The Potential Role of Radiology in Diagnosis of Traumatic Versus Non-Traumatic Cerebral Hemorrhages for Medicolegal Application

Mohamed Khairy[1], Dina A. Shokry[2], Ehab Abdelhaleem[3], Reham Nafad Elbendary[2]

[1]Armed Forces College of Medicine (AFCM), 6 Ehsan Abd El Kodous Street, Cairo 11774, Egypt, [2]Department of Forensic Medicine and Clinical Toxicology, [3]Department of Neurosurgery, Faculty of Medicine, Cairo University, Kasr Alainy Street, Cairo 11562, Egypt.

Abstract

Background: Radiography is traditionally used as a complement tool for forensic examination. CT applications became widely used. Traumatic cerebral hemorrhage occurs in up to 15% of patients following head injury and non-traumatic cerebral hemorrhage accounts for up to 44% of all strokes. These two disorders are therefore very common. So there is a need for accurate diagnosis of cerebral hemorrhage form medicolegal aspect. This study aims to differentiate between traumatic and non-traumatic cerebral hemorrhage by using CT.

Methods: This prospective study, was conducted on 100 patients with intracranial hemorrhage and divided in two equal groups (traumatic and non-traumatic cerebral hemorrhage) both groups were examined by CT head and the results were analyzed.

Results: There was statistically significant difference between traumatic and non-traumatic cerebral hemorrhage groups in CT finding as regard type of hemorrhage with epidural, subarachnoid and intraventricular with P value (0.001, 0.005 and 0.001) respectively. Also according to site of hemorrhage in frontal lobe and subcortical with P value (0.001) equally.

Conclusion: we conclude that equation

Function (f) = - 0.976 (constant) + 2.873(Epidural) + 2.017 (Subarachnoid) - 0.416 (Intraventricular) + 0.984 (Frontal) -3.047 (Subcortical)

If the function (f) = + values, it will be traumatic hemorrhage and if the function (f) = - values it will be pathological hemorrhage

***Keywords**: CT, traumatic, non-traumatic, cerebral hemorrhage, forensic*

Introduction

Radiography is traditionally used as a complement tool for forensic examination, serving primarily to document metallic bullet fragments, foreign bodies, fractures, and injury patterns[1] . CT applications became widely used and had been introduced as a routine investigation in forensic medicine[2] .

The frequency of traumatic brain injuries is high among young children and elder age groups due to road traffic accidents, work or sport accidents, firearms, and falls from height[3]. On the other hand, non-traumatic cerebral hemorrhage caused by hypertension (36%), aneurysm (36%), arteriovenous malformation (11%) and other causes (17%)[4] .

There is a need for accurate diagnosis of different types of cerebral hemorrhage including epidural, subdural, subarachnoid and intracerebral hemorrhage with the increasing awareness of its high prevalence[5]. Imaging methods may be capable of detecting a number of the pathoanatomical and pathophysiological consequences of focal and diffuse traumatic brain

injury[6].

The location of the hemorrhage is very important in the diagnosis of the nature of the hemorrhage. Subdural hemorrhage and epidural hemorrhage are mainly traumatic, while a subarachnoid hemorrhage and intracerebral hemorrhage when not accompanied with bruises and lacerations of the brain it can be non-traumatic[7].

Radiological imaging such as CT offering a non-invasive approach and unlimited storage and can provide as a second opinion in the court[8].

Material and Method

This study is a prospective, case control study conducted on 100 patients with intracranial hemorrhage selected from cases presented to the Neurosurgery department, Faculty of medicine, Cairo University, from February 2017 to January 2018.

Intracranial hemorrhage may be non-traumatic or traumatic in nature, so the patients were divided into two groups according to history of trauma as following:

♦ **Group 1 (Traumatic):** 50 patients with history of trauma.

♦ **Group 2 (Non-traumatic):** 50 patients without history of trauma.

