RESEARCH

The day after intracerebral hemorrhage: platelet mass index as predictor of survival—a retrospective cohort study

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Abstract

Background Platelets are implicated in the pathophysiology of intracerebral hemorrhage (ICH). Platelet count (PLT) is affected by platelet loss, while mean platelet volume (MPV) by platelet replenishment. Whether platelet mass index (PMI), the product of PLT and MPV, might predict survival after ICH, remains unknown.

Methods All first-ever ICH patients, admitted to Xanthi General Hospital between January 2018 and May 2020 and met eligibility criteria, were enrolled in this retrospective cohort study. Demographics, medical record, first-symptom-to-admission time, vital signs, modified Rankin Scale, ICH score, arterial blood gas test, complete blood count, blood biochemistry, and CT scan test were collected for each patient. PMI values on day 1 (admission; PMI_1), day 2 (PMI_2), and day 7 (PMI_7), along with PLT, MPV, platelet distribution width (PDW), and platelet large cell ratio (P-LCR), were evaluated as potential predictors of 12-month survival using Repeated Measures General Linear Model. Binary discretization of predictors was based on optimal scaling and evaluated using binary regression.

Results From 59 patients enrolled (aged 75.7 ± 12.0 years; 31 females), 29 were still alive 12 months after ICH. Age, arterial hypertension, diabetes mellitus, hemoglobin level (Hb), and oxygen saturation (O_2Sat) were correlated with 12-month survival. After adjustment for these parameters, PMI_1 and PMI_2 were independently correlated with 12-month survival ($P = 0.048$ and $P = 0.004$, respectively), while PMI_7 was not ($P = 0.332$). $PMI_2 \geq 2,400$ fL/μL was best to discriminate survivors from non-survivors (age, arterial hypertension, diabetes mellitus, Hb, and O_2Sat adjusted OR 0.123 with 95% CI: 0.023–0.694; $P = 0.018$).

Conclusions PMI within the first day after admission for ICH might be used as early predictors of survival. Properly designed prospective studies are needed to further evaluate their contribution as such.

Keywords Platelets, Platelet mass index, Intracerebral hemorrhage

Background

Intracerebral hemorrhage (ICH) is a major public health issue causing high rate of mortality as well as disability [1]. ICH is the second commonest subtype of stroke, accounting for 10–20% of all stroke cases [2]. Increased age, male sex, hypertension, diabetes, and high alcohol intake are well-described risk factors for ICH [3, 4]. Anticoagulant and antiplatelet treatment also increase the risk for ICH [5, 6], and platelet count (PLT) might be a true risk factor for anticoagulant-associated ICH [6].

Many scoring systems have been developed for the prediction of outcome in ICH. The ICH score uses Glasgow Coma Scale (GCS), age ≥ 80 years, infratentorial origin of ICH, ICH volume, and presence of intraventricular hemorrhage to assess 30-day mortality [7]. The FUNC score

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incorporates age, GCS, ICH location, ICH volume, and pre-ICH cognitive impairment то predict functional outcome 3 months after ICH [8]. Moreover, single parameters, as low hemoglobin (Hb) level [9], hyperglycemia [10], and increased serum C-reactive protein [11] have also been recognized as potential prognosticators of poor outcome or death in ICH.

It has been demonstrated that PLT was significantly lower in hemorrhagic strokes when compared with controls [12]. PLT on the first day after admission, when considered as scale variable, might be a good predictor of mortality in hemorrhagic stroke [13]. Moreover, PLT has been proposed as an independent predictor of poor outcome at time of discharge in cerebellar hemorrhage [14]. Of note, thrombocytopenia (PLT < $150 \cdot 10^{-9}$/L) itself did not affect functional outcome among ICH independently of antiplatelet treatment [15]. As far as platelet indices are concerned, only scarce evidence regarding their potential role of in ICH is available. Increased (> 13 fL) mean platelet volume (MPV) has been associated with hemorrhagic stroke, when compared to controls; nevertheless, neither MPV nor PLT were associated with outcome prognosis [16]. Platelet mass index (PMI), which is the product of PLT and MPV, has been proposed as predictor of intraventricular hemorrhage in very-low birth-weight newborns [17].

Despite the emerging evidence that platelets are contributing to the risk for ICH, their role remains partly understood. On the other hand, it is known that alterations of PLT and platelet indices including MPV, platelet distribution width (PDW), and platelet large cell ratio (P-LCR; the percentage of platelets with volume > 12 fL) are observed in platelet activation, consumption and replenishment [17].

The present study aimed to investigate whether initial measurements as well as dynamic changes in PMI can be of predictive value regarding 12-month survival after ICH.

Methods
Study design
This retrospective cohort study was conducted at Xanthi General Hospital between January 2018 and May 2020. The study protocol was approved by the Scientific Board of Xanthi General Hospital (Decision No. 103/May 17, 2021). The report was prepared according to the STROBE guidelines [18].

