survival and functional outcome with age, GCS at arrival and immediately preoperative GCS, first CT and last preoperative ASDH thickness, first CT and last preoperative midline shift, and with surgical timing groups.

Statistical analysis was performed using JASP, an R based software developed by the JASP team University of Amsterdam (Netherlands), Version 0.16.2; significance was set at 0.05.

3. Results

Demographics, radiological and clinical data

Demographical, radiological and clinical data of the included patients are reported in Table 1. We included 136 patients 70 years operated on for a traumatic ASDH along a 3-year time span who met our inclusion criteria. The mean age was 78.5 5.7 years (Min-Max: 70-92) and 76 (56%) patients were males. Mean CCI was 5.3 1.7, with 84 patients (61.8%) under antithrombotic drugs.

We divided patients according to three surgical timing groups: 30 (22%) underwent ultra-early surgery; 76 (56%) had early surgery, and 30 (22%) a delayed surgery.

As regards to the timing of surgery, in general, at worsening GCS level corresponded an earlier surgical procedure. Patients undergoing ultra-early surgery were those arrived in a significantly worse clinical status (lower GCS) and also showed a more severe neuroradiological picture at first CT-scan, namely thicker ASDH and wider midline shift compared with patients undergoing surgery after 6 hours from admission. The post-hoc analysis in fact showed a significant difference between ultra-early and delayed surgery groups in mean GCS at presentation and at first CT-scan parameters.

Some patients instead showed a worsening clinical and/or radiological picture during their stay in emergency department leading to shift from a first conservative approach to a surgical indication. Indeed, preoperative GCS showed no significant difference among the different surgical timing groups.

From a radiological point of view, 43.3% of patients included in the delayed surgery group showed worsening neuroimaging parameters at last preoperative CT-scan compared with the first one, with a significant difference if compared with the other groups ($p<.001$). In particular, the midline shift observed in the delayed surgery group showed a mean increase of 3 mm, which appeared significant if compared with that of 0.25 mm observed in ultra-early surgery group and of 1.8 mm in early surgery group.

In summary, we did not observe significant differences in GCS status, hematoma thickness and preoperative midline shift among the three surgical timing groups.

A significant difference was instead seen in duration of surgery, which appeared usually longer in early surgery group.

Primary decompressive craniectomy (DC) was performed in 11 cases: 3 ultra-early, 6 early, 2 delayed surgery, respectively. Three early-surgery cases underwent secondary DC, due to post-operative brain swelling.

Regarding complications, both as surgery related ones (rebleeding, stroke, new-onset seizures or deficits, wound problems) and as systemic complications (cardio-pulmonary, systemic infection, wound problems), we did not observe significant differences among surgical timing groups. In particular, rebleeding occurred in 11 cases: 3 in ultra-early, 7 in early and 1 in delayed surgical timing group, respectively. Three were on anticoagulation and 4 on antiplatelets, while 4 patients were not on antithrombotics. Reoperation was performed in 3 of these cases. All rebleeding patients had a poor outcome at discharge: 7 died, 2 were in vegetative state, and 2 had a severe disability.

Relationship between surgical timing and clinical outcome

Overall, 91 patients (67%) were alive at discharge, but only 33 (24% of the total number of patients) appeared in a good functional outcome.

Surgical timing did not appear associated neither with survival nor with good functional outcome; on the other hand, we observed a trend of association with worse outcome in ultra-early surgery group (Table 2).

Stratification of outcomes according to preoperative GCS classes showed a significant higher rate of mortality in patients with mild GCS undergoing ultra-early surgery compared with the other groups. However, these patients were significantly older than those showing mild GCS operated later than 6 hours from diagnosis. Moreover, this subgroup of patients also showed a larger midline shift at both first and last preoperative CT-scan compared with the other patients operated in mild GCS, even though these did not reach a statistically significant level.

Preoperative midline shift appeared as the only covariate associated with survival and functional outcome at logistic regression analysis (Table 3).

Table 1. Demographical, radiological and clinical data.