Patients' Inclusion Criteria:

1. Both gender was included.
2. Different age groups (> 18 , 18-54 , < 55).
3. Craniocerebral hemorrhage as a primary cause of neurological deficit regardless of the etiology.

Patients' Exclusion Criteria:

1- Cases due to thrombotic embolization.

2- Cases due to intracerebral infection.

3- Cases due to congenital anomalies (Except vascular anomalies).

4- Cases due to neoplastic lesions unless the incidence is acute due to associated hemorrhage.

Cases were analyzed with respect to:

- patients age and sex
- Presence or absence of history of head trauma to classify cerebral hemorrhage to traumatic and non-traumatic
- In traumatic group: the cause of trauma as road traffic accident (RTA), assault, fall from height or others.
- Data from application of cranial CT on Toshiba Alexon 16-slice multidetector CT scanners to detect**:**

- Cause of hemorrhage in pathological group aneurysm, hypertension (HTN) or arterovenous malformation (AVM).

- Type of hemorrhage and combined types of hemorrhages.

- Site of hemorrhage and combined sites of hemorrhages.

Statistical analysis:

- Data were coded and entered using the statistical package SPSS version 25. The comparisons between quantitative variables were done using the non-parametric Mann-Whitney test[9]. And for comparing categorical data, Chi square ($\chi 2$) test was performed. Exact test was used instead when the expected frequency is less than 5 [10]. P-values less than 0.05 were considered as statistically significant.

Discriminant analysis was done to discriminate between pathological and traumatic. Stepwise statistics revealed the significant predictors which were used to determine the discriminate function. Then group centroids (group means) were calculated, they represent the determinant points for discrimination between traumatic and pathological. Classification of the percentage of accurately classified cases according to the discriminate function was performed[11].

Finding

This study was conducted on 100 patients with intracranial hemorrhage and divided into two equal groups according to history of trauma (traumatic group and non-traumatic group.

Results showed that the mean age was (33.78) years old in (Traumatic) and (49.30) years old in (non-traumatic).

Regarding gender the majority of the cases are males which represent (68%) and female cases represent (32%).

Regarding types of trauma in traumatic group the most common cause is RTA (42%) then followed by assault (34%) then followed by fall from height (20%).

According to pathological causes in non-traumatic group, the most common cause is aneurysm (54%) then followed by HTN (38%).

Table (1): Show comparison between Traumatic group and Non-traumatic group as regard type of hemorrhage according to CT finding. It shows statistical significant difference with epidural, subarachnoid and intraventricular with P value (0.001, 0.005 and 0.001) respectively.

Table (1): Comparison between two groups as regard types of hemorrhage:

Type of hemorrhage on CT		**Group**				
	Traumatic		**Non-traumatic**		**P value**	
	Count	**%**	**Count**	**%**		
Epidural	yes	24	48.0%	0	0.0%	0.001
	no	26	52.0%	50	100.0%	
Subdural	yes	8	16.0%	9	18.0%	0.790
	no	42	84.0%	41	82.0%	
Subarachnoid	yes	20	40.0%	34	68.0%	0.005
	no	30	60.0%	16	32.0%	
Intracerebral or Intraparechymal	yes	9	18.0%	12	24.0%	0.461
	no	41	82.0%	38	76.0%	
Intraventricular	yes	0	0.0%	11	22.0%	0.001
	no	50	100.0%	39	78.0%	

Table (2): Show comparison between Traumatic group and Non-traumatic group as regard site of hemorrhage according to CT finding. It shows statistical significant difference in frontal lobe and subcortical with P value (0.001) equally.

