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COMPARATIVE EVALUATION OF INTRACRANIAL HEMORRHAGE ON COMPUTED TOMOGRAPHY IN CHILDREN, ADULTS AND ELDERLY

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Keywords

Comparative, evaluation, Intracerebral hemorrhage, computed tomography, children's, adults, elderly

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Abstract

Background:

Intracranial hemorrhage (ICH) is a lethal neurological disorder having high mortality and morbidity rate. Computed tomography is the modality of choice for the initial and immediate diagnosis of intracranial hemorrhage including the assessment of its types, sites, and severity. Age related changing significantly affect ICH the distribution, clinical signs, symptoms and causes as well. This study aims to compare the intracranial CT imaging characteristics and clinical features among the different age group such as children, adults and elderly patients.

Objective:

To evaluate and compare the CT imaging features of intracranial hemorrhage in children with those in adult and elderly populations to identify age-related diagnostic differences.

Methods:

A prospective, cross-sectional comparative study was conducted on 70 patients of intracranial hemorrhage. The Variables included patient age, gender, causes, types of ICH, location, fracture, midline shift (mm), GCS score and associated findings. Data collected through questionnaire, summarize and analyze with the help of Statistical Package of Social Sciences (SPSS version 26). Descriptive statistics, ANOVA and Pearson correlation tests applied to determine the relationships between different variables.

Results:

The predominant etiology of intracranial hemorrhage is trauma particularly in children and adult groups while non traumatic etiologies such as hypertension and microvascular cerebral amyloid angiopathy more common in elderly group. The types of ICH differently distributed among the different age groups such as extra axial types of ICH like subdural and epidural more common in adult patients whereas intraparenchymal hemorrhage more common in elderly patients. Statistically significant difference in midline shift among the different age groups $F(35, 34) = 3.99$, $p < 0.001$, *which demonstrating that the radiological features shows severity with advance age and ICH type. Other than that also significant difference in GCS scores between different age groups (*$r = -0.876$, $p < 0.001$*) which means that GCS score lesser in elderly patients in comparison with other groups due to severe neurological deficit. Furthermore, negative correlation* *concluded between GCS and midline shift which demonstrating that the more severe the hemorrhage causes more mass effect which further result in lower GCS score or poor clinical outcomes. Overall the results emphasizing that computed tomography is the modality of choice for the diagnosing, classification and evaluation of prognosis in patients with intracranial hemorrhage. It also allow to compare the radiological characteristics with clinical outcomes which play crucial role in understanding the severity, management and outcomes in emergency situation.*

Conclusion:

This study concluded that the age, etiologies and ICH types significantly influence the radiological characteristics and clinical features in patients presented with intracranial hemorrhage. Elderly patients showed the lower GCS score and severe midline shift which reflected the poor prognosis. The negative correlation between midline shift and GCS indicate the importance of radiological features and clinical presentations for evaluating the clinical outcomes and improving the management plans for patients present with ICH.

INTRODUCTION

One of the most fatal neurological condition or catastrophic situations is known as intracranial hemorrhage which is abbreviated as ICH. Intracranial hemorrhage is a broad term that can be defined as all types of bleeding within the skull, due to bleeding intracranial pressure may raise which can further cause herniation or other complication as well and death may occur if not diagnosed or treated properly and timely. [1] It has various sub types which are categorized on the basis of exact location of bleeding. Including intracerebral hemorrhage, Intraparenchymal hemorrhage, intraventricular hemorrhage, extra axial hemorrhage, subarachnoid hemorrhage, subdural hemorrhage and epidural hemorrhage, each type has its own causes, pathophysiology and radiological features of different medical imaging modalities. [2] Epidural hemorrhage, EDH is bleeding occurs as a result of arterial injury mostly middle meningeal artery, between dura mater which is the outer meningeal membrane and the skull. Due to which blood accumulate in this area and seen as convex shape hyperdense lesion on CT scan. If EDH not treated timely it may lead to cause herniation which may further result in fatal consequences. [3] Subdural hemorrhage, SDH is bleeding occurs as a result of bridging veins injury or rupture due to which blood accumulate between outer and middle meningeal membrane such as dura mater and arachnoid mater. SDH forming crescent shape blood collection and seen on CT scan across the suture lines. SDH mostly occur in elderly and infant patients because at this age group vein rupture is more susceptible due to brain atrophy or weak venous attachment even with minimal traumatic injury. [4] Subarachnoid hemorrhagic, SAH is bleeding occurs as a result of aneurysm rupture or injury to cortical vessels in subarachnoid space. On Computed Tomography scan, Subarachnoid Hemorrhage (SAH) is seen as blood collection within basal cisterns and cortical sulci. There is a risk of high mortality when aneurysm rupture involves in subarachnoid hemorrhage. [5] Intraparenchymal hemorrhage (IPH) and Intracerebral hemorrhage (ICH) is bleeding occurs directly within brain tissue due to small penetrating arteries rupture resulting from hypertension. It may occurs in deep brain tissues such as basal ganglia, thalamus and pons. There are several causes or risk factors of IPH and intracerebral hemorrhage which are usually non traumatic such as amyloid angiopathy, tumor and vascular malformation. [6] Intraventricular hemorrhage (IVH) is bleeding occur as a result of fragile arteries rupture near or within the ventricles, typically resulting from the subarachnoid hemorrhage or intraparenchymal hemorrhage extension. IVH mostly occur in premature infants and can cause obstructive hydrocephalus which further raised the intracranial

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pressure and resulting in poor prognosis. [7] Intracranial hemorrhage is a medical emergency with a high percentage of mortality and morbidity. The pathophysiology of this critical condition involves the rupture of vessel by different traumatic and non-traumatic factors resulting in bleeding due to which lesser the oxygenated blood reaches the brain cells resulting in tissue destruction. As brain cells do not store the oxygen so when blood supply decreases to brain cells within four to minute's cell death started which causes mechanical tissue destruction and neurological symptoms begins after that. Due to blood pooling the intracranial pressure raised and ultimately reduces the tissue perfusion which causes secondary ischemia.[8] These pathological processes started complex biochemical reaction such as excitotoxicity, inflammatory reactions, and oxidative stress which further causes neuronal injury.[9] Due to these pathophysiological mechanism patient present in emergency department with various neurological sign and symptoms with the different severity which depends on site and size of hemorrhage. Results of different patients varies depending on the cause, type, size and intervention timeliness. Although by providing optimal care the mortality rates still remain high especially in intracerebral hemorrhage at which 30-50% patients expire within the initial 30 days and only minimal percentage of patients regain normal physiological independence.[10] Early diagnosis by medical imaging like using CT scan for diagnostic purpose play a crucial role in classifying patients for surgical intervention or medical treatment and also predicting prognosis on the basis of bleeding volume, mass effect, midline shifting, and intraventricular extension.[11] Worldwide stroke is a major leading cause of morbidity and mortality and intracranial hemorrhage only accounts for 10-20% of all the cases as compared to stroke but it contributing excessively in stroke related deaths.[12,13] As per global burden disease study 2019, the age related cases of intracranial hemorrhage is 24.6 cases per 100,000 peoples per year, with demise rate surpassing 15 per 100,000.[14] The burden is considerably high in low and middle socio economic status countries which come up with 80% of all intracranial hemorrhagic deaths just because of limited availability to emergency neuroimaging and specialized healthcare.[15] Even with remarkable advancement in medical imaging modalities with their specific disease related radiological characteristics and immediate care or emergency management the end results remain inadequate mostly in elderly patients and others who presenting in emergency department with severe blood loss and with intraventricular extension.[16] In spite of remarkable improvements in stroke management and care the occurrence of intracranial hemorrhage still same for past twenty years in comparison with ischemic stroke. This lack of progressive development consider due to certain risk factors such as uncontrolled hypertension, more use of anticoagulants and increasing the rates on traumatic brain injury because of road traffic accidents and falls.[17] In child age group ICH considered 10-15% of all pediatric strokes but it causes the worsen neurological impairment.[18] In olde age group there are certain coexisting conditions such as hypertension, micro vascular amyloid angiopathy and anticoagulant drugs which significantly increases the rate of both ICH incidence and mortality.[19] The signs and symptoms of intracranial hemorrhage are different in different patients its entirely depends on the site of bleeding. It may include complete or partial loss of consciousness, sudden shivering, numbness, inability to move, severe migraine, headache, drowsiness, slurred speech, difficulty swallowing and paresis. These symptoms need immediate medical attention as it worsen with the time and may cause the irreversible damage.[20] There are several risk factors and causes of intracranial hemorrhage, the most common risk factor is hypertension. Anti-platelet therapy, anticoagulant medication, alcohol abuse, cholesterol and rupture of intracranial aneurysm can also increases the risk of hemorrhage. Cerebral amyloid angiopathy is another cause of hemorrhage, which is a vascular disorder in which amyloid proteins builds up within the arterial wall due to which arterial walls become weakens and more vulnerable to rupture. This mostly occurs in patients of 55 years of age and older than this. There are some risk factors that can preventable including hypertension, cocaine and tobacco use and on the other hand some symptoms that are not preventable including personal history and family history of subarachnoid hemorrhage, large size aneurysm,