Patients
All consecutive patients, admitted for ICH at Xanthi General Hospital between January 2018 and May 2020, were considered for eligibility. Inclusion criteria were: a) age ≥ 18 years, b) first-ever episode of ICH. Exclusion

criteria were: a) history of previous stroke, b) treatment with anti-rheumatic agents, and c) hospitalization for less than 24 h after admission. The follow-up period for each patient was set to 12 months after the episode of ICH. Follow-up was aided by the use of public insurance records. Demographics, medical record, first-symptom-to-admission time, vital signs, modified Rankin Scale (mRS), ICH score, arterial blood gas test, complete blood count, blood biochemistry, and computed tomography (CT) scan test were collected for each patient. PMI values on day 1 (admission; PMI_1), day 2 (PMI_2), and day 7 (PMI_7), along with PLT, MPV, PDW, and P-LCR values, were evaluated as potential predictors of 12-month survival.

CT scan
The CT scan was used to assess the presence of intraventricular hemorrhage, determine the origin of ICH (Infratentorial or not), and compute the ICH hematoma volume in cm^3 by two separate specialists. In detail, the ½*(*A*)*(*B*)*(*C*) formula was preferred, where *A* represents the greatest diameter on the largest hemorrhage slice in cm, *B* the diameter perpendicular to *A* in cm, and *C* the approximate number of axial slices with hemorrhage multiplied by 0.5 cm, namely the slice thickness [7].

Statistical analysis
To compare scale as well as nominal variables between different outcomes, Student's t-test and Chi-square test were used respectively. However, regarding the latter, the Fisher exact test was alternatively used in cases that expected frequencies were ≤ 5 in ≥ 25% of cells. Correlations were assessed using the Pearson's parametric correlation coefficient.

The repeated measures General Linear Model was used for analysis of within-subject and between-subject variance of the same variable measured more than once in each patient.

Optimal cut-offs were determined by transformation of scale variables to binary ones through optimal scaling; in detail, discretization to two groups, regularization using ridge regression, and tenfold cross-validation were performed through SPSS CATREG procedure.

To explore the potential value of PMI_2 to predict outcome as binary variable independently of age, diabetes mellitus, hypertension, Hb, and sPO_2, multivariate analysis was performed using binary regression model (the probability for stepwise entry and removal were set to 0.05 and 0.10, respectively; the classification cut-off was set to 0.5; the maximum number of iterations was set to 20).

Sample sizes were selected to detect less than 20% difference tolerating 0.05 type I error and 0.10 type II error.

For that purpose, the relevant on-line tool freely available at https://www.stat.ubc.ca/~rollin/stats/ssize/n1.html. was used.

Descriptive statistics are provided either as means along with their relevant standard deviations, or percentages, for scale and nominal variables respectively. All reported p values are two-sided. The level of statistical significance was set to $p = 0.05$. All numerical values are given with at least two significant digits. Missing data were excluded. Statistical analysis and visualization of results was performed with the use of IBM SPSS Statistics software, version 26.0, for Windows; MedCalc Version 20.218 (MedCalc Software Ltd; 2023) was used to illustrate forest plots.

Results

Fifty-nine patients (31 women), aged 75.7 ± 12.0 years, were enrolled. Twenty-nine were still alive 12 months after ICH. As far as non-survivors are concerned, 28/30 (93.3%) succumbed within the first 30 days after ICH. In detail, the leading causes of death were arrhythmia (11/30; 36.7%), infection/sepsis (8/30; 26.7%), and cardiovascular disease (7/30; 23.3%), followed by respiratory failure (2/30; 6.7%) and recurrent hemorrhage (2/30; 6.7%). A flow diagram is provided as Fig. 1.

Characteristics of patients and detailed comparisons between 12-month survivors and non-survivors are presented in Table 1. Of note, 4/59 patients (6.8%) presented thrombocytopenia due to infection/sepsis (1 case), liver cirrhosis (1 case), myelodysplastic syndrome (1 case), and bone marrow infiltration from metastatic lung cancer (1 case)". No patient received platelets, fresh frozen plasma, or any other treatment for thrombocytopenia.

Univariate analysis demonstrated that younger age ($P = 0.001$), absence of diabetes mellitus ($P = 0.013$), absence of arterial hypertension ($P = 0.019$), elevated Hb ($P = 0.019$), elevated glucose ($P = 0.021$), and increased sPO_2 at admission ($P = 0.023$) were correlated with survival (Table 1). Moreover, increased PMI_2 ($P = 0.020$) and PLT at day 2 ($P = 0.017$) were correlated with survival (Table 2).

