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Extra-axial hematomas due to road traffic accidents and their outcome: a ten-year study

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Abstract. – OBJECTIVE: The main objectives of this study were to describe the epidemiological characteristics, the associated factors and outcomes of extra-axial hematoma (EAH) in patients of traumatic brain injury (TBI) due to road traffic accident (RTA) and to assess their survival probability after 6 and 12 months to RTA.

PATIENTS AND METHODS: This was a retrospective record-based study. A total of 520 patients diagnosed with EAH due to RTA-related TBI were studied. This study covered ten years from January 1, 2010, to December 31, 2019. Descriptive statistics, including frequencies, percentages, mean, standard deviation, median and range were used. To test for significance in the difference between proportions, a chi-square test was applied and adjusted standardized residual to confirm the differences between groups. The Kaplan-Meier curve was plotted, and mean survival rates were calculated for each type of EAH. A two-sided p-value less than 0.05 (5%) at 95% CI was considered to be statistically significant.

RESULTS: EAH occurred in 42.1% of RTA-related TBI. Subdural hematoma (SDH) was the most common RTA-related EAH. Age and sex differences exist in the type of EAH with male preponderance and a significantly higher rate of SDH in patients aged 55 years or above. The total EHA mortality was 18.7%, and most occurred within the first month of the incident. Traumatic subarachnoid hemorrhage (tSAH) was associated with poorer outcome in terms of mortality. Epidural hematoma (EDH) has the best prognosis and survival probability at six months and one year from the accident.

CONCLUSIONS: Extra-axial hematomas are very common in RTA-related TBIs and have high mortality. SDH is the most common, tSAH had the highest mortality, while EDH has the best survival. Aggressive efforts are compulsory to reduce RTA-related TBI.

Key Words:

Traffic accident, Brain injury, EDH, SDH, SAH, Survival.

Introduction

Injury is the primary cause of disability and fatality in Saudi Arabia (SA)[1]. The majority of injury-related fatalities are caused by road traffic accidents (RTAs)[1,2]. RTA-related injuries therefore are a national health problem in SA, yet the relevant research is severely deficient[2].

Furthermore, traumatic brain injury (TBI) is among the foremost serious RTA related injuries and a minimum of one-third of all injury-related deaths have TBI[3]. Though RTA is known leading source of TBI worldwide, studies on RTA-related TBI are scarce, especially in developing countries[2]. Additionally, since RTA is the foremost reason for TBI globally, an in-depth analysis of its resulting injuries is important for a far better understanding of the disease, better prevention, and superior treatment programs.

Among TBI victims, intracranial hemorrhage is common and often causes serious medical emergency involving critical management decisions[4]. Traumatic intracranial hemorrhage or hematoma refers to any bleeding within the intracranial vault and is classified into an intra-axial and extra-axial hemorrhage. Extra-axial hemorrhage (EAH) is further categorized into extradural (EDH), subdural (SDH), and subarachnoid hemorrhage (SAH). Among TBI lesions, EAH is one of the most lethal owing to its consequences of severe increases in intracranial pressure (ICP), secondary brain injuries, herniation, and death[4,5].

Although RTA is a primary cause of TBI, with EAH representing primary lethal TBI lesions, the literature describing RTA-related EAH is deficient. The epidemiologic and outcome data on TBI from several mechanisms cannot be generalized to TBI caused by specific trauma mechanism, such as RTA. Studies[6,7] have revealed that the prevalence, multiplicity, and pattern of intracranial lesions are distinct in traffic-related TBI

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from non-traffic-related TBI. Furthermore, data reflecting local epidemiologic details of RTA-related TBI are essential for health care planning and public policy. Information on rates of EAHs, their risk factors, mortality, survival data and other short-term outcomes like intensive care unit (ICU) admission rates and length of hospital treatment may guide clinicians for better patient management and aid public health professionals to design proper interventions.

The current study aims to describe the RTA-related traumatic extra-axial hemorrhages of a tertiary care hospital-based trauma registry in Aseer, southwest Saudi Arabia, from the past decade in terms of epidemiological features, outcomes, mortality, and survival statistics. The results from this study will provide helpful information on RTA-related injuries and help fill the knowledge gap on TBI-related EAH due to RTA.