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female gender, connective tissue disorder and older age.[21] Due to differences among the different age groups regarding the anatomy, physiology and etiology therefore both the clinical and radiological features varies in different age groups such as child, adult and elderly of intracranial hemorrhage. In children the ICH in not common but it is linked with the genetics and different abnormal developments such as arteriovenous malformation, aneurysms and others coagulation abnormalities. Pediatric ICH resulting from trauma usually due to fall or non-accidental injuries. Due to high brain plasticity they have better ability to recover but the mortality rate is higher persistently in case of large volume hemorrhage.[22] On the other hand in adult age group the primary cause of ICH is hypertension, trauma, drugs abuse, narcotics and vascular malformations. If we categorize ICH into two types on the basis of its causes then traumatic ICH seen as extra axial hemorrhage such as EDH or SDH and non-traumatic ICH seen as affected or altered structure of deep gray matter. In older age group the cerebral atrophy is a concerning point which is vulnerable to bridging veins and causing them to rupture which further leads to form the SDH after minor traumatic injury. Other than that micro vascular cerebral angiopathy also causes the vessels to become fragile and leads to lobar hemorrhage. The recurrent rate of ICH is larger and even mortality rate as well due to age related vascular fragility and certain drug usage for long term such as anticoagulant therapy. [23] The outcomes of ICH usually not well at this age group because of certain coexisting conditions and reduces the physiological functions.[24] Age is very crucial factor to determine the ICH form, site and its prognosis. According to Asch et al. and Feigin et al. Although the rate of ICH progressively increasing with age but the mortality rate is considerably high in elderly age group due to hematoma enlargement and poor reparative capacity. Computed tomography is the modality of choice for acute neurological emergencies such as intracranial hemorrhage the reason is, it is quick, readily available, noninvasive, sensitive and specific to acute hemorrhage. Modern day CT scanners such as multidetector CT scan (MDCT) has the ability to produce the high resolution images within seconds, which further helps in timely diagnosis and treatment certain emergencies. [25] The time is very crucial for assessing the ICH because outcomes depends entirely on early detection and timely management. In acute phase intracranial blood shows different x-ray attenuation characteristics which is easily detected by non-contrast CT scan. Fresh bleeding demonstrated as hyperdense (bright/white) area as compared to surrounding normal brain parenchyma.[26] The hyper-density (HU 50-90) depends on time and hematocrit values.[27] Over the time when blood evolve the density of blood decreases due to which its appearance changes, so CT scan consider useful during initials 72 hours for the detection of ICH at this stage the sensitivity of CT is 95% for accurately detecting the ICH.[28] Other than this, CT consider superior modality of choice for the detection of fatal complications such as bleeding, herniation, mass effect, intraventricular extension, and hydrocephalus. Due to its timely detection, it allows the physician to assess the condition timely and make the decision promptly weather surgical intervention required or not, which making the CT is crucial and critical tool in trauma centers all over the world. [29] The other pros of CT scan which is also considerably very important is, compatibility of CT with non-stable patients. CT scan unlike the MRI accommodating more with other medical devices such as ventilators and other monitoring equipment. It also allows the safe and secure imaging of pediatric patients with sedation and other critically ill patients as well. It also helpful in poly trauma cases where whole body imaging required to evaluate the abnormalities. It also able to detect the secondary effects caused by ICH. [30] The image characteristics of CT in ICH is different according to the type. Site, size, time and cause. In Extra Dural Hemorrhage, CT shows convex shape hyperdense area. It is sometimes associated with midline shift. [31] In Subdural Hemorrhage, crescent shape hyper dense area seen that may cross the sutures line it becomes hypodense over the time. [32] In SAH hyperdense areas of different sizes seen in basal cisterns, sulci and ventricles. CT sensitivity is very high for detecting SAH in initial 6 hours but it decreases over the time. [33] In IPH hyper dense well circumscribed lesion seen sometimes with surrounding edema. In IVH ventricles filled with hyperdense area, it sometimes associated with

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hydrocephalus. In the detection of ICH CT scan shows higher sensitivity and specificity. Several studies published that report 100% sensitivity in initial 24 hours for different types of acute ICH.[34] Nevertheless the CT sensitivity and specificity decreases with the passage of time such as in subacute and chronic stage when its density decreases over the time.[35] Modern advancement in CT technologies such as dual energy CT and spectral CT demonstrated more abilities to diagnose and differentiate ICH from other similar appearing abnormalities such as calcification and contrast leakage.[36] these advancing technologies also able to detect the active bleeding by demonstrating spot sign, is a crucial marker which increased the mortality rate. According to diagnostic accuracy of CT scan it become the gold standard medical imaging modality to diagnose the acute intracranial hemorrhage. It is useful in follow up scans and pre-operative evaluation as well.[37]Even though MRI is superior modality for soft tissue imaging and in subacute and chronic stage of blood product is consider more sensitive than other imaging modalities but in emergency acute stage of ICH MRI is less practical than CT due to multiple reasons such as high cost, longer scanning time, and patient preparation.[38] on the other hand CT angiography and perfusion imaging demonstrate the more valuable results than non-contrast CT scans. Although these advanced CT techniques and technologies considerably more superior in detecting the various vascular disorders and differentiate between hemorrhage and ischemia as well, non-contrast CT scan is still consider gold standard modality in detecting and managing the acute ICH. [39] There are the certain key prognosticators of ICH outcomes for which CT provide the quantitative assessment such as bleed size and mass effect. The formula used for the calculation of bleed size or volume is ABC/2, introduced in study published by kothari et al. In 1996. According to this formula A shows the length of hematoma in axial section. B shows the diameter and C shows the total number slices that contains hemorrhage multiply by slice thickness. [40] Volume greater than 30mL in supratentorial or greater than 10mL in brain stem is linked with high mortality rate. There are also some other markers such as midline shift, intraventricular extension and HU measurement. Although there is extensive research studies present on intracranial hemorrhage but most of them focus specifically just focus on hypertensive or spontaneous ICH and comparative studies on different age group still remain uncommon. The ICH studies for pediatric and geriatric patients are not abundant as well due to their limitation in variety of things such as small sample size, different research methodologies and very limited causes for focusing such as microvascular amyloid angiopathy and vascular malformations. Furthermore, although CT is consider first modality of choice for the detection of acute ICH and some investigations compared systematically the CT features, quantitative parameters and results across the different age groups.[41] Majority of research studies focusing on the population of developed countries while the research data is not available from the poor or developing countries population where the mortality rate already higher in case of ICH and no readily availability of diagnostic services.[42]

Rationale of Study

Intracranial hemorrhage (ICH) presents with a wide range of etiologies, CT imaging characteristics, and clinical outcomes among different age groups, but mostly research studies which are currently present just focus on adult group, due to which there is a gap present in order to understand the comparative analysis. A few research studies conducted and published on ICH among pediatric, adult and elderly age groups. For that reason, this study on comparative evaluation of CT imaging features, types of hemorrhage, associated findings, and clinical outcomes among different age groups is rationalized to reduce the gap, with the aim of improving the diagnostic accuracy and most importantly age related management methodologies for intracranial hemorrhage (ICH).