Aiming to elucidate whether PMI values might be used as early predictors of survival, repeated measures General Linear Model was used. In that model, PMI_1 and PMI_2 were independently correlated with survival ($P = 0.048$ and $P = 0.004$, respectively), while PMI_7 was not ($P = 0.332$), after adjustment for age, diabetes mellitus, arterial hypertension, Hb, and sPO_2 at admission (Table 2, Fig. 2). Glucose was initially excluded from
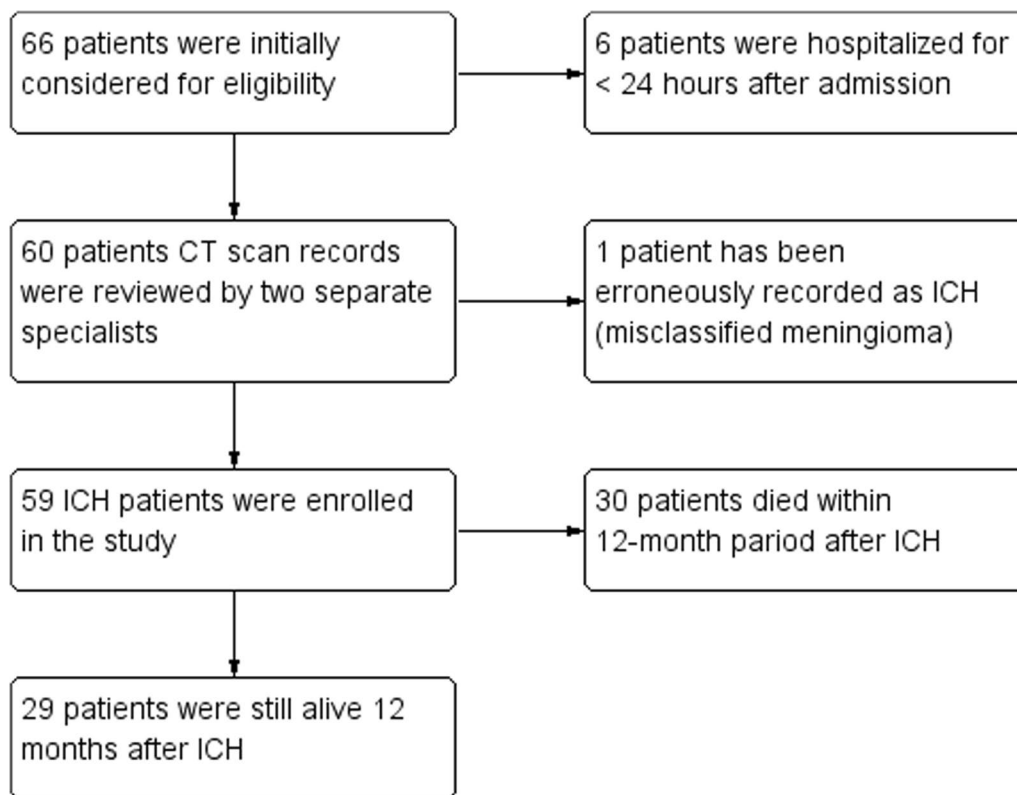

Fig. 1 Flow diagram of the study

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Table 1 Patients' characteristics and univariate analysis based on 12-month survival status

Parameters	Mean ± SD[†]; N (%)[‡]	12-month survival		P
		Yes (n = 29)	No (n = 30)	
Gender				
Males	28 (47.5)	13 (44.8)	15 (50.0)	0.691
Females	31 (52.5)	16 (55.2)	15 (50.0)	
Age (years)				
Mean ± SD	75.7 ± 12.0	70.6 ± 11.4	80.7 ± 10.5	0.001
Arterial hypertension				
Yes	42 (69.5)	16 (55.2)	25 (83.3)	0.019
No	18 (30.5)	13 (44.8)	5 (16.7)	
CAD				
Yes	8 (13.6)	3 (10.3)	5 (16.7)	0.478
No	51 (86.4)	26 (89.7)	25 (83.3)	
Diabetes mellitus				
Yes	9 (15.3)	1 (3.4)	8 (26.7)	0.026[¶]
No	50 (84.7)	28 (96.6)	22 (73.3)	
Dyslipidemia				
Yes	23 (39.0)	9 (31.0)	14 (46.7)	0.288
No	36 (61.0)	20 (69.0)	16 (53.3)	
Antiplatelets				
Yes	14 (23.7)	7 (24.1)	7 (23.3)	0.942
No	45 (76.3)	22 (75.9)	23 (76.7)	
Anticoagulants				
Yes	7 (11.9)	3 (10.3)	4 (13.3)	1.000[¶]
No	52 (88.1)	26 (89.7)	26 (86.7)	
Admission time (h)				
Mean ± SD	13.6 ± 33.8	14.0 ± 35.0	13.3 ± 33.1	0.931
Hemoglobin (g/dL)				
Mean ± SD	13.3 ± 1.4	13.7 ± 1.1	12.8 ± 1.5	0.019
Glucose (mg/dL)				
Mean ± SD	124 ± 46	110 ± 25	138 ± 57	0.021
Potassium (mmol/L)				
Mean ± SD	3.97 ± 0.55	4.02 ± 0.49	3.93 ± 0.60	0.530
Sodium (mmol/L)				
Mean ± SD	141 ± 3	141 ± 4	141 ± 3	0.552
BUN (mg/dL)				
Mean ± SD	42.6 ± 27.0	42.7 ± 33.7	42.5 ± 19.1	0.971
Creatinine (mg/dL)				
Mean ± SD	0.97 ± 0.92	1.03 ± 1.17	0.91 ± 0.60	0.531
AST (IU/dL)				
Mean ± SD	21.2 ± 11.6	21.0 ± 11.6	21.4 ± 12.1	0.906
ALT (IU/dL)				
Mean ± SD	16.6 ± 12.5	19.1 ± 17.1	14.3 ± 5.8	0.151
pH				
Mean ± SD	7.40 ± 0.07	7.41 ± 0.06	7.40 ± 0.08	0.744
sPO$_2$ (%)				
Mean ± SD	95.0 ± 2.9	95.9 ± 1.5	94.2 ± 3.6	0.023
Bicarbonates (mmol/L)				
Mean ± SD	23.2 ± 3.5	23.0 ± 3.3	23.3 ± 3.7	0.763
Lactates (mmol/L)				