Table (2): Comparison between two groups as regard sites of hemorrhage:

Site of hemorrhage		**Group**				
	Traumatic		**Non-traumatic**		**P value**	
	Count	**%**	**Count**	**%**		
Temporal	yes	17	34.0%	11	22.0%	0.181
	no	33	66.0%	39	78.0%	
Frontal	yes	14	28.0%	2	4.0%	0.001
	no	36	72.0%	48	96.0%	
Pareital	yes	26	52.0%	20	40.0%	0.229
	no	24	48.0%	30	60.0%	
Occipital	yes	7	14.0%	3	6.0%	0.182
	no	43	86.0%	47	94.0%	
Subcortical	yes	0	0.0%	30	60.0%	0.001
	no	50	100.0%	20	40.0%	

The patients with single site of hemorrhage were higher in Traumatic group where the patient with combined site of hemorrhage were higher in Non-traumatic group with statistical significant difference.

Table (3,4): Show discriminant function analysis to discriminate between non-traumatic and traumatic cerebral hemorrhage using CT findings, we collect significant parameter in analysis in table 1 (types of hemorrhage) which is epidural, subarachnoid and intraventricular hemorrhage and significant parameter in analysis in table 2 (sites of hemorrhage) which in frontal and subcortical, then we done discriminant function analysis model. (Table 3)

Table (3): Discriminant Function Coefficients:

	Function
Type of hemorrhage on CT= Epidural	2.873
Type of hemorrhage on CT= Subarachnoid	2.017
Type of hemorrhage on CT=Intraventricular	-0.416-
Site of hemorrhage=Frontal	0.984
Site of hemorrhage=Subcortical	-3.047-
(Constant)	-0.976-

We found that equation:

Function (f) = - 0.976 (constant) + 2.873 (Epidural) + 2.017 (Subarachnoid) - 0.416 (Intraventricular) + 0.984 (Frontal) -3.047 (Subcortical)

Table (4): Functions at Group Centroids:	
Group	Function
Non-traumatic	-1.485-
Traumatic	1.485

According the result of previous equation to functions at group centroids (table 4) which showing that non-traumatic (-1.485) and traumatic (1.485). So we conclude that if the function (f) = + values (> 0) it was traumatic hemorrhage and if the function (f) = - values (< 0) it was non-traumatic hemorrhage.

Table (5): Shows classification to show accuracy of predicted group membership by discriminant function analysis, we found that (90%) of cases were truly classified as 44 patients of non-traumatic cases which represent (88%) were truly classified as non-traumatic and 46 patients of traumatic cases which represent (92%) were truly classified as traumatic with accuracy of that model is 90%.

Table (5): Classification to show accuracy of predicted group membership by discriminant function analysis:

		Group Non-traumatic	Predicted Group Membership		Total
			Traumatic		
Original	Count	Non-traumatic	44	6	50
		Traumatic	4	46	50
	%	Non-traumatic	88.0	12.0	100.0
		Traumatic	8.0	92.0	100.0

Discussion

Traumatic cerebral hemorrhage and non-traumatic cerebral hemorrhage are therefore very common[12]. So the accurate diagnosis of cerebral hemorrhage is important from medicolegal aspect.

The study showed that the mean age was (33.78) years old in Traumatic group and the mean age was (49.30) years old in Non-traumatic group.

These results were in agreement with those of **Zhou**[13] who found that the incidence of acute spontaneous intracranial hemorrhage tended to increase with increasing age, the incidence of traumatic brain injury tended to decrease with decreasing age.

Regarding sex, it was found that male patients were higher which represent (68%) and female cases represent (32%).

These results were in agreement with those of **Pruitt**[14] who found that (61.1%) of patients were males.

Also it was found in the present study that male patient are higher in Traumatic group and female patient are higher in Non-traumatic group. This result agrees with those of **Al-Yessary**[15] who found males were more frequent among traumatic group, while females were the more frequent gender in spontaneous group and it was explained according to **van Beijnum**[16] that the traumatic intracranial hemorrhage had mostly occurred in males because they usually expose to violence and trauma more than females. Spontaneous intracranial hemorrhage had mostly occurred in females, and that may be due to their higher reaction to emotional stress than that of males.

Regarding the type of trauma in traumatic group in the present study, it was found that the most common cause of traumatic intracranial hemorrhage is road traffic

This disagrees with the study conducted by **Pruitt**[14] who found the most common cause of injury was fall which represent (69.6%).