OBJECTIVE

To evaluate and compare the CT imaging features of intracranial hemorrhage in children with those in adult and elderly populations to identify age-related diagnostic differences.

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MATERIAL AND METHODS

A prospective cross-sectional comparative study was conducted over four months at multiple DHQ hospitals in Punjab, enrolling 70 patients through convenient sampling. Patients of both genders with suspected intracranial hemorrhage on non-contrast CT performed within 24 hours of symptom onset or trauma were included, while poor-quality scans, prior neurosurgical cases, and non-hemorrhagic lesions were excluded. Standardized NCCT brain protocols using multi-slice or spiral CT scanners were applied, with thin axial slices and multiplanar reconstructions as needed. Demographic and imaging data were recorded and analyzed using descriptive statistics, while comparative analyses (Chi-square, t-test, or ANOVA) were performed to assess differences in CT features of ICH across pediatric, adult, and elderly groups.

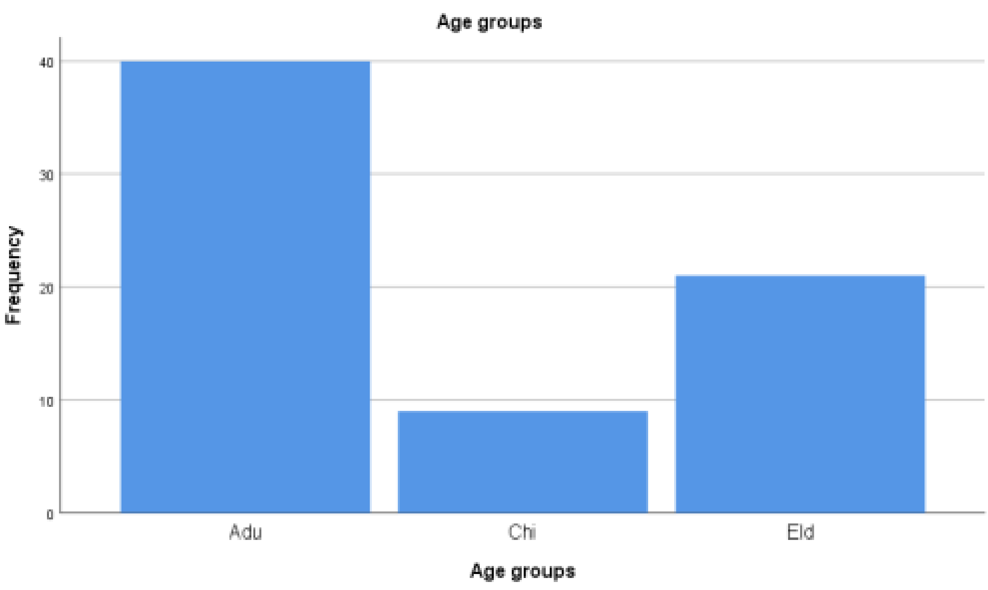
RESULTS

Table 1: Frequency table of age groups

Age groups					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Adu	40	57.1	57.1	57.1
	Chi	9	12.9	12.9	70.0
	Eld	21	30.0	30.0	100.0
	Total	70	100.0	100.0	

Frequency table of patients with different age group. Above table demonstrating **that** 9 (12.9%) children, 40 (57.1%) adults and 21 (30%) elderly patients which included in this study while total number of patients 70 (100%).

Figure 1: Frequency bar chart of age group



Frequency bar chart of patients with different age group. Above figure demonstrating that 9 (12.9%) children, 40 (57.1%) adults and 21 (30%) elderly patients which included in this study while total number of patients 70 (100%).

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Table 2: Descriptive statistics of age

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
AGE (years)	70	.3	100.0	47.119	25.3168
Valid N (listwise)	70				

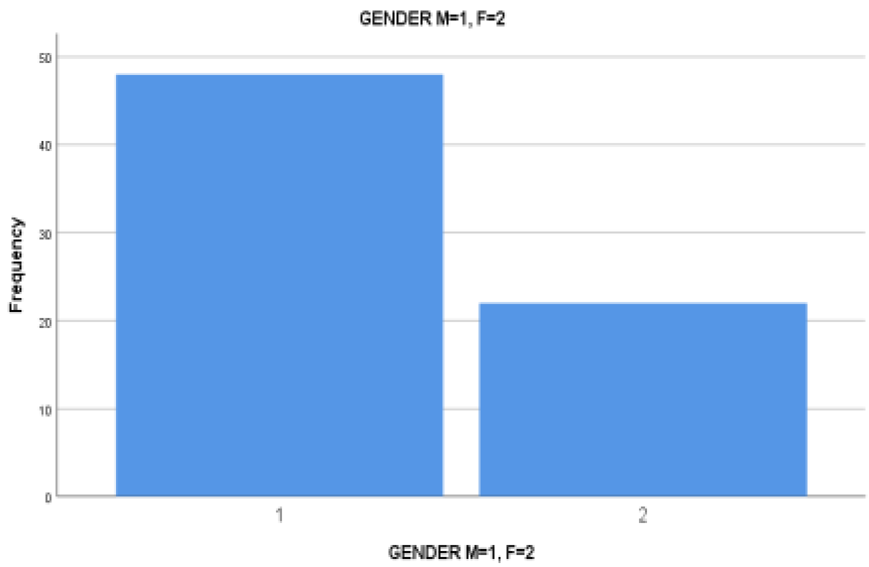
Table of patient age. Above table demonstrating that the **mean age of patients 47.11 ± 25.3 with** minimum 0.3 and maximum 100 years while total number of patients 70 (100%).

Table 3: Frequency table of gender

GENDER M=1, F=2					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	48	68.6	68.6	68.6
	2	22	31.4	31.4	100.0
	Total	70	100.0	100.0	

Frequency table of patient's gender. Above table demonstrating that **48 (68.6%) male and 22 (31.4%)** females' patients included in this study while total number of patients 70 (100%).

Figure 2: Frequency bar chart of patient gender



Frequency bar chart of patient's gender. Above table demonstrating that **48 (68.6%) male and 22 (31.4%)** females' patients included in this study while total number of patients 70 (100%).