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Table 1 (continued)

Parameters	Mean ± SD[†]; N (%)[‡]	12-month survival		P
		Yes (n = 29)	No (n = 30)	
Mean ± SD	1.85 ± 1.32	1.72 ± 1.53	1.97 ± 1.09	0.457
CRP (mg/dL)				
Mean ± SD	1.43 ± 1.54	1.15 ± 1.55	1.71 ± 1.50	0.168
Temperature (°C)				
Mean ± SD	36.2 ± 0.4	36.1 ± 0.3	36.2 ± 0.5	0.549
SBP (mmHg)				
Mean ± SD	171 ± 30	173 ± 31	168 ± 28	0.483
DBP (mmHg)				
Mean ± SD	94.3 ± 14.4	94.1 ± 15.3	94.4 ± 13.8	0.931
Pulse rate (min^{-1})				
Mean ± SD	86.8 ± 16.7	83.9 ± 16.8	89.5 ± 16.3	0.199
Hemorrhage volume (hematoma size) (cm^3)				
Mean ± SD	25.1 ± 39.2	19.8 ± 18.0	30.3 ± 52.0	0.303
Intraventricular hemorrhage				
Yes	17 (28.8)	8 (27.6)	9 (30.0)	0.838
No	42 (71.2)	21 (72.4)	21 (70.0)	
Infratentorial origin				
Yes	5 (8.5)	1 (3.4)	4 (13.3)	0.353[¶]
No	54 (91.5)	28 (96.6)	26 (86.7)	
mRS				
Mean ± SD	3.69 ± 1.12	3.17 ± 0.93	4.20 ± 1.06	< 0.001
ICH score				
Mean ± SD	1.95 ± 1.25	1.31 ± 0.89	2.57 ± 1.25	< 0.001
Thrombocytopenia				
Yes	4 (6.8)	1 (3.4)	3 (10.0)	0.612[¶]
No	55 (93.3)	28 (96.6)	27 (90.0)	
Fresh Frozen Plasma				
Yes	0 (0.0)	0 (0.0)	0 (0.0)	ND
No	59 (100.0)	29 (100.0)	30 (100.0)	
Platelet transfusion				
Yes	0 (0.0)	0 (0.0)	0 (0.0)	ND
No	59 (100.0)	29 (100.0)	30 (100.0)	

Bold vaues correspond to statistcally significant *p*-values

SD Standard Deviation, *ND* not determined

[†] For scale variables

[‡] For nominal variables

[¶] Fisher exact test

adjustment due to collinearity issues attributed to diabetes mellitus.

To further investigate the contribution of additional potential confounders to within-samples variability concerning the consecutive measurements of PLT and PMI, Repeated Measures GLM multivariate models based on 12-month survival status adjusted for age, diabetes, hypertension, Hb, and sPO$_2$ were performed (Table 3). These models suggested that hyperlipidemia, glucose, lactates, and temperature, but not gender, history of

coronary artery disease (CAD), antiplatelets, and anticoagulants, might constitute true confounders. PMI$_2$ were still independently correlated with survival (P = 0.012) after adjustment for these additional confounders (Table 2).

Binary discretization of PMI$_2$, after adjustment for age, diabetes mellitus, arterial hypertension, Hb, and sPO$_2$ at admission, suggested 2,400 fL/µL as cut-off (Fig. 3). Using binary regression, PMI$_2 \geq$ 2,400 fL/µL was independently correlated with survival (OR

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Table 2 Platelet number and indices (measured at admission, day 2, and day 7), as well as univariate and multivariate analysis based on 12-month survival status