Preoperative GCS (Total n= 136)			Surgical Timing: Ultra-Early (within 6 hours) n= 30 (22%)	Surgical Timing: Early (6-24 hours) n= 76 (60%)	Surgical Timing: Delayed (after 24 hours) n= 30 (22%)	p
Overall	**Survival**	**Alive** (n= 91; 70%)	16 (53.3%)	55 (72.4%)	20 (66.7%)	*ns*
		Dead (n= 45; 45%)	14 (46.7%)	21 (27.6%)	10 (33.3%)	
	Functional Outcome	**Good** (n= 33; 24%)	5 (16.7%)	18 (23.7%)	10 (33.3%)	*ns*
		Poor (n= 103; 76%)	25 (83.3%)	58 (76.3%)	20 (66.7%)	
Mild	**Total (n= 33; 24.2%)**		**5 (16.7%)**	**15 (19.7%)**	**13 (43.3%)**	**0.02**
	Mean Age		84.2±4.5*	77.7±4.5*	79.8±5	**0.04**
	Mean GCS at A&E arrival		13.75±0.9	14.3±0.7	14±1.6	*ns*
	Mean first CT ASDH thickness in mm		15±8	13.9±3.4	13.8±9.5	*ns*
	Mean first CT midline shift in mm		8.8±4.8	5.4±3.8	4.7±3.5	*ns*
	Mean preoperative GCS		13.75±0.9	14.3±0.7	14.4±0.7	*ns*
	Mean preoperative ASDH thickness in mm		17.8±8.2	15.8±4.5	14.9±8.5	*ns*
	Mean preoperative midline shift in mm		9.6±4.2	9.2±5.7	5.8±2.6	*ns*
	Survival	**Alive** (n= 25; 75.8%)	1 (20%)	13 (86.7%)	11 (84.6%)	**0.007**
		Dead (n= 8; 24.2%)	4 (80%)	2 (13.3%)	2 (15.4%)	
	Functional Outcome	**Good** (n= 14; 42.4%)	1 (20%)	8 (54.3%)	5 (38.5%)	*ns*
		Poor (n= 19; 57.6%)	4 (80%)	7 (46.7%)	8 (61.5%)	
Moderate	**Total (n=36; 26.5%)**		**6 (20%)**	**22 (28.9%)**	**8 (26.7%)**	***ns***
	Mean Age		78±4.7	77±6.4	78.9±5	*ns*
	Mean GCS at A&E arrival		11.8±1.9	11.2±1.4	12.9±2.3	*ns*
	Mean first CT ASDH thickness in mm		13.2±6.3	16.1±7.7	10.3±5.2	*ns*
	Mean first CT midline shift in mm		7.4±4.3	7.8±4.9	4.8±3.9	*ns*

	Mean preoperative GCS		10.6±0.9	10.4±1	10.3±1.1	*ns*
	Mean preoperative ASDH thickness in mm		13.2±6.3	17.9±5.4	15.7±4.4	*ns*
	Mean preoperative midline shift in mm		7.4±4.3	8.5±3.9	12.4±6.4	*ns*
	Survival	**Alive** (n=28; 77.8%)	4 (66.7%)	19 (86.4%)	5 (62.5%)	*ns*
		Dead (n= 8; 22.2%)	2 (33.3%)	3 (13.6%)	3 (37.5%)	
	Functional Outcome	**Good** (n= 12; 33.3%)	3 (50%)	6 (27.3%)	3 (37.5%)	*ns*
		Poor (n= 24; 67.7%)	3 (50%)	16 (72.7%)	5 (62.5%)	
Severe	**Total (n=67; 49.3%)**		**19 (63.3%)**	**39 (51.3%)**	**9 (30%)**	**0.03**
	Mean Age		77.6±5.6	78.4±5.9	80.9±6	*ns*
	Mean GCS at A&E arrival		6.4±4.2	7.6±4.6	10.2±4.8	*ns*
	Mean first CT ASDH thickness in mm		19.3±4.4	15.8±6.8	12.3±7.2	*ns*
	Mean first CT midline shift in mm		13.4±7.2	10.4±6.3	7.2±5.3	*ns*
	Mean preoperative GCS		4.9±1.9	5±2.1	4.9±1.6	*ns*
	Mean preoperative ASDH thickness in mm		19.7±4.3	17.5±6.4	16±7.7	*ns*
	Mean preoperative midline shift in mm		13.6±7	12±5.8	9.4±4	*ns*
	Survival	**Alive** (n= 38; 56.7%)	11 (57.9%)	23 (59%)	4 (44%)	*ns*
		Dead (n= 29; 43.3%)	8 (42.1%)	16 (41%)	5 (55.6%)	
	Functional Outcome	**Good** (n= 7; 10.4%)	1 (5.3%)	4 (10.3%)	2 (22.2%)	*ns*
		Poor (n= 60; 89.6%)	18 (94.7%)	35 (89.7%)	7 (77.8%)	

Legend: All figures express mean standard deviation or frequency (percentage) of data referred to the corresponding column. * Significative difference between groups at post-hoc test Abbreviations: GCS: Glasgow Coma Scale; A&E: Accident and Emergency Department; CT: Computed-Tomography; ASDH: acute subdural hematoma.