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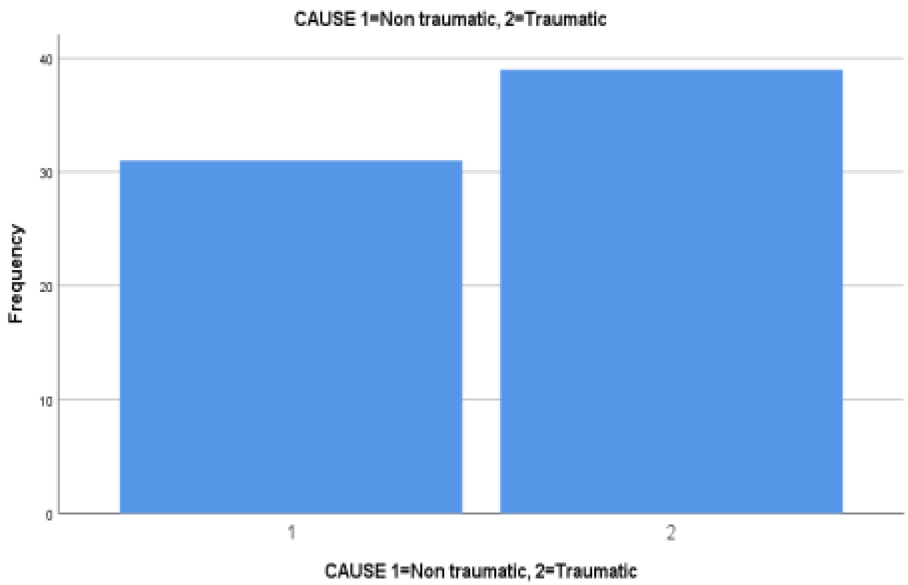
Table 4: Frequency table of causes

CAUSE 1=Non traumatic, 2=Traumatic					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	31	44.3	44.3	44.3
	2	39	55.7	55.7	100.0
	Total	70	100.0	100.0	

Frequency table of causes. Above table demonstrating that 31 (44.3%) non traumatic and 39 (55.7%) traumatic patients **included in this study while total number of patients 70 (100%).**

Figure 3: Frequency bar chart of causes



Frequency bar chart of causes. Above figure demonstrating that 31 (44.3%) non traumatic and 39 (55.7%) traumatic patients included in this study while total number of patients 70 (100%).

Table 5: Frequency table of types of ICH

Types of intracranial hemorrhage 1=SAH, 2=IPH, 3=SDH, 4=EDH, 5=Intraventricular, 6=Intracerebral					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	16	22.9	22.9	22.9
	2	13	18.6	18.6	41.4
	3	13	18.6	18.6	60.0
	4	11	15.7	15.7	75.7
	5	7	10.0	10.0	85.7
	6	10	14.3	14.3	100.0

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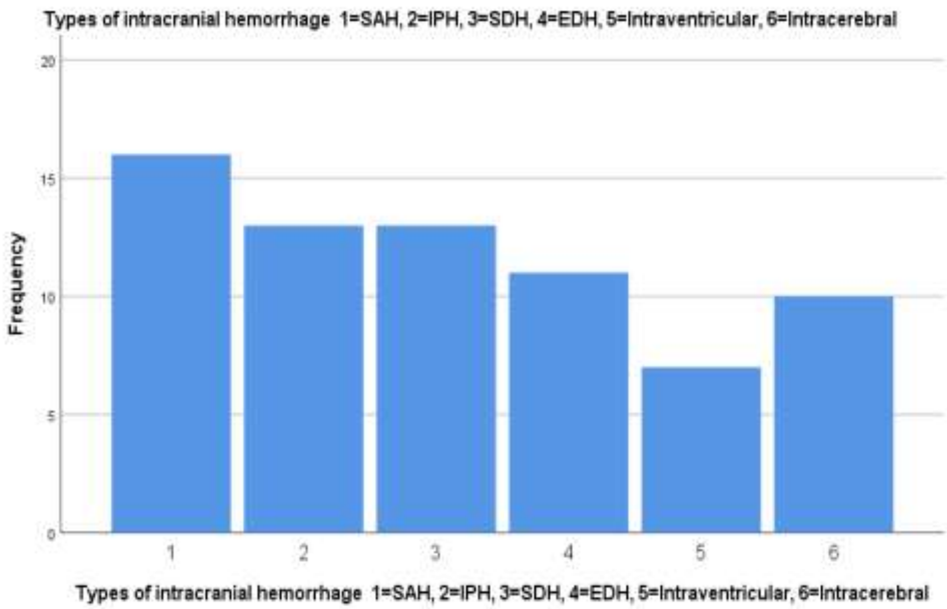
	Total	70	100.0	100.0	

Frequency table of types of intracranial hemorrhage. Above table demonstrating that 16 (22.9%) subarachnoid hemorrhage (SAH), 13 (18.6%) intraparenchymal hemorrhage (IPH), 13 (18.6%) subdural hemorrhage, 11 (15.7%) epidural hemorrhage, 7 (10%) intraventricular hemorrhage and 10 (14.3%) intracerebral hemorrhage included in this study while the overall 70 (100%) patients with different types of ICH presented.

Figure 4: Frequency bar chart of types of ICH



Frequency bar chart of types of intracranial hemorrhage. Above figure demonstrating that 16 (22.9%) subarachnoid hemorrhage (SAH), 13 (18.6%) intraparenchymal hemorrhage (IPH), 13 (18.6%) subdural hemorrhage, 11 (15.7%) epidural hemorrhage, 7 (10%) intraventricular hemorrhage and 10 (14.3%) intracerebral hemorrhage included in this study while the overall 70 (100%) patients with different types of ICH presented.

Table 6: Frequency table of midline shift

MIDLINE SHIFT 1=Yes, 2=No					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	8	11.4	11.4	11.4
	2	62	88.6	88.6	100.0
	Total	70	100.0	100.0	

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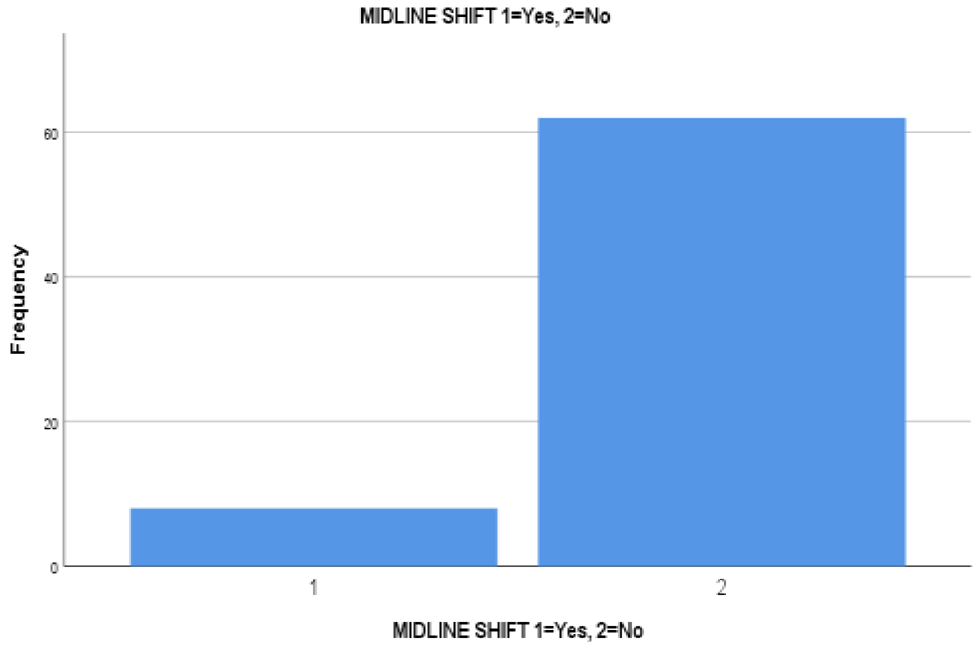
Frequency table of midline shift. Above table demonstrating that 8 (11.4%) **patients presented with midline shift while 62** (88.6%) **patients** presented without midline shift. While the total number of patients presented 70 (100%).