Parameters	Mean ± SD†; N (%)‡	12-month survival		P-value	P-value (Adjusted)¶	P-value (Adjusted)§
		Yes (n = 29)	No (n = 30)			
PMI (fL/mL)						
Admission	2.36 ± 0.77	2.47 ± 0.90	2.25 ± 0.62	0.279	**0.048**	0.071
Day 2	2.40 ± 0.67	2.61 ± 0.65	2.18 ± 0.63	**0.020**	**0.004**	**0.006**
Day 7	3.00 ± 0.90	3.06 ± 0.83	2.93 ± 1.00	0.636	0.332	0.367
PLT (10^9/L)						
Admission	222 ± 75	234 ± 87	211 ± 60	0.231	0.069	0.105
Day 2	223 ± 65	243 ± 62	202 ± 61	**0.017**	**0.008**	**0.012**
Day 7	274 ± 94	277 ± 90	271 ± 100	0.819	0.460	0.580
MPV (fL)						
Admission	10.7 ± 1.0	10.6 ± 0.9	10.8 ± 1.0	0.657	0.713	0.811
Day 2	10.8 ± 1.0	10.6 ± 0.9	10.9 ± 1.0	0.184	0.692	0.782
Day 7	11.0 ± 1.0	11.0 ± 1.0	11.0 ± 1.1	0.975	0.800	0.850
PDW (fL)						
Admission	13.2 ± 2.5	13.0 ± 2.6	13.3 ± 2.4	0.734	0.606	0.692
Day 2	13.2 ± 2.2	12.8 ± 1.9	13.6 ± 2.3	0.166	0.550	0.597
Day 7	13.6 ± 2.3	13.3 ± 1.7	13.9 ± 2.8	0.385	0.497	0.725
P-LCR (%)						
Admission	30.6 ± 8.0	29.9 ± 7.7	31.2 ± 8.3	0.538	0.720	0.820
Day 2	31.3 ± 7.6	29.8 ± 7.1	32.8 ± 8.0	0.166	0.661	0.760
Day 7	32.0 ± 7.3	31.4 ± 6.5	32.7 ± 8.4	0.548	0.741	0.935

Bold vaues correspond to statistcally significant *p*-values

SD Standard Deviation

† For scale variables

‡ For nominal variables

¶ For age, diabetes, hypertension, Hb, and sPO_2 using Repeated Measures GLM

§ For age, diabetes, hypertension, dyslipidemia, Hb, glucose, sPO_2, lactates, and temperature, using Repeated Measures GLM

0.123; 95% CI: 0.022–0.694; P = 0.018), after adjustment for age (OR 1.872 per decade; 95% CI: 0.959–3.655; P = 0.066), diabetes mellitus (OR 3.527; 95% CI: 0.231–53.910; P = 0.365), arterial hypertension (OR 9.837; 95% CI: 1.318–73.426; P = 0.026), Hb (OR 0.395 per g/dL; 95% CI: 0.187–0.834; P = 0.015), and sPO_2 at admission (OR 0.664 per %; 95% CI: 0.434–1.016; P = 0.059) (Fig. 4).

PLT values, when measured at day 2, were also independently correlated with survival (P = 0.017); however, PLT values, when measured at admission and day 7, failed to demonstrate prognostic value (P = 0.069 and P = 0.460, respectively). Moreover, MPV, PDW, and P-LCR had no prognostic value (Table 2).

Of note, PLT_2 (r = − 0.312; P = 0.022), and PMI_2 (r = − 0.285; P = 0.038) were negatively correlated with mRS. Moreover, these parameters presented a weaker, yet significant negative correlation with ICH score (PLT_2: r = − 0.278; P = 0.042), and PMI_2: r = − 0.275; P = 0.046) (Fig. 5A–D).

Discussion

Our study has demonstrated that increased PMI_1, PMI_2, and PLT_2 values were correlated with 12-month survival after first-ever episode of ICH independently of age, diabetes mellitus, arterial hypertension, hemoglobin level, and sPO_2 at admission. PMI proved to be earlier and stronger prognosticator. The most accurate binary predictive model was based on PMI_2, using ≥ 2,360 fL/mL as cutoff. To the best of our knowledge, this is the first time that PMI has been studied, in parallel with PLT and platelet indices, at three different time-points during hospitalization (admission, day 2, and day 7), as potential predictors of 12-month survival after ICH. In detail, increased PMI at both admission and day 2 characterize survivors.
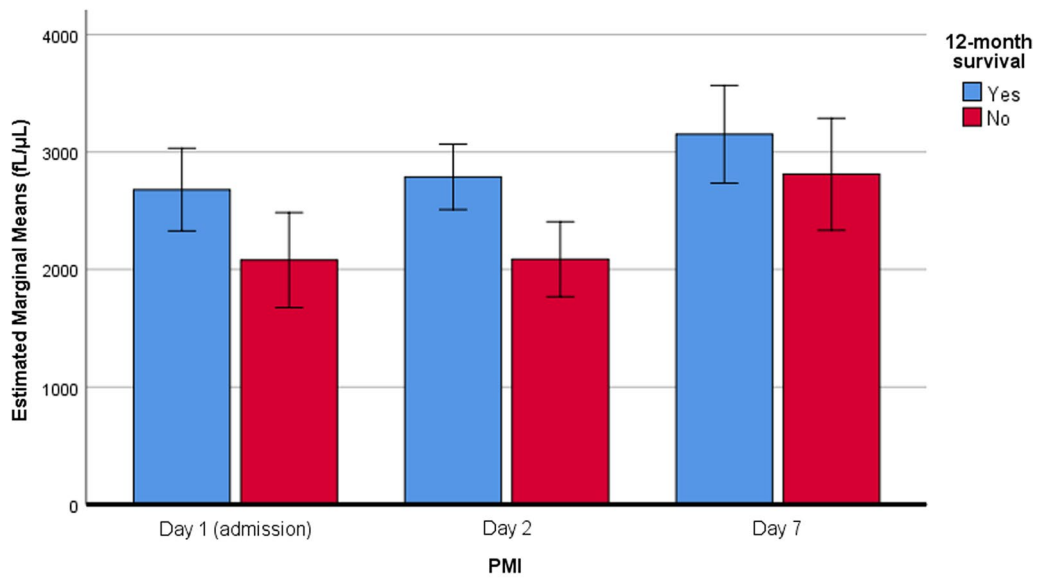
Fig. 2 Estimated Marginal Means of 12-month survival at mean of covariates (age, hypertension, diabetes, Hb, and sPO_2) for PMI_1 (day 1; admission), PMI_2 (day 2), and PMI_7 (day 7) using Repeated Measures General Linear Model