Table 2. Demographics and outcomes stratified by preoperative GCS.

	Preoperative GCS (Total n= 136)		**Surgical Timing**			**p**
			Ultra-Early (within 6 hours) n= 30 (22%)	**Early (6-24 hours) n= 76 (60%)**	**Delayed (after 24 hours) n= 30 (22%)**	
Overall	**Survival**	**Alive** (n= 91; 70%)	16 (53.3%)	55 (72.4%)	20 (66.7%)	*ns*
		Dead (n= 45; 45%)	14 (46.7%)	21 (27.6%)	10 (33.3%)	
	Functional Outcome	**Good** (n= 33; 24%)	5 (16.7%)	18 (23.7%)	10 (33.3%)	*ns*
		Poor (n= 103; 76%)	25 (83.3%)	58 (76.3%)	20 (66.7%)	
Mild	**Total (n= 33; 24.2%)**		**5 (16.7%)**	**15 (19.7%)**	**13 (43.3%)**	**0.02**
	Mean Age		84.2±4.5*	77.7±4.5*	79.8±5	**0.04**
	Mean GCS at A&E arrival		13.75±0.9	14.3±0.7	14±1.6	*ns*
	Mean first CT ASDH thickness in mm		15±8	13.9±3.4	13.8±9.5	*ns*
	Mean first CT midline shift in mm		8.8±4.8	5.4±3.8	4.7±3.5	*ns*
	Mean preoperative GCS		13.75±0.9	14.3±0.7	14.4±0.7	*ns*
	Mean preoperative ASDH thickness in mm		17.8±8.2	15.8±4.5	14.9±8.5	*ns*
	Mean preoperative midline shift in mm		9.6±4.2	9.2±5.7	5.8±2.6	*ns*
	Survival	**Alive** (n= 25; 75.8%)	1 (20%)	13 (86.7%)	11 (84.6%)	**0.007**
		Dead (n= 8; 24.2%)	4 (80%)	2 (13.3%)	2 (15.4%)	
	Functional Outcome	**Good** (n= 14; 42.4%)	1 (20%)	8 (54.3%)	5 (38.5%)	*ns*
		Poor (n= 19; 57.6%)	4 (80%)	7 (46.7%)	8 (61.5%)	
Moderate	**Total (n=36; 26.5%)**		**6 (20%)**	**22 (28.9%)**	**8 (26.7%)**	***ns***
	Mean Age		78±4.7	77±6.4	78.9±5	*ns*
	Mean GCS at A&E arrival		11.8±1.9	11.2±1.4	12.9±2.3	*ns*
	Mean first CT ASDH thickness in mm		13.2±6.3	16.1±7.7	10.3±5.2	*ns*
	Mean first CT midline shift in mm		7.4±4.3	7.8±4.9	4.8±3.9	*ns*
	Mean preoperative GCS		10.6±0.9	10.4±1	10.3±1.1	*ns*
	Mean preoperative ASDH thickness in mm		13.2±6.3	17.9±5.4	15.7±4.4	*ns*
	Mean preoperative midline shift in mm		7.4±4.3	8.5±3.9	12.4±6.4	*ns*
	Survival	**Alive** (n=28; 77.8%)	4 (66.7%)	19 (86.4%)	5 (62.5%)	*ns*

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		Dead (n= 8; 22.2%)	2 (33.3%)	3 (13.6%)	3 (37.5%)	
	Functional Outcome	**Good** (n= 12; 33.3%)	3 (50%)	6 (27.3%)	3 (37.5%)	*ns*
		Poor (n= 24; 67.7%)	3 (50%)	16 (72.7%)	5 (62.5%)	
Severe	**Total (n=67; 49.3%)**		**19 (63.3%)**	**39 (51.3%)**	**9 (30%)**	**0.03**
	Mean Age		77.6±5.6	78.4±5.9	80.9±6	*ns*
	Mean GCS at A&E arrival		6.4±4.2	7.6±4.6	10.2±4.8	*ns*
	Mean first CT ASDH thickness in mm		19.3±4.4	15.8±6.8	12.3±7.2	*ns*
	Mean first CT midline shift in mm		13.4±7.2	10.4±6.3	7.2±5.3	*ns*
	Mean preoperative GCS		4.9±1.9	5±2.1	4.9±1.6	*ns*
	Mean preoperative ASDH thickness in mm		19.7±4.3	17.5±6.4	16±7.7	*ns*
	Mean preoperative midline shift in mm		13.6±7	12±5.8	9.4±4	*ns*
	Survival	**Alive** (n= 38; 56.7%)	11 (57.9%)	23 (59%)	4 (44%)	*ns*
		Dead (n= 29; 43.3%)	8 (42.1%)	16 (41%)	5 (55.6%)	
	Functional Outcome	**Good** (n= 7; 10.4%)	1 (5.3%)	4 (10.3%)	2 (22.2%)	*ns*
		Poor (n= 60; 89.6%)	18 (94.7%)	35 (89.7%)	7 (77.8%)	