Figure 5: Frequency bar chart of midline shift



Frequency bar chart of midline shift. Above figure demonstrating that 8 (11.4%) patients presented with midline shift while 62 (88.6%) patients presented without midline shift. While the total number of patients presented 70 (100%).

Table 7: Frequency table of fracture

FRACTURE 1=Yes, 2=No					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	28	40.0	40.0	40.0
	2	42	60.0	60.0	100.0
	Total	70	100.0	100.0	

Frequency table of fracture. Above table demonstrating that **28** (**40.0**%) patients presented with fracture while 42 (60.0%) patients presented without fracture. While the total number of patients presented 70 (100%).

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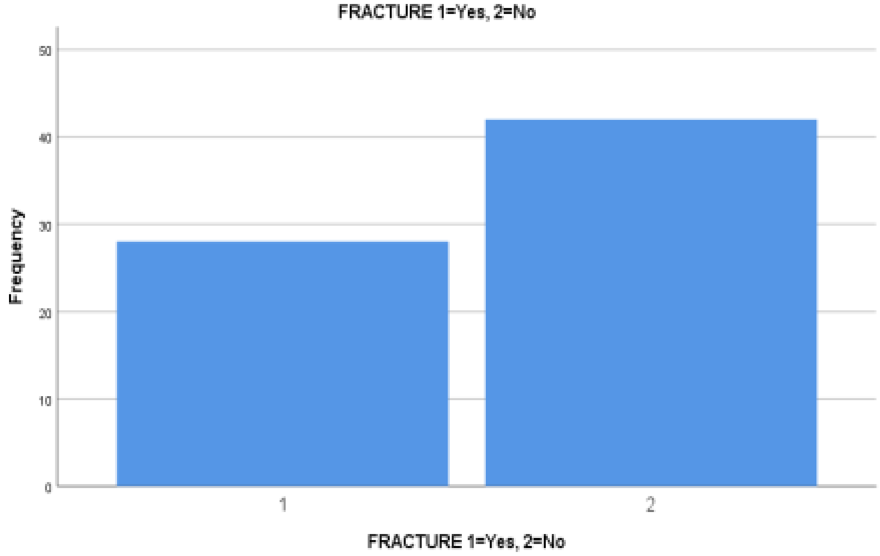
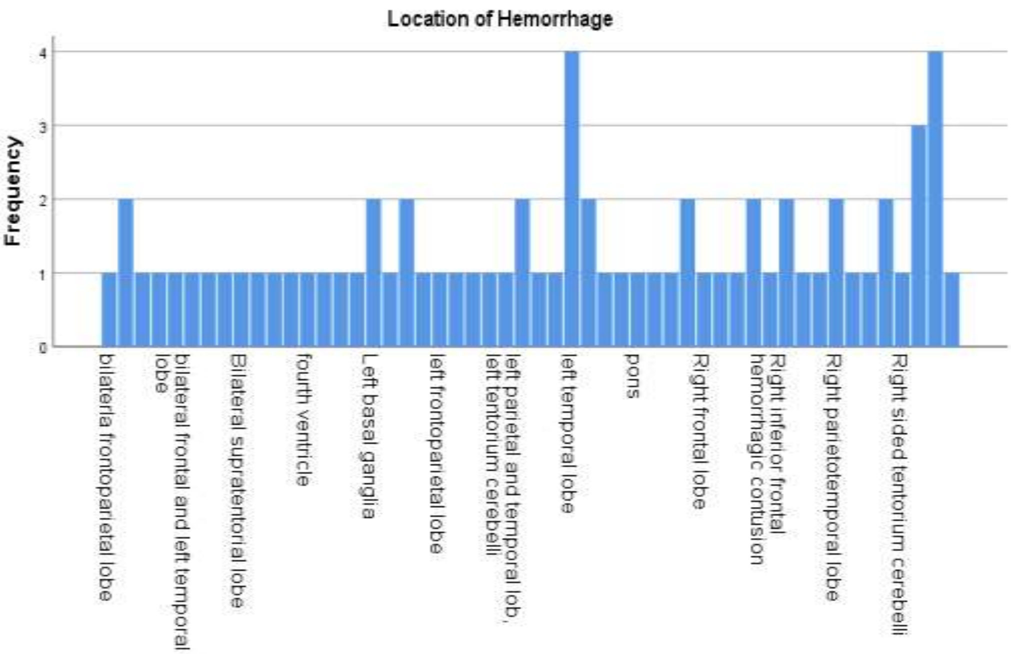
Figure 6: Frequency bar chart fracture



Frequency bar chart of fracture. Above figure demonstrating that 28 (40.0%) patients presented with fracture while 42 (60.0%) patients presented without fracture. While the total number of patients presented 70 (100%).

Figure 7: Frequency bar chart of location of hemorrhage



Frequency bar chart of location of hemorrhage. Above figure demonstrating the different locations of hemorrhage for each patient presented with ICH.

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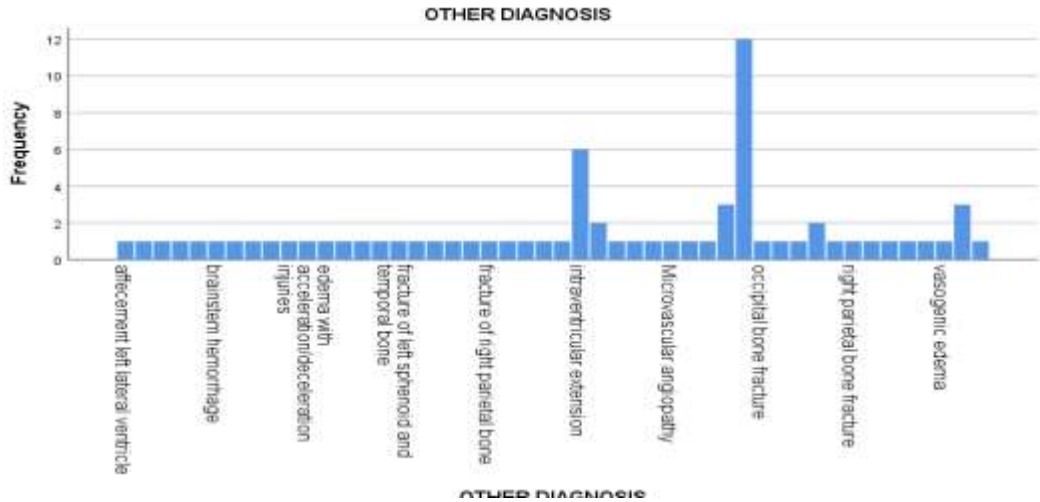
Figure 8: Frequency bar chart of other associated diagnosis



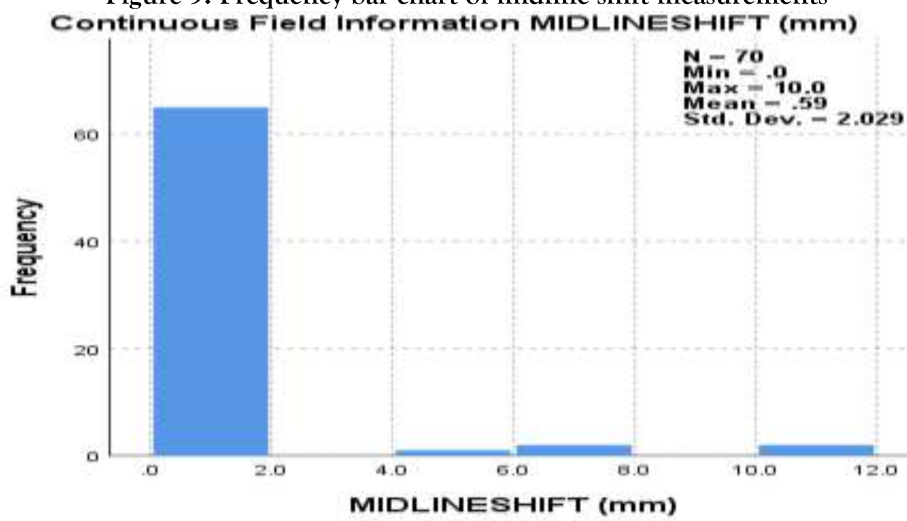
Frequency bar chart of others diagnosis. Above figure demonstrating the different others associated diagnosis of each patient presented with ICH.