Patients and Methods

We used the Aseer Hospital register for road traffic injuries for retrospective identification of the entire 1235 (among them, 520 patients admitted with the diagnosis of EAH) patients admitted with traumatic brain injury sustained in road traffic accidents. The study covered the ten-years period between the 1st of January 2010, and the 31st of December 2019. The collected data were examined for completeness, consistency and accuracy. The SPSS statistical package (version 23, IBM, Armonk, NY, USA) was used for statistical analysis of the tested data. Patients diagnosed with any type of acute extra-axial hemorrhage (EDH, SDH, SAH) or any combination of these types were selected from the RTA-related TBI cases. These combinations created seven groups of EAH: EDH, SDH, SAH, EDH+SDH, EDH+SAH, SDH+SAH, and EDH+SDH+SAH. After analysing the descriptive data of the seven groups of EAHs, the cases with more than one type of extra-axial bleed were labelled as complex EAH for additional statistical analysis. Furthermore, the EAHs were correspondingly classified according to the number of different hematomas per patient (1, 2, or 3 subtypes).

In addition, the medical records were assessed to determine patient demographic data, like age, sex, ICU admission rates, the duration of hospital treatment, discharge status, and mortality. Age was dichotomized into less than 55 and 55 years or more. Descriptive statistics included frequencies, percentages, mean, standard deviation, median, and range. The duration of hospital treatment was ordered by the time spent for treatment as up to a month and more than one month. To test the significance of the difference between proportions, the chi-square test was applied. Post-hoc analysis was run to confirm where the differences occurred among the studied groups utilizing adjusted standardized residual. A two-sided *p*-value less than 0.05 was considered statistically significant. Survival analysis was conducted to measure survival probability in the different groups of EAH at one month and maximum duration of hospital treatment (approximately one year). The Kaplan-Meier curve was plotted, and mean survival rates were calculated for each hematoma type. Approval of this research work was obtained from the Research Ethics Committee of King Khalid University. The informed consent was waived because the analysis was done on de-identified patient data.

Results

Extra-axial hematoma occurred in 42.1% of RTA-related traumatic brain injuries. The demographic data for these 520 patients with EAH have been presented in Table I. From the total population of 1235 RTA-related TBIs, 183 (14.82%) had SDH, 167 (13.53%) had EDH, and 97 (7.86%) had SAH. The total number of incidents for each EAH type in isolation or as part of a complex EAH was SDH in 247 (47.5%), EDH in 202 (38.84%), and SAH in 107 (20.5%) of all EAH cases. Complex EAH (i.e., more than one type of EAH in different combinations) constituted 14.04% of EAH. Thus, most patients suffered a single type of EAH (85.96%).

The mean age of patients suffering RTA-related EAH was 28.67±17.99 years with an age range of 0-86 years. The distribution by the patient's age of different groups of EAH shows SDH, SAH, and their combined groups to have more cases above the median age (as shown in Figure 1). Older patients (outliers) are more in SDH, SAH, and the combined group (SDH+SAH).

The association of EAH with different socio-demographic characteristics of patients and the disease outcome was analyzed using the Chi-square test (as shown in Table II). Age, sex, extra-cranial injury, ICU admission, discharge status, and mortality were significantly associated with the different types of EAH. We confirmed

Table I. Demographic data for patients with extra-axial hematoma.

EAH	Total	% of EAH	% of total TBI population	Mean age in years	Range
Isolated EDH	167	32.11	13.53	22.5 ±11.1	0-60
Isolated SDH	183	35.19	14.82	32.5±21.35	0-86
Isolated SAH	97	18.65	7.86	31.0±18.84	0-80
EDH+SDH	25	4.8	2.02	28.3±13.58	13-74
SDH+SAH	38	7.3	3.07	32.1±20.16	0-80
EDH+SAH	9	1.7	0.72	26.8±11.26	16-49
EDH+SDH+SAH	1	0.19	0.08	—	—
Total	520	100	42.10	28.67±17.99	0-86
Number of EAH types					
1 type	447	85.96	36.19	28.1±18.15	0-86
2 types	72	13.8	5.80	30.19±17.12	0-80
3 types	1	0.19	0.08	—	—
Total incidents of each EAH type					
EDH	202	38.84	16.35		
SDH	247	47.5	20.0		
SAH	107	20.5	8.66		

EAH: extra-axial hematoma, TBI: traumatic brain injury, EDH: epidural hematoma, SDH: subdural hematoma, SAH: subarachnoid hemorrhage.