Table 3 PLT and PMI (measured at admission, day 2, and day 7) multivariate analysis based on 12-month survival status additionally adjusted for age, diabetes, hypertension, Hb, and sPO_2 using Repeated Measures GLM: Contribution of potential confounders to within-samples variability

Parameters	PLT			PMI		
	Admission	Day 2	Day 7	Admission	Day 2	Day 7
Gender	0.071	0.244	0.314	0.069	0.251	0.311
CAD	0.905	0.546	0.770	0.694	0.416	0.582
Dyslipidemia	0.399	**0.033**	0.219	0.383	**0.030**	0.192
Antiplatelets	0.639	0.445	0.609	0.489	0.402	0.451
Anticoagulants	0.297	0.253	0.534	0.275	0.172	0.120
Admission time	0.323	0.974	0.476	0.350	0.953	0.855
Glucose	**0.016**	**0.031**	**0.003**	**0.017**	**0.018**	**0.005**
Potassium	0.957	0.954	0.136	0.915	0.883	0.132
Sodium	0.519	0.860	0.574	0.429	0.967	0.395
BUN	0.487	0.388	0.550	0.605	0.762	0.642
Creatinine	0.169	0.099	0.163	0.250	0.257	0.190
pH	0.399	0.764	0.110	0.664	0.889	0.098
Bicarbonates	0.674	0.739	0.793	0.559	0.521	0.797
Lactates	**0.030**	**0.049**	0.323	**0.022**	0.068	0.440
CRP	0.205	0.655	0.508	0.215	0.567	0.492
Temperature	0.205	**0.021**	0.309	0.338	0.058	0.751
SBP	0.757	0.802	0.470	0.996	0.454	0.647
DBP	0.583	0.842	0.363	0.729	0.874	0.513
Pulse rate	0.989	0.201	0.907	0.917	0.132	0.741