Table 8: Descriptive statistics of midline shift

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
MIDLINESHIFT (mm)	70	.0	10.0	.591	2.0294
Valid N (listwise)	70				

Table of midline shift measurement in millimeters (mm). Above table demonstrating that the **mean midline shift measures 0.591 mm with minimum 0** and maximum 10 mm. The total number of patients 70 (100%).

Figure 9: Frequency bar chart of midline shift measurements



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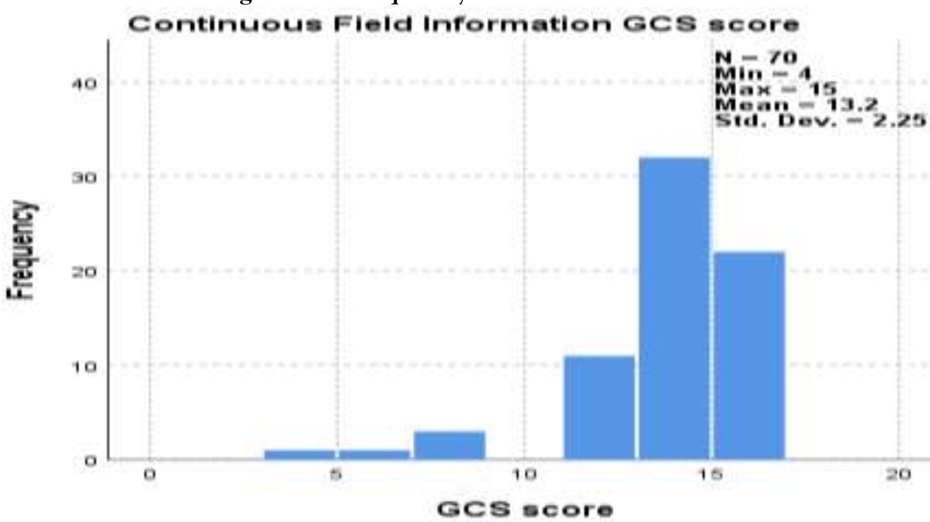
Bar chart of midline shift measurement in millimeters (mm). Above figure demonstrating that the **mean midline shift measures 0.591 mm with minimum 0 and maximum 10 mm. The total number of patients 70 (100%).**

Table 9: Descriptive statistics of GCS score

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
GCS score	70	4	15	13.21	2.252
Valid N (listwise)	70				

Table of Glasgow comma scale (GCS) score. Above table demonstrating that the mean GCS score 13.21 with minimum 4 and maximum 15. The total number of patients 70 (100%).

Figure 10: Frequency bar chart of GCS score



Bar chart of Glasgow comma scale (GCS) score. Above figure demonstrating that the **mean GCS** score 13.21 with minimum 4 and maximum 15. The total number of patients 70 (100%).

Table 10: Cross tabulation between age group and types of ICH

AGE GROUP 1=child, 2=adult, 3=elderly (Child0-17, 18-59 adult, above 60 elderly) * Types of intracranial hemorrhage 1=SAH, 2=IPH, 3=SDH, 4=EDH, 5=Intraventricular, 6=Intracerebral Crosstabulation									
			Types of intracranial hemorrhage 1=SAH, 2=IPH, 3=SDH, 4=EDH, 5=Intraventricular, 6=Intracerebral						Total
			1	2	3	4	5	6	
AGE GROUP 1=child, 2=adult, 3=elderly	1	Count	2	3	2	2	0	0	9
		Expected Count	2.1	1.7	1.7	1.4	.9	1.3	9.0
		% within AGE GROUP 1=child, 2=adult, 3=elderly	22.2%	33.3%	22.2%	22.2%	0.0%	0.0%	100.0%
	2	Count	9	5	9	9	3	5	40
		Expected Count	9.1	7.4	7.4	6.3	4.0	5.7	40.0

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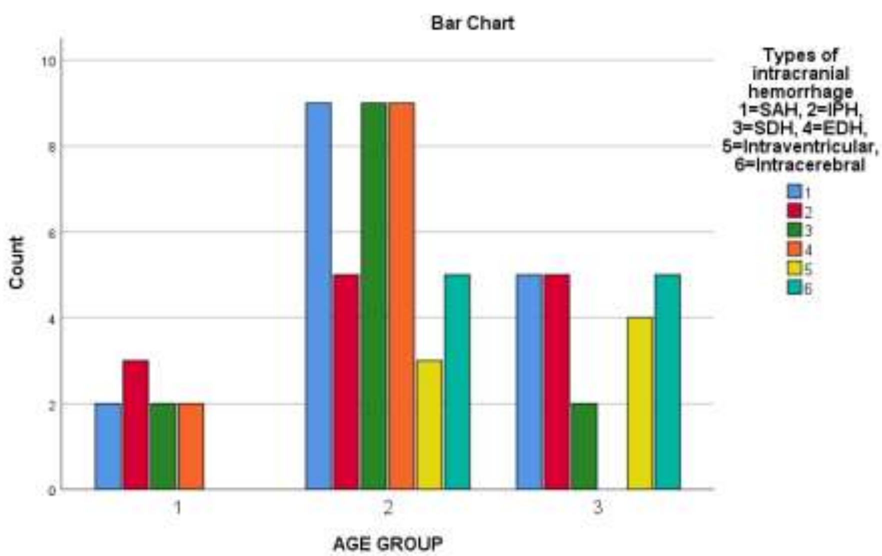
		% within AGE GROUP 1=child, 2=adult, 3=elderly	22.5%	12.5%	22.5%	22.5%	7.5%	12.5%	100.0%
	3	Count	5	5	2	0	4	5	21
		Expected Count	4.8	3.9	3.9	3.3	2.1	3.0	21.0
		% within AGE GROUP 1=child, 2=adult, 3=elderly	23.8%	23.8%	9.5%	0.0%	19.0%	23.8%	100.0%
Total		Count	16	13	13	11	7	10	70
		Expected Count	16.0	13.0	13.0	11.0	7.0	10.0	70.0
		% within AGE GROUP 1=child, 2=adult, 3=elderly	22.9%	18.6%	18.6%	15.7%	10.0%	14.3%	100.0%

Cross tabulation between types of intracranial hemorrhage and patient age group demonstrating different types of hemorrhage among the pediatric adult and elderly patients. Total 16 (22.9%) SAH in which 2 (22.2%) in pediatric, 9 (22.5%) in adults, and 5 (23.8%) in elderly patients seen. Total 13 (18.6%) IPH in which 3 (33.3%) in pediatric, 5 (12.5%) in adults and 5 (23.8%) in elderly patients seen. Total 13 (18.6%) SDH in which 2 (22.2%) in pediatric, 9 (22.5%) in adults and 2 (9.5%) in elderly patients seen. Total 11 (15.7%) EDH in which 2 (22.2%) in pediatric, 9 (22.5%) in adults and 0 (0.0%) in elderly patients seen. Total 7 (10.0%) IVH in which 0 (0.0%) in pediatric, 3 (7.5%) in adults and 4 (19.0%) in elderly patients seen. Total 10 (14.3%) ICH in which 0 (0.0%) in pediatric, 5 (12.5%) in adults and 5 (23.8%) in elderly patients seen. Overall 9, 40 and 21 pediatric, adult and elderly patients presented with ICH, total 70 patients recorded.