the significant group using Pearson's standardized residuals. Age was dichotomized into two groups for analyzing the effect of older age, and it was found that SDH was significantly more common in the older age group (p<0.001). SDH is also significantly more frequent in males. Cranial fractures were present in more than one-third of complex EAHs and one-fourth of EDH cases, however, with no significant differences between the groups. The need for ICU and mortality were

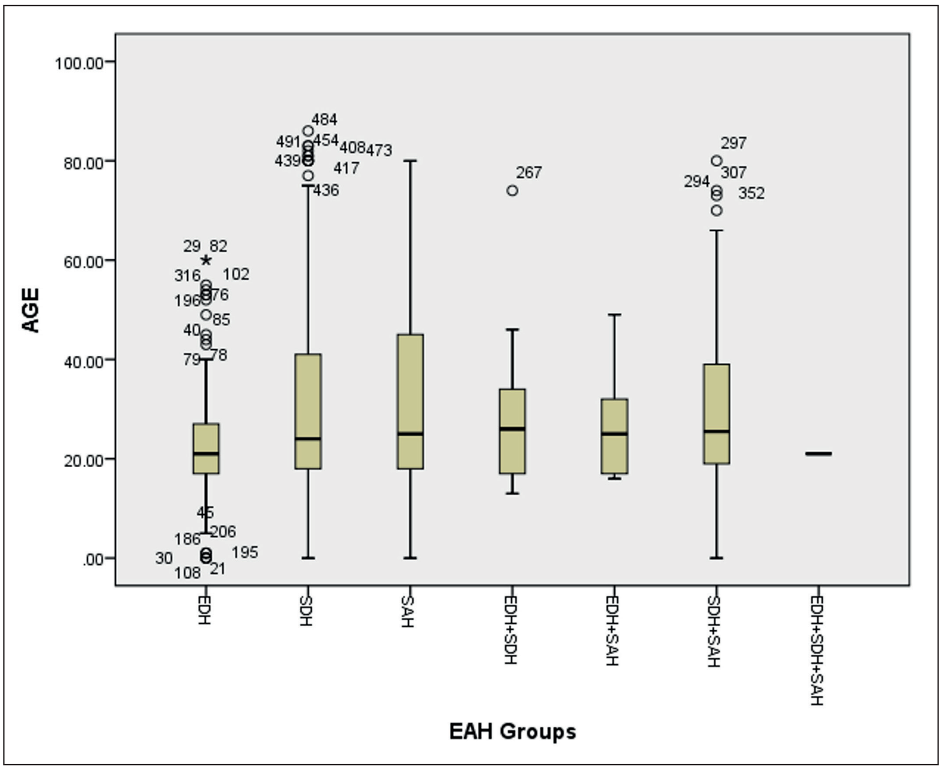

Figure 1. Box plot of age of patients with extra-axial hematoma. EAH: extra-axial hematoma, EDH: epidural hematoma, SDH: subdural hematoma, SAH: subarachnoid hemorrhage.

Table II. Logistic regression analysis for probable independent associated factors with mortality as dependent prognostic factor.

Variables	Type of EAH					χ^2	*p*-value
	EDH	SDH	SAH	Complex	Total		
Age							
<55	164 (98.2)	148 (80.9)	81 (83.5)	66 (90.4)	459 (88.3)	28.03	<0.001*
≥55	3 (1.8)	35 (19.1)*	16 (16.5)	7 (9.6)	61 (11.7)		
Sex							
Male	151 (90.4)	177 (96.7)*	86 (88.7)	71 (97.3)	485 (93.3)	10.77	0.013*
Female	16 (9.6)	6 (3.3)	11 (11.3)	2 (2.7)	35 (6.7)		
Skull fracture							
No	125 (74.9)	148 (80.9)	76 (78.4)	48 (65.8)	397 (76.3)	7.03	0.071
Yes	42 (25.1)	35 (19.1)	21 (21.6)	25 (34.2)	123 (23.7)		
Extra-cranial injury							
No	97 (58.1)	114 (62.3)	80 (82.5)*	36 (49.3)	327 (62.9)	23.38	<0.001*
Yes	70 (41.9)	69 (37.7)	17 (17.5)	37 (50.7)	193 (37.1)		
Outcomes							
Treatment							
≤ 1 month	141 (84.4)	146 (79.8)	70 (72.2)	53 (72.6)	410 (78.8)	7.52	0.057
>1 month	26 (15.6)	37 (20.2)	27 (27.8)	20 (27.4)	110 (21.2)		
ICU admission							
Required	19 (11.4)	49 (26.8)	64 (66.0)*	52 (71.2)	184 (35.4)	21.86	<0.001*
Not required	148 (88.6)	134 (73.2)	33 (34.0)	21 (28.8)	336 (65.6)		
Discharge status							
Home	152 (91.0)*	140 (76.5)	62 (63.9)	50 (68.5)	404 (77.7)	31.44	<0.001*
Died/Transferred	15 (9.0)	43 (23.5)	35 (36.1)	23 (31.5)	116 (22.3)		
Mortality							
Died	12 (7.2)	34 (18.6)	31 (32)*	20 (27.4)	97 (18.7)	29.46	<0.001*
Alive	155 (92.8)	149 (81.4)	66 (68.0)	53 (72.6)	423 (81.3)		