Bold vaues correspond to statistcally significant *p*-values
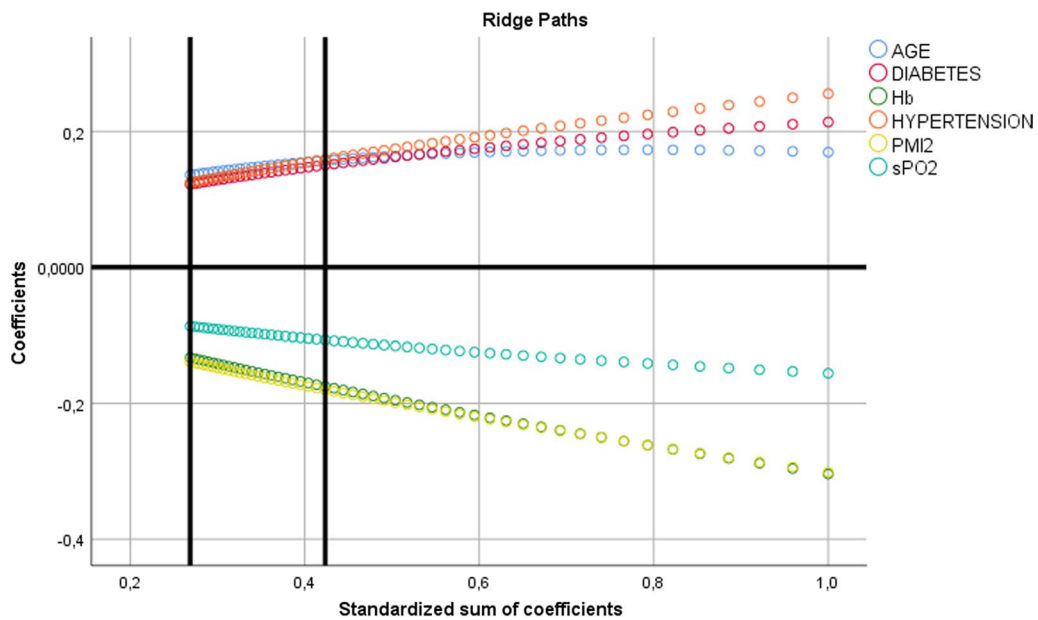
Fig. 3 Ridge paths determining the best cut-off for PMI_2 (2,400 fL/µL)
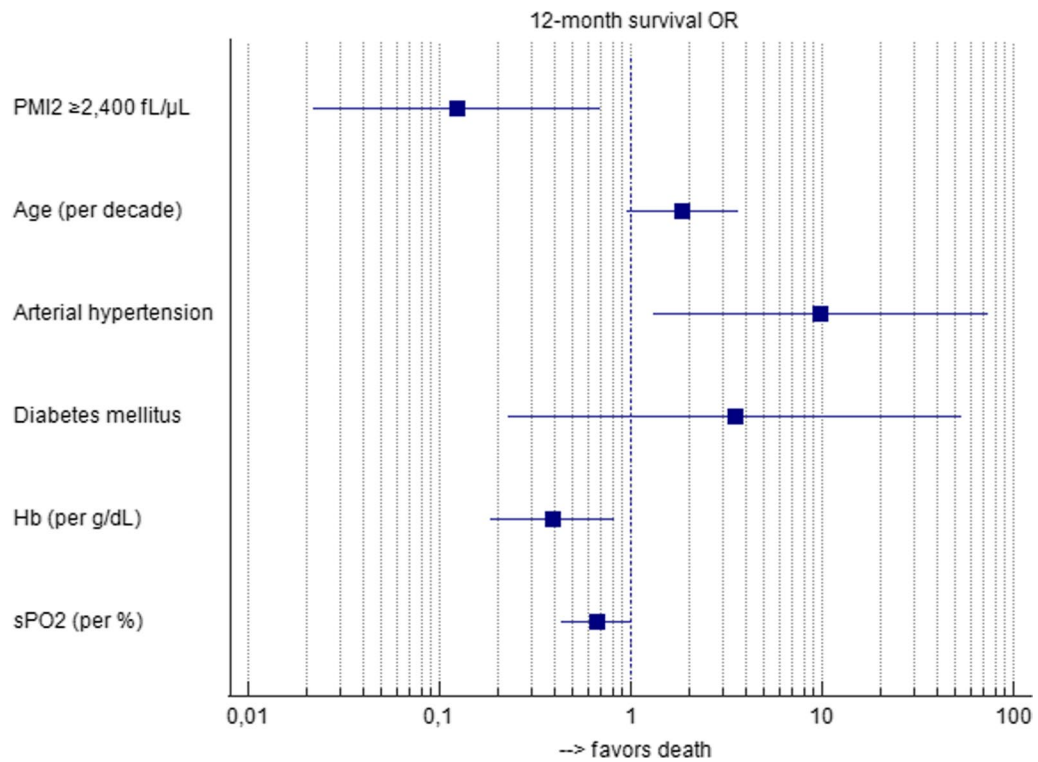
Fig. 4 Forest plot depicting binary regression model for $PLT_2 \geq 2,400$ fL/µL; OR < 1 favors 12-month survival
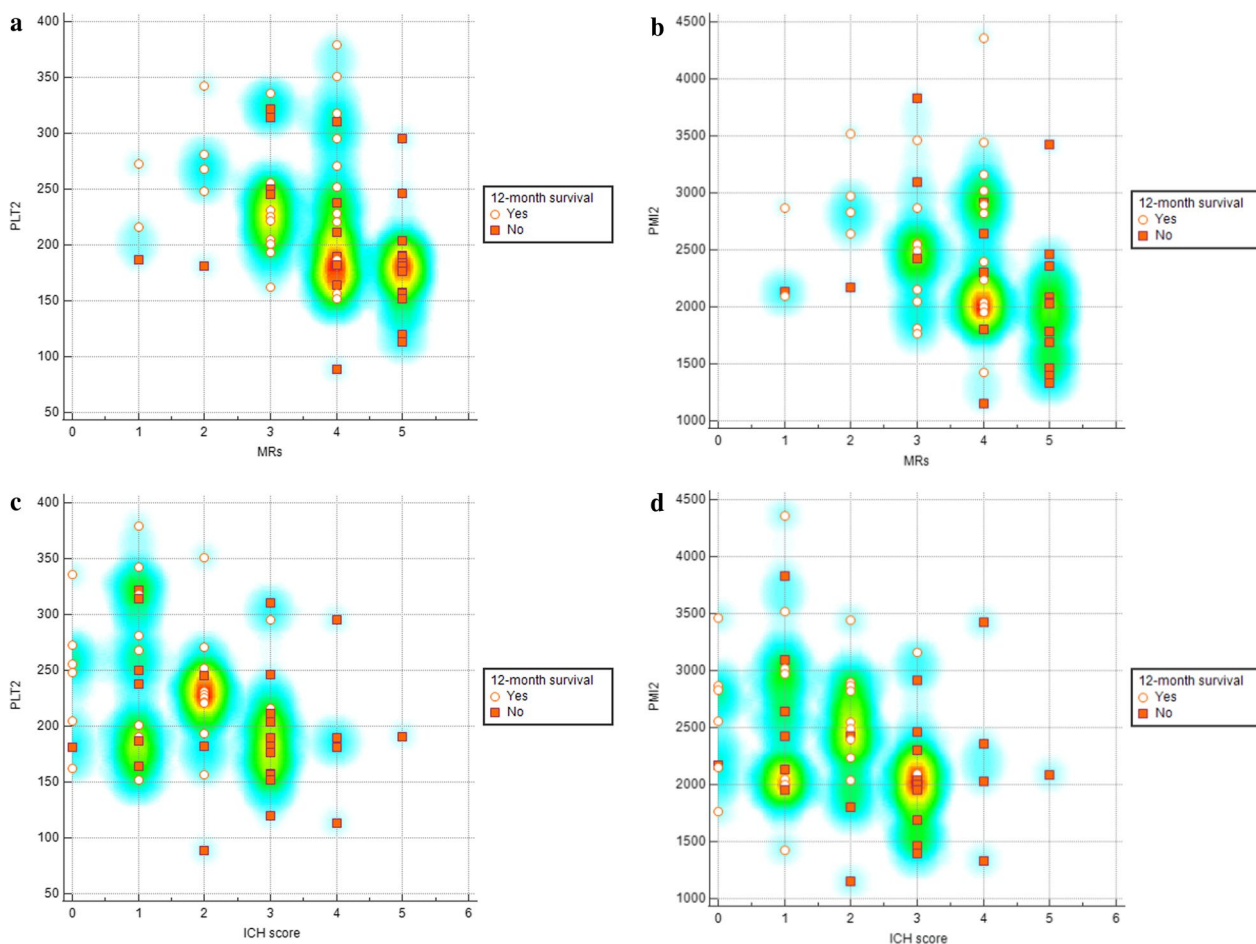
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Fig. 5 Scatterplots depicting correlations between **A** PLT_2 with MRs (left column; upper row), **B** PMI_2 with MRs (right column; upper row), **C** PLT_2 with ICH score (left column; lower row), and **D** PMI_2 with ICH score (right column; lower row)