Figure 11: Graph between age group and types of ICH



Bar chart between patients of different age group and types of ICH. Above figure demonstrating that SAH, SDH and EDH more commonly seen in adult group of patient while pediatric patients only demonstrated the SAH, IPH, SDH and EDH in which IPH more commonly seen in this group of patients.

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Furthermore, SAH, IPH and ICH more commonly seen in elderly patients as compare to other groups.

Table 11: Cross tabulation between age group and fracture

AGE GROUP 1=child, 2=adult, 3=elderly (Child0-17, 18-59 adult, above 60 elderly) * FRACTURE 1=Yes, 2=No Crosstabulation					
			FRACTURE 1=Yes, 2=No		Total
			1	2	
AGE GROUP 1=child, 2=adult, 3=elderly	1	Count	7	2	9
		Expected Count	3.6	5.4	9.0
		% within AGE GROUP 1=child, 2=adult, 3=elderly	77.8%	22.2%	100.0%
	2	Count	19	21	40
		Expected Count	16.0	24.0	40.0
		% within AGE GROUP 1=child, 2=adult, 3=elderly	47.5%	52.5%	100.0%
	3	Count	2	19	21
		Expected Count	8.4	12.6	21.0
		% within AGE GROUP 1=child, 2=adult, 3=elderly	9.5%	90.5%	100.0%
Total		Count	28	42	70
		Expected Count	28.0	42.0	70.0
		% within AGE GROUP 1=child, 2=adult, 3=elderly	40.0%	60.0%	100.0%

Cross tabulation between fracture status and patient age group demonstrating fracture present or not among the pediatric adult and elderly patients. Total

9 pediatric patients presented with ICH out of which 7 (77.8%) with fracture and 2 (22.2%) without fracture. Total 40 adult's patients presented out which 19 (47.5%) with fracture and 21 (52.5%) without fracture. Total 21 elderly patients presented out of which 2 (9.5%) with fracture and 19 (90.5%) without fracture. Overall out of 70 patients 28 (40.0%) with fracture and 42 (60.0%) without fracture presented.

Table 12: Cross tabulation between age group and midline shift

AGE GROUP 1=child, 2=adult, 3=elderly (Child0-17, 18-59 adult, above 60 elderly) * MIDLINE SHIFT 1=Yes, 2=No Crosstabulation					
			MIDLINE SHIFT 1=Yes, 2=No		Total
			1	2	
AGE GROUP 1=child, 2=adult, 3=elderly	1	Count	1	8	9
		Expected Count	1.0	8.0	9.0
		% within AGE GROUP 1=child, 2=adult, 3=elderly	11.1%	88.9%	100.0%
	2	Count	3	37	40
		Expected Count	4.6	35.4	40.0

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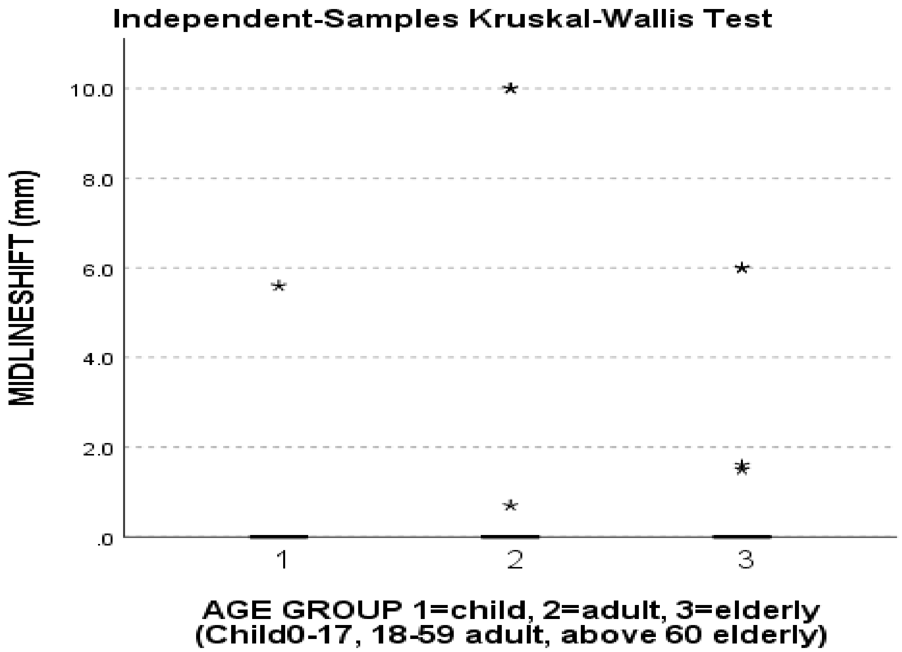
		% within AGE GROUP 1=child, 2=adult, 3=elderly	7.5%	92.5%	100.0%
	3	Count	4	17	21
		Expected Count	2.4	18.6	21.0
		% within AGE GROUP 1=child, 2=adult, 3=elderly	19.0%	81.0%	100.0%
Total		Count	8	62	70
		Expected Count	8.0	62.0	70.0
		% within AGE GROUP 1=child, 2=adult, 3=elderly	11.4%	88.6%	100.0%

Cross tabulation between midline shift status and patient age group demonstrating midline shit present or not among the pediatric adult and elderly patients. Total 9 pediatric patients presented with ICH out of which 1 (11.1%) with midline shift and 8 (88.9%) without midline shift. Total 40 adults patients presented out which 3 (7.5%) with midline shift and 37 (92.5%) without midline shift. Total 21 elderly patients presented. out of which 4 (19.0%) with midline shift and 17 (81.0%) without midline shift. Overall out of 70 patients 8 (11.4%) with midline shift and 62 (88.6%) without midline shift presented.

Figure 12: Graph between age group and midline shift



Graph between midline shift status and patient age group demonstrating midline shit present or not among the pediatric adult and elderly patients. Total 9 pediatric patients presented with ICH out of which

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1 (11.1%) with midline shift and 8 (88.9%) without midline shift. Total 40 adults patients presented out of which 3 (7.5%) with midline shift and 37 (92.5%) without midline shift. Total 21 elderly patients presented out of which 4 (19.0%) with midline shift and 17 (81.0%) without midline shift. Overall out of 70 patients 8 (11.4%) with midline shift and 62 (88.6%) without midline shift presented.