EAH: extra-axial hematoma, EDH: epidural hematoma, SDH: subdural hematoma, SAH: subarachnoid hemorrhage, Complex: more than one type of EAH.

significantly associated with SAH, while extra-cranial injury was significantly less common in patients with SAH than other types of EAH. A statistically significant association was found between EDH and discharge home. The mortality rate was lowest in EDH (7.2%) and highest in SAH (32%, $p<0.001$). We analyzed the proportion of deaths occurring within one month, which was 87.6%, and was statistically significant (χ^2 =5.51, odds ratio= 2.13, 955 CI=1.12-4.07; $p=0.01$) (data not shown).

Kaplan-Meier estimate was used to compute the survival probability over time for different types of EAH (as shown in Figure 2A and 2B). Patients with EDH fare better with more than 80% survival at one month and six months. Most unsatisfactory rates were for patients with SAH with less than 20% survival probability at six months.

The mean survival time for different types of EAH is presented in Table III. The longest mean survival at one month was found in patients with EDH (26 days) and at one year in SDH (223.55 days). The shortest mean survival at one month was in complex EAH (17 days) and at one year in SAH (112.89 days). As seen in Table III, median survival for EDH is undefined, as survival is greater than 50% at the last time point.

Log-rank test was run to determine if there were differences in the survival distribution for the different types of EAH. The survival distributions for the different kinds of hematoma were significantly different at one month and one year, χ^2 = 19.33 and 17.52, $p<0.05$ (Table IV). Furthermore, post-hoc pairwise comparison by log-rank (Mantel-Cox), Breslow (Generalized Wilcoxon), and Tarone-Ware tests confirmed that as compared to EDH; SDH, SAH, and complex EAH had a significant ($p<0.05$) effect on mortality, (Data has been depicted in Table V).