It was noticed that different of most common cause of head injury from country to another. It was explained by **Odero**[17] as he mentioned that increasing rate head injury in developing nations due to increasing incidence of road traffic accidents.

Regarding the pathological causes in Non-traumatic group, it was found the most common cause of non-traumatic intracranial hemorrhage was aneurysm (54%) then followed by HTN (38%)

According to **Van**[18] the majority causes of nontraumatic intracranial hemorrhage was hypertension (36 %), aneurysm (36 %) with equally percent.

Regarding type of hemorrhage, it was found that patients with epidural hemorrhage was more common in Traumatic group while patients with subarachnoid and intracerebral were more common in Non-traumatic group.

These results were in agreement with those of **Suthar**[5] as they found in their study subarachnoid hemorrhage,

intracerebral hemorrhage and intraventricular hemorrhage were more common in spontaneous intracranial hemorrhage and epidural hemorrhage and subdural hemorrhage were more common in traumatic intracranial hemorrhage.

Regarding combined types of hemorrhage, it was found that patients without combined types of hemorrhage (one type) were (82%) in Traumatic group and (72%) in Non-traumatic group and patients with combined types of hemorrhage (18%) in Traumatic group and (28%) in Non-traumatic group.

These results were in agreement with those of **Pruitt**[14] as they found that (74.3%) of traumatic patients had a single type of intracranial lesion versus (24%).

Regarding site of hemorrhage in the present study, it was found that Patients with hemorrhage in frontal lobe were (28%) in Traumatic group and (4%) in Non-traumatic group and patients with hemorrhage in subcortical (0%) in Traumatic group and (60%) in Non-traumatic group.

These results were in agreement with those of **Suthar**[5] as they found in their study that the most common site of hemorrhage was basal ganglia (subcortical) (60%) in spontaneous intracranial hemorrhage.

Our results showed that most common site in traumatic intracranial hemorrhage was parietal, frontal and temporal. These results were in agreement with those of **Adekanmi**[19] who found that most of the bleeds were located in the parietal and frontal lobes, followed by temporal.

Conclusion

From the present study, it was concluded that:

- Males were more commonly affected by cranial hemorrhages than females and higher in traumatic group but females were higher in non-traumatic group and the traumatic patients were younger than non-traumatic patient.
- The most common cause of traumatic intracranial hemorrhage is RTA followed by assault and the most common cause of non-traumatic intracranial hemorrhage is aneurysm then followed by HTN
- The most common type of hemorrhage in traumatic group was epidural while in non-traumatic group was subarachnoid hemorrhage.
- The most common site of hemorrhage in traumatic group was in parietal while in non-traumatic was in subcortical.
- The patients with single site of hemorrhage were higher in traumatic group while patients with combined site of hemorrhage were higher in non-traumatic group.
- We conclude the most important and significant finding in CT brain and we done discriminant function analysis model to discriminate between traumatic and non-traumatic cerebral hemorrhage and we found that equation

Function (f) *= - 0.976 (constant) + 2.873(Epidural) + 2.017 (Subarachnoid) - 0.416 (Intraventricular) + 0.984 (Frontal) -3.047 (Subcortical)*

According to function at group centroids we found non-traumatic was (-1.485) and traumatic was (1.485), so if we have the function (f) = + values (> 0) most probably it will be traumatic hemorrhage and if the function (f) = - values (< 0) most probably it will be non-traumatic hemorrhage as the accuracy of that model is 90%.

Conflict of Interests: The authors declared that they have no competing interests

Ethical approval: The study work was conducted after the approval of Ethical Committee, Faculty of medicine, Cairo University

Source of Funding: Self

References

1. Kahana, T., & Hiss, J. Forensic Radiology. In Forensic Pathology Reviews, M. Tsokos, ed. (Totowa, NJ: Humana Press), 2005**.** pp. 443–460.
2. Ishida, M., Gonoi, W., Okuma, et al. Common Postmortem Computed Tomography Findings Following Atraumatic Death: Differentiation between Normal Postmortem Changes and Pathologic Lesions. Korean J. Radiol. 2015. 16, 798.
3. Zygun, D.A., Laupland, K.B., Hader, W.J., et al. Severe Traumatic Brain Injury in a Large Canadian Health Region. Can. J. Neurol. Sci. 2005. 32, 87–

92.