Legend: All figures express mean standard deviation or frequency (percentage) of data referred to the corresponding column. * Significative difference between groups at post-hoc test Functional Outcome classified according to Glasgow Outcome Scale: "Good" = Good Recovery/ Moderate Disability; "Poor" = Severe Disability/ Vegetative State/ Death Abbreviations: GCS: Glasgow Coma Scale; A&E: Accident and Emergency Department; CT: Computed-Tomography; ASDH: acute subdural hematoma.

Table 3. Binomial logistic regression: analysis of variables associated to survival and functional outcome.

Dependent Variable	AUC	Covariates	Odds Ratio	p-value	95% Confidence interval	
					Lower bound	Upper bound
Survival ("Dead" coded as class 1)	0.746	Age	1.060	0.204	-0.032	0.148
		GCS at A&E arrival	0.962	0.653	-0.206	0.129
		First CT ASDH thickness (mm)	1.075	0.498	-0.137	0.282
		First CT midline shift (mm)	0.878	0.284	-0.368	0.108
		Preoperative GCS	0.954	0.566	-0.207	0.113
		Preoperative ASDH thickness (mm)	0.895	0.261	-0.305	0.083
		Preoperative midline (mm)	1.230	**0.044***	0.005	0.409
		Surgical timing (Ultra-Early)	0.016	0.237	-11.071	2.738
		Surgical timing (Early)	0.006	0.138	-12.004	1.662
		Surgical timing (Delayed)	0.008	0.174	-11.911	2.149
Functional Outcome ("Poor" coded as class 1)	0.805	Age	1.034	0.498	-0.063	0.130
		GCS at A&E arrival	0.884	0.237	-0.327	0.081
		First CT ASDH thickness (mm)	1.123	0.289	-0.098	0.329
		First CT midline shift (mm)	0.902	0.482	-0.389	0.184
		Preoperative GCS	0.902	0.184	-0.255	0.049
		Preoperative ASDH thickness (mm)	0.885	0.228	-0.320	0.076
		Preoperative midline (mm)	1.282	**0.038***	0.013	0.483
		Surgical timing (Ultra-Early)	1.309	0.946	-7.509	8.048
		Surgical timing (Early)	0.414	0.819	-8.428	6.664
		Surgical timing (Delayed)	0.553	0.880	-8.267	7.083

Legend: * Statistically significant. Functional Outcome classified according to Glasgow Outcome Scale: "Good" = Good Recovery/ Moderate Disability; "Poor" = Severe Disability/ Vegetative State/ Death Abbreviations: AUC: Area Under the Curve; GCS: Glasgow Coma Scale; A&E: Accident and Emergency Department; CT: Computed-Tomography; ASDH: acute subdural hematoma.

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4. Discussion

Surgical evacuation represents the only possible life-saving treatment in severely symptomatic ASDH. However, survival and good functional outcome remain poor in many elderly patients despite an aggressive treatment [13–16]. Therefore, in this age range, treatment of choice is still debated and object of ongoing trials [6,7] and most of neurosurgeons prefer an initial conservative treatment, opting for surgery only in case of impaired state of consciousness. Although, in fact, surgery has shown having a major life-saving role also in these patients when presenting with a severe clinical status, several studies reported a high rate of poor functional outcome both at discharge and at 6 months follow-up often due to higher incidence of perioperative complications [8].