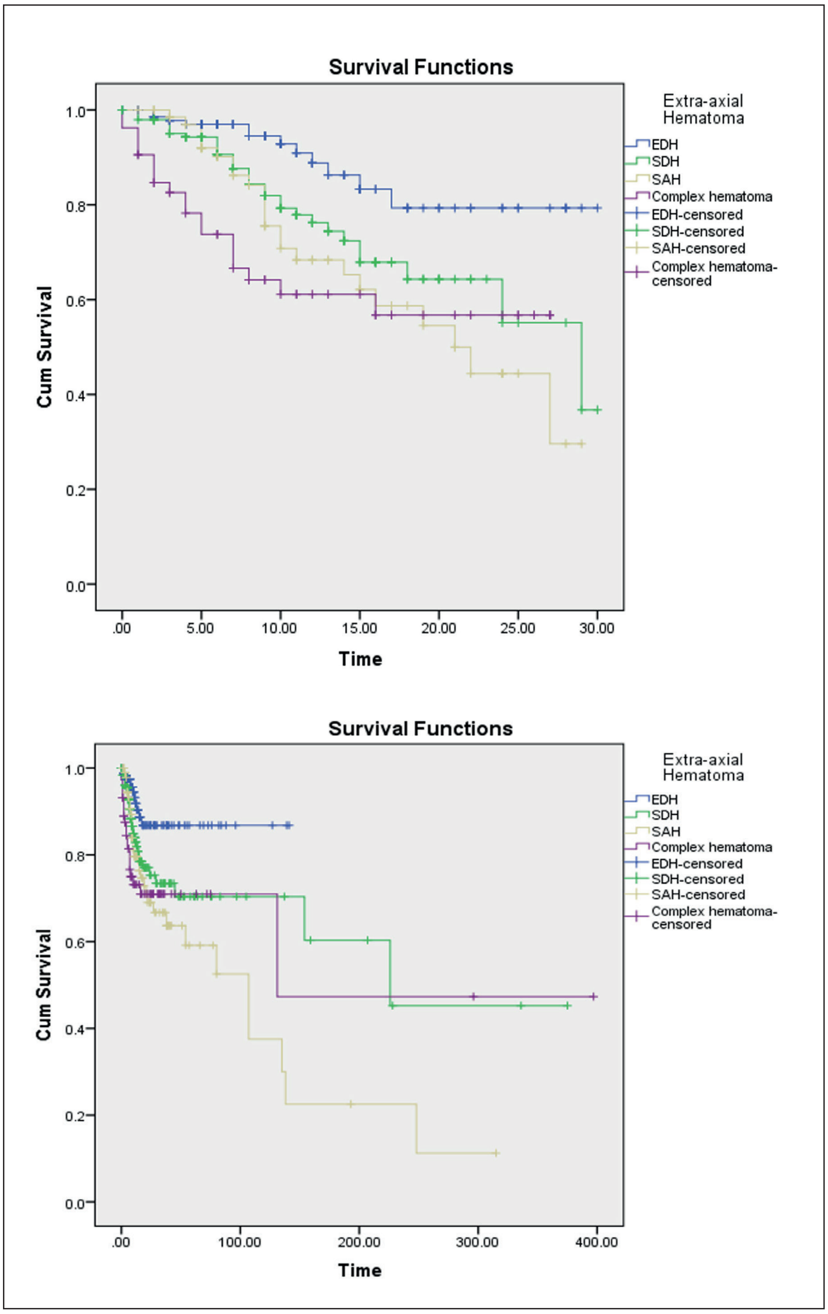

Figure 2. Kaplan Meier survival analysis curves for different types of extra-axial hematoma. **A**, One-month survival anaysis (**B**) One-year survival analysis. EDH: epidural hematoma, SDH: subdural hematoma, SAH: subarachnoid hemorrhage, Complex hematoma: more than one type of EAH.

Discussion

Traumatic brain injury (TBI) is the primary cause of death in young adults while a leading cause of death and disability in all other age groups globally[8-10]. Among injuries victims, TBI is responsible for half of injury-related deaths[10,11]. Extra-axial hematoma (EAH) is a critical category of TBI because it can enlarge, giving rationale for surveillance and early intervention. Furthermore, TBI with EAH is associated with a poorer prognosis compared to TBI without EAH[4,11]. EAH is generally associated with high-energy trauma, especially road accidents[12]. Saudi Arabia is among the leading nations in road traffic accidents and their related injuries[1,2,13]. Though it should be a public health priority, there is an evident information gap on epidemiological features of RTA-related traumatic injuries, particularly grave injuries, such as EAHs.

Table III. Means and Medians for Survival Time at one month and one year.

Time	EAH	Mean[a]				Median			
		Estimate	S.E.	95% Confidence Interval		Estimate	S.E.	95% Confidence Interval	
				Lower Bound	Upper Bound			Lower Bound	Upper Bound
30 days	EDH	26.160	1.066	24.070	28.250	-	-	-	-
	SDH	22.061	1.198	19.713	24.409	29.000	4.475	20.229	37.771
	SAH	19.430	1.422	16.644	22.216	21.000	3.665	13.816	28.184
	Complex	17.657	1.673	14.379	20.936	-	-	-	-
	Overall	22.478	0.686	21.133	23.823	29.000	-	-	-
One year	EDH	123.780	4.962	114.054	133.506	-	-	-	-
	SDH	223.550	30.036	164.680	282.420	226.000	-	-	-
	SAH	112.893	21.210	71.321	154.465	107.000	27.129	53.828	160.172
	Complex	220.283	54.223	114.005	326.560	131.000	-	-	-
	Overall	203.632	22.761	159.020	248.244	154.000	51.223	53.602	254.398

[a]Estimation is limited to the largest survival time if it is censored. S.E.= standard error. EAH: extra-axial hematoma, EDH: epidural hematoma, SDH: subdural hematoma, SAH: subarachnoid hemorrhage, Complex: more than one type of EAH.