4. Quinet, S., & Turski, P. Imaging of Spontaneous Nontraumatic Intracerebral Hemorrhage. In Neurovascular Imaging, From Basics to Advanced Concepts, L. Saba, & E. Raz, eds. (New York, NY: Springer New York), 2016. pp. 233–292.
5. Suthar, N.; Patel, K.;Saparia, C. Study of clinical and radiological profile and outcome in patients of intracranial hemorrhage. Ann Afr Med.2016. Apr-Jun; 15(2):69:77
6. Benson, R.R., Gattu, R., Sewick, B., et al. Detection of hemorrhagic and axonal pathology in mild traumatic brain injury using advanced MRI: implications for neurorehabilitation. NeuroRehabilitation.2012. 31, 261–279.
7. Massoni, F., Ricci, L., Crusco, M.A., et al. Medico Legal Consideration in Postmortem Diagnostic of Intracranial Haemorrhage. J. Clin. Diagn. Res.2015. 9, HJ01.
8. Paperno, S., Riepert, T., Krug, B., et al. Value of postmortem computed tomography in comparison to autopsy. RöFo Fortschritte Auf Dem Gebiete Der Röntgenstrahlen Und Der Nukl.2005. 177, 130–136.
9. Chan YH. Biostatistics102: Quantitative Data – Parametric & Non-parametric Tests. Singapore Med J. 2003a; 44(8): 391-396.
10. Chan YH. Biostatistics 103: Qualitative Data – Tests of Independence. Singapore Med J. 2003b; 44(10): 498-503.
11. Chan YH. Biostatistics 303: Discriminant analysis. Singapore Med J.; 2005. 46(2): 54-62.
12. Siddque, M.S.; Barbara, A. G.; Helen, M.F. et al. Comparative study of traumatic and spontaneous intracerebral hemorrhage, J Neurosurg.2002. 96:86–89.
13. Zhou, Y.T.; Tong, D.; Wang, S. et al. Acute spontaneous intracerebral hemorrhage and traumatic brain injury are the most common causes of critical illness in the ICU and have high early mortality. BMC Neurology.2018. 18:127.
14. Pruitt, P.; Penn, J.; Peak, D. et al. Identifying patients with mild traumatic intracranial hemorrhage at low risk of decompensation who are safe for ED observation. American Journal of Emergency Medicine.2017. 35:255–259.
15. Al-Yessary, Y.S.; Al-Khateeb, N.G. and Al-Naaimi, A.S. Medico-legal comparative study between traumatic and spontaneous intracerebral hemorrhage: The Iraqi postgraduate medical journal.2013. VOL.12, NO 2, 259-267.
16. Van, B.J, Lovelock C.E, Cordonnier C,et al. Outcome after spontaneous and arteriovenous malformation-related intracerebral haemorrhage: population-based studies. Brain.2009. 132:537.
17. Odero, W.; Khayesi, M. and Heda, P.M. Road traffic injuries in Kenya: Magnitude, causes and status of intervention. Inj Control Saf Promot.2003. 10:53-61
18. Van, G.J.; Kerr, R.S. and Rinkel, G.J. Subarachnoid haemorrhage. Lancet.2007. 369: 306-18.
19. Adekanmi, A.J.; Adeniji-Sofoluwe, A.T. and Obajimi, M.O. Computed tomographic pattern of traumatic head injury at a tertiary hospital in Ibadan, South-Western Nigeria: A 10 year review. African Journal of Trauma. 2015. Vol. 4. Issue 2.p:45-50.