Timing of surgery has been often considered as an important variable associated with outcome in ASDH evacuation [9–11]. However, several studies have failed to demonstrate a strict association between the timing of surgery and outcome [17–19] and only few of them specifically focused on elderly, also failing to show an advantage of early aggressive management compared with a delayed surgery in these patients [12,13]. Our study also seems to confirm these findings, but it is always necessary taking in mind that different surgical timings generally reflect different clinical severities at onset [9,20]. In agreement, our data additionally show that in this age range the leading indication for surgery was lower GCS and higher ASDH thickness with midline shift, which represented the strongest motivation for indicating surgery earlier than for other categories. Interestingly, on the other hand, age, general comorbidities, antithrombotic drugs assumption did not appear influencing the timing of surgery.

Similarly, a different category of patients characterized by an apparent mismatch between the radiological picture (considered as alarming for impending clinical worsening) and a mild GCS status at onset were usually earlier operated on despite an older age (Table 2). Nonetheless, these patients (overall 5) showed a worse outcome compared with those with similar GCS undergoing surgery with a delayed timing. Possible reasons for this apparently discordant result can be the radiological criteria leading to ultra-early surgery and the more advanced age of these 5 patients.

In our series the main outcome predictor for survival and functional outcome was the entity of the preoperative midline shift, which is usually, together with GCS, the main prognostic factor in elderly patients with ASDH21.

The detailed analysis of GCS trend and radiological parameters showed that clinicians used less strict criteria to indicate surgery in elderly patients with ASDH with mean ASDH thickness >1 cm and mean midline shift >5 mm at first CT-scan in those patients undergoing a delayed surgery. Also mean presenting GCS in these delayed surgery patients was rather low (12.4 3.5) compared to what expected in ASDH cases undergoing surgery. This is probably due to the awareness of the intrinsic high risk of this surgery in elderly patients [8,16,21–23], thus reflecting the current uncertainty of the best initial treatment in these patients7. Furthermore, this reflects the tendency of most neurosurgeons to choose to delay a possible craniotomy in elderly patients who do not show an initial serious clinical condition in the hope of a secondary chronicization of the hematoma, opening the possibility of its evacuation with a minimally invasive technique [24,25]. However, all the patients included in this case series were operated during the acute phase of the hematoma. Furthermore, it was recently shown that minicraniotomy even in local anaesthesia may be an appropriate treatment of ASDHs in elderly patients [26–28].

Study limitations

The main limitations of our study are its retrospective nature and the possible heterogeneous indications for surgery that influenced its timing among the different centers as well as among different surgeons in the same hospital.

In general ultra-early surgery was reserved to patients with worse clinical and radiological findings at arrival, which is known to strongly influence outcome [16,20,21,29]. Moreover, the clinical and radiological scenario of ASDH patients is dynamic and

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heterogeneous, with a number of patients who will maintain stable conditions and others who will suffer a worsening which will eventually influence timing of surgery and post-operative outcome [30]. To partially overcome this limitation, we stratified patients according to their preoperative GCS (Table 2), with no substantial difference among surgical timing groups. This reinforces the concept that clinical/radiological findings are critical in determining outcome and that we should avoid to wait to operate until patients get to a critical condition. Indeed, it is not the intention of the present study to convey the message to delay surgery in critical cases. This series depicts our real world practice, where critical patients more often underwent ultra-early surgery.

Moreover, the low number of patients in each group may have limited the statistical power preventing some variables as GCS and ASDH thickness to reach a significance.

Also, due to the retrospective multicentric nature of the study, post-operative management was not set according to a standard protocol as any participant Center may have customized some details. These could have concurred in influencing outcomes. However, all the Centers followed standard clinical practice and guidelines in terms of ICP and blood pressure management, as in terms of VTE and seizures prophylaxis. Therefore we believe that post-operative management could have only marginally influenced outcomes in the present series.

A prospective trial where patients with similar preoperative clinical and radiological characteristics, for whom different timing of surgery could be appropriate, would be randomized among different surgical timing groups and following the same post-operative management, could further clarify the influence of surgical timing on outcomes.

Lastly, we did not take into account the occurrence of concomitant brain contusions in influencing final outcome, even though we did not observe in any case a significant contusion growth needing intervention [31].

5. Conclusions

Our multicentric retrospective analysis of 136 patients   70 years operated for a post-traumatic ASDH in a 3-year period suggests that in this age group the main factors associated to timing of surgery are GCS and radiological findings as ASDH thickness and midline shift, with preoperative midline shift emerging as the only factor associated to survival and functional outcome at multivariate analysis. The timing of surgery did not influence neither survival nor functional outcome. However, critical patients are almost always treated in an ultra-early timing.

Further randomized studies are needed to confirm if timing of surgery is not related to outcome in patients with homogeneous clinical and radiological findings.

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