This study analyzed the records of 520 RTA-related TBI cases diagnosed with EAH (EDH, SDH, SAH, or their combination) for age and sex distribution and measured their outcomes.

Our results show that all types of extra-axial hematoma are more in men than in women. This is commonly reported across studies, mainly because the road accident data is skewed towards the male population[2,8]. In this study, EAH was present in 42% of RTA-related TBIs. This indicates that EAH is a prevalent lesion in RTA victims suffering from TBI. The prevalence of EAH reported here is similar to the overall prevalence of intracranial bleeding (IB) in TBI from various mechanisms[4,12,14]. In this study, SDH was the most common EAH, followed by EDH, and then, SAH. SDH was two times more common than SAH. Previous studies[4,12,15,16] confirmed SDH as the most common extra-axial bleeding in TBI, but with inconsistency on the relative frequency of SAH *vs.* EDH.

Studies[16-18] consistently show SDH to be the most common intracranial hematoma in the elderly victims of TBI. This was verified in our study, where SDH is a statistically significant lesion among the elderly. In contrast, elderly patients affected by an EDH were a minority (1.8%), consistent with other studies[12,17,18].

Reported TBI mortality varies considerably between studies. This is related to the differences between studies regarding population age, injury severity, trauma mechanism, specific TBI diagnosis, and timing of death, among others. In this study, the overall EAH mortality rate was 18.7%, which is close to the 22% from a study that looked at TBI-related IB due to any mechanism[4]. The same study found the presence of IB, wherever located, as a predictor of mortality. The majority (87.6%) of deaths in our study occurred within 30

Table IV. Test of equality of survival distributions for the different types of extra-axial hematoma.

Time	Log rank test	Chi-Square	df	Sig.
30 days	(Mantel-Cox)	19.331	3	0.000
	Breslow (Generalized Wilcoxon)	28.805	3	0.000
	Tarone-Ware	24.648	3	0.000
One year	(Mantel-Cox)	17.526	6	0.008
	Breslow (Generalized Wilcoxon)	20.358	6	0.002
	Tarone-Ware	18.086	6	0.006

Table V. Pairwise comparison of survival curves for the different types of extra-axial hematoma.

Log rank Test	EAH type	EDH Chi-Square	Sig	SDH Chi-Square	Sig	SAH Chi-Square	Sig	Complex Chi-Square	Sig
At 30 days									
(Mantel-Cox)	EDH	-	-	6.312	0.012	11.986	0.001	13.768	0.000
	SDH	6.312	0.012	-	-	2.419	0.120	1.865	0.172
	SAH	11.986	0.001	2.419	0.120	-	-	0.001	0.972
	Complex	13.768	0.000	1.865	0.172	0.001	0.972	-	-
Breslow	EDH	-	-	5.800	0.016	7.342	0.007	19.092	0.000
(Generalized	SDH	5.800	0.016	-	-	0.258	0.611	5.509	0.019
Wilcoxon)	SAH	7.342	0.007	0.258	0.611	-	-	2.142	0.143
	Complex	19.092	0.000	5.509	0.019	2.142	0.143	-	-
Tarone-Ware	EDH	-	-	6.172	0.013	9.243	0.002	16.843	0.000
	SDH	6.172	0.013	-	-	0.765	0.382	3.770	0.052
	SAH	9.243	0.002	0.765	0.382	-	-	0.791	0.374
	Complex	16.843	0.000	3.770	0.052	0.791	0.374	-	-
At one year									
(Mantel-Cox)	EDH	-	-	7.480	0.006	12.302	0.000	19.095	0.000
	SDH	7.480	0.006	-	-	1.126	0.289	4.153	0.042
	SAH	12.302	0.000	1.126	0.289	-	-	0.463	0.496
	Complex	19.095	0.000	4.153	0.042	0.463	0.496	-	-
Breslow	EDH	-	-	6.429	0.011	8.652	0.003	27.491	0.000
(Generalized	SDH	6.429	0.011	-	-	0.321	0.571	10.212	0.001
Wilcoxon)	SAH	8.652	0.003	0.321	0.571	-	-	4.685	0.030
	Complex	27.491	0.000	10.212	0.001	4.685	0.030	-	-
Tarone-Ware	EDH	-	-	7.073	0.008	10.636	0.001	24.918	0.000
	SDH	7.073	0.008	-	-	0.654	0.419	7.686	0.006
	SAH	10.636	0.001	0.654	0.419	-	-	2.480	0.115
	Complex	24.918	0.000	7.686	0.006	2.480	0.115	-	-

EAH: extra-axial hematoma, EDH: epidural hematoma, SDH: subdural hematoma, SAH: subarachnoid hemorrhage, Complex: more than one type of EAH.

days of injury. We found no significant difference in mortality based on gender, which is supported by other studies[4,19,20].