Interestingly, the use of both PLT_2 and PMI_2 as prognosticators of outcome is in keeping with well-established and widely used clinical scores, namely the mRS and the ICH score.

Lower PLT is a known risk factor for ICH, while even lower PLT_2 values in non-survivors reflect platelet consumption [12, 13]. Moreover, it has been proposed that platelet consumption and hyperreactivity coexist in animal models of experimental traumatic hemorrhage [19]. ICH, as a clinical analogue of these models in humans, is accompanied by platelet hyperdestruction, followed by immediate onset of reactive megacaryopoiesis, and production of young, large, and reactive platelets; the younger the replenished platelets, the bigger and more reactive they are [20]. This is in keeping with increased PMI values, a phenomenon that is more pronounced at day 2 and wanes at day 7. In fact, PMI has been introduced as a composite marker to simultaneously assess platelet destruction (attributed to PLT) and replenishment (attributed to MPV). The present study proposed that the larger their value, the better prognosis an ICH patient has for 12-month surviving.

There is evidence suggesting that increased platelet number and reactivity, as reflected mainly by increased MPV and PLT, and thus PMI, shares a strong genetic component influencing variation in platelet reaction at the site of vessel wall injury [21]. Platelet reactivity might be further perplexed by ICH-induced post-traumatic vasospasm, occurring mainly in cases of intraventricular hemorrhage [22]. Moreover, emerging megakaryopoiesis and thrombopoiesis during the ICH acute phase may alter the bone marrow environment affecting the molecular signature of platelets and other cellular compartments [23, 24]. The effect of these alterations on injured brain tissue, locally and/or systematically, is largely unknown and thus remains to be elucidated.

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The well-defined limitations of a retrospective cohort study, such as the absence of data on potential confounding factors and the difficulty to identify study and control groups, remain a concern; the present study lacks credible data concerning smoking habits and alcohol consumption, though not decisive for the quality of the analysis. On the other hand, PLT and platelet indices are immediate and inexpensive parameters that are widely available in almost any health setting.

Conclusions

As a conclusion, PMI values at admission and second day of hospitalization might be used as early predictors of survival in ICH, rendering the measurement of PLT, and MPV a valuable and inexpensive tool. Properly designed prospective studies are needed to further evaluate their contribution as such.

Abbreviations

ICH	Intracerebral hemorrhage
PLT	Platelet count
MPV	Mean platelet volume
PMI	Platelet mass index
PDW	Platelet distribution width
P-LCR	Platelet large cell ratio
Hb	Hemoglobin level
O_2Sat	Oxygen saturation
GCS	Glasgow Coma Scale
mRS	Modified Rankin Scale
CT	Computed tomography
CAD	Coronary artery disease

Author contributions
DA collected, analyzed, and interpreted the patients' data and prepared the manuscript; RG reviewed CT scans and prepared the manuscript, AS reviewed CT scans and prepared the manuscript, VP conceived the protocol, performed the statistical analysis, prepared the manuscript, and supervised the study. All authors read and approved the final manuscript.

Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The study protocol was approved by the Scientific Board of Xanthi General Hospital (Decision No. 103/May 17, 2021).

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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