The type of EAH, on the other hand, had a significant effect on mortality, which varied between 7.2% in EDH to 32% in SAH. Our data showed that traumatic SAH (tSAH) has the highest mortality, shortest mean survival time, and poorer survival rates at one month and one year compared to the other EAHs. The findings of significantly fewer extra-cranial injuries, yet significantly more ICU admissions and higher mortality support non-isolated traumatic SAH as an indicator of increased head injury severity.

Several studies[4,21,22] support our findings and disclose non-isolated traumatic SAH as a prognostic marker for poor survivability. Most of the studies[23-26] that showed good prognosis for tSAH were limited to mild head injuries, isolated tSAH, or both. In fact, a study has shown the adjusted odd ratio for mortality to increase by 27 times in non-isolated tSAH compared to isolated tSAH[26].

The low mortality reported here for EDH and finding EDH as a good prognostic factor for decreased mortality, compared to other EAH, is consistent with the literature[11,27,28]. In our study, SDH mortality was 18.6% which is similar to some studies[29,30]. However, there is a wide variation in the reported rate of SDH mortality due to the difference in population cohorts and severity of cases studied. The very high mortality reported by some studies on acute SDH is essentially a reflection of the advancing age which stands as one of the most critical factors influencing acute SDH mortality[31,32]. Our population of RTA-related EAH tended to be younger than previous studies, which might have impacted the overall mortality of SDH. It is also possible that the trauma mechanism plays a role in EAH injury-specific mortality.

Therefore, we conclude that SAH in RTA-related TBI with mostly non-elderly population is a more independent reliable predictor of mortality than SDH.

Cranial fractures were present in more than one-third of complex EAHs and one-quarter of EDH cases, with no significant differences between the proportion of specific EAH. The rate of skull fracture reported here is less than reported by others which could be related to the injury severity, mechanism, and the relatively young age of our population[28,33].

In terms of patient disposition, 91% of EDHs were discharged home. With more than 80% survival at six months, EDH patients fared significantly better than other EAH types. These findings are consistent with existing evidence supporting EDH favourable outcome[27,28,33]. It should be noted that EDH was present as alone or combined with other hematomas in a percentage of 32.11% and 38.84% of EAHs, respectively. Therefore, special attention to search for and treat EDH in RTA-related TBI should be of utmost importance given its high frequency, treatability, and significantly favourable outcome.

The survival analysis indicated the longest mean survival for SDH among all expired EAH patients. This indicates that SDH is the hardest EAH to treat, with many patients dying after a prolonged hospitalization. Previous studies[31,34] support our findings that acute SDH is more expected to have increased duration of hospital treatment and poorer rates of discharge home compared to other EAHs. This finding is pertinent when it comes to case management planning and resources allocations.

Limitations

This research studied admitted patients and, therefore, milder TBI cases that required no admission and the fatal ones that died before admission were not included. Data on injury severity measured by validated tools such as the Glasgow coma scale or injury severity score was not available. Moreover, some of the statistical analyses were restricted by small numbers of patients in certain subgroups. Even with these limitations, this work provided a unique insight into the epidemiology, patterns, and outcome of extra-axial hematomas caused by road traffic accidents. The researcher was able to show consistent, significant relationships between socio-demographic characteristics and the outcomes of the different types of EAH. It is expected that the information generated from this study will help clinicians to provide better care to patients presenting with TBI and assist in establishing and implementing strategies to reduce RTA-related injuries and deaths.

Conclusions

The current study showed that SDH is the most common RTA-related EAH. Sex and age do influence the type of hemorrhage with male preponderance and a significantly higher rate of SDH in elderly patients. Most of the fatalities associated with extra-axial hematoma occur within the first month of trauma. SAH is associated with increased mortality, while EDH has the best prognosis and survival probability at six months and one year from the incident. In RTA-related TBI, SAH may be a more reliable predictor of mortality than SDH.

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Conflict of Interests

The author declares he has no conflict of interests.

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