Table 13: Cross tabulation between age group and GCS score

AGE GROUP 1=child, 2=adult, 3=elderly (Child0-17, 18-59 adult, above 60 elderly) * GCS score Crosstabulation

			GCS score									Total
			4	5	7	8	11	12	13	14	15	
AGE GROUP 1=child, 2=adult, 3=elderly	1	Count	0	0	1	0	0	0	4	1	3	9
		Expected Count	.1	.1	.1	.3	.3	1.2	1.9	2.2	2.8	9.0
		% within AGE GROUP	0.0%	0.0%	11.1%	0.0%	0.0%	0.0%	44.4%	11.1%	33.3%	100.0%
	2	Count	1	1	0	0	1	4	8	10	15	40
		Expected Count	.6	.6	.6	1.1	1.1	5.1	8.6	9.7	12.6	40.0
		% within AGE GROUP	2.5%	2.5%	0.0%	0.0%	2.5%	10.0 %	20.0%	25.0%	37.5%	100.0%
	3	Count	0	0	0	2	1	5	3	6	4	21
		Expected Count	.3	.3	.3	.6	.6	2.7	4.5	5.1	6.6	21.0
		% within AGE GROUP	0.0%	0.0%	0.0%	9.5%	4.8%	23.8 %	14.3%	28.6%	19.0%	100.0%
Total		Count	1	1	1	2	2	9	15	17	22	70
		Expected Count	1.0	1.0	1.0	2.0	2.0	9.0	15.0	17.0	22.0	70.0
		% within AGE GROUP	1.4%	1.4%	1.4%	2.9%	2.9%	12.9 %	21.4%	24.3%	31.4%	100.0%

Cross tabulation between GCS score and patient age group demonstrating GCS score among the pediatric adult and elderly patients. Total 9 pediatric patients presented with ICH out of which 1 (11.1%) with GCS score 7, 4 (44.4%) with 13, 1 (11.1%) with 14 and 3 (33.3%) with 15. Total 40 adults patients presented out which 1 (2.5%) with 4, 1 (2.5%) with 5, 1 (2.5%) with 11, 4 (10.0%) with 12, 8 (20.0%) with 13, 10 (25.0%) with 14 and 15 (37.5%) with 15 GCS score. Total 21 elderly patients presented out of which 2 (9.5%) with 8, 1 (4.8%) with 11, 5 (23.8%) with 12, 3 (14.3%) with 13, 6 (28.6%) with 14 and 4 (19.0%) with 15 GCS score. Overall out of 70 patients single (1.4%) with 4,5 and 7, 2 (2.9%) with 8 and 11, 9 (12.9%) with 12, 15 (21.4%) with 13, 17 (24.3%) with 14 and 22 (31.4%) with 15 GCS score presented.

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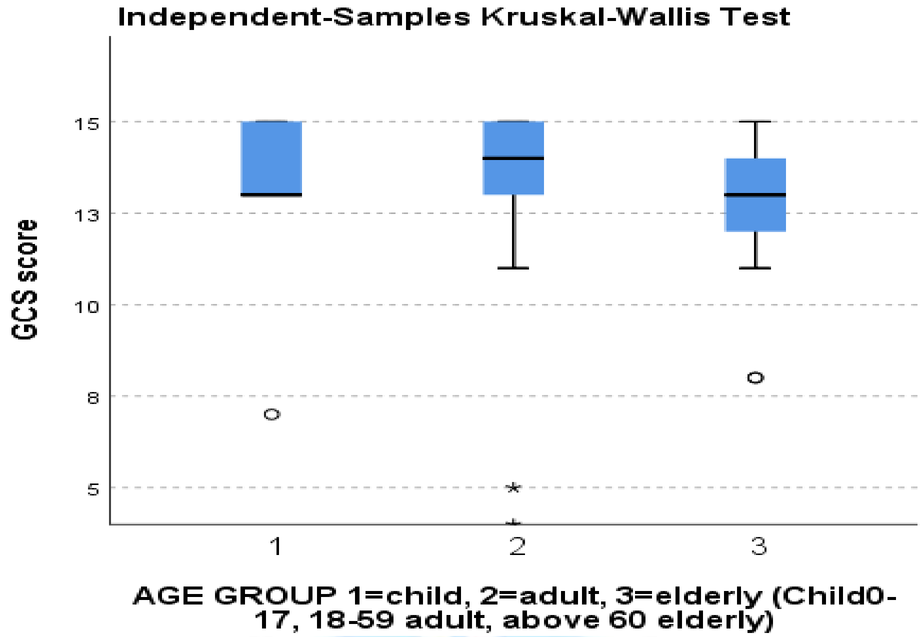
Figure 13: Graph between age group and GCS score



Graph between GCS score and patient age group demonstrating GCS score among the pediatric adult and elderly patients. Total 9 pediatric patients presented with 7, 13, 14 and 15 GCS score. Total 40 adults patients presented with 4, 5, 11, 12, 13, 14 and 15 GCS score. Total 21 elderly patients presented with 8, 11, 12, 13, 14 and 15 GCS score.

Table 14: Cross tabulation between midline shift and causes

MIDLINE SHIFT 1=Yes, 2=No * CAUSE 1=Non traumatic, 2=Traumatic Crosstabulation

			CAUSE 1=Non traumatic, 2=Traumatic		
			1	2	Total
MIDLINE SHIFT 1=Yes, 2=No	1	Count	3	5	8
		Expected Count	3.5	4.5	8.0
		% within MIDLINE SHIFT 1=Yes, 2=No	37.5%	62.5%	100.0%
	2	Count	28	34	62
		Expected Count	27.5	34.5	62.0
		% within MIDLINE SHIFT 1=Yes, 2=No	45.2%	54.8%	100.0%
Total		Count	31	39	70
		Expected Count	31.0	39.0	70.0
		% within MIDLINE SHIFT 1=Yes, 2=No	44.3%	55.7%	100.0%

Cross tabulation between midline shift status and cause which demonstrating that total number of patients presented with midline shift 8 out of which 3 (37.5%) non traumatic and 5 (62.5%) traumatic. 62 patients presented with no midline shift out of which 28 (27.5%) non traumatic and 34 (54.8%) traumatic.

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Table 15: Cross tabulation between types of ICH and Causes

Types of intracranial hemorrhage 1=SAH, 2=IPH, 3=SDH, 4=EDH, 5=Intraventricular, 6=Intracerebral * CAUSE 1=Non traumatic, 2=Traumatic Crosstabulation

			CAUSE		
			1	2	Total
Types of intracranial hemorrhage	1	Count	8	8	16
		Expected Count	7.1	8.9	16.0
		% within Types of intracranial hemorrhage	50.0%	50.0%	100.0%
	2	Count	7	6	13
		Expected Count	5.8	7.2	13.0
		% within Types of intracranial hemorrhage	53.8%	46.2%	100.0%
	3	Count	2	11	13
		Expected Count	5.8	7.2	13.0
		% within Types of intracranial hemorrhage	15.4%	84.6%	100.0%
	4	Count	0	11	11
		Expected Count	4.9	6.1	11.0
		% within Types of intracranial hemorrhage	0.0%	100.0%	100.0%
	5	Count	7	0	7
		Expected Count	3.1	3.9	7.0
		% within Types of intracranial hemorrhage	100.0%	0.0%	100.0%
	6	Count	7	3	10
		Expected Count	4.4	5.6	10.0
		% within Types of intracranial hemorrhage	70.0%	30.0%	100.0%
Total		Count	31	39	70
		Expected Count	31.0	39.0	70.0
		% within Types of intracranial hemorrhage	44.3%	55.7%	100.0%

Cross tabulation between types of ICH and cause demonstrating that 16 patients presented with SAH out of which 8 (50.0%) non traumatic and 8 (50.0%) traumatic. 13 patients presented with IPH out of which 7 (53.8%) non traumatic and 6 (46.2%) traumatic. 13 patients presented with SDH out of which 2 (15.4%) non traumatic and 11 (84.6%) traumatic. 11 patients presented with EDH out of which 0 (0.0%) non traumatic and 11 (100%) traumatic. 7 patients presented with IVH out of which 7 (100%) non traumatic and 0 (0.0%) traumatic. 10 patients presented with ICH out of which 7 (70.0%) non traumatic and 3 (30.0%) traumatic. Overall 70 patients presented ICH out which 31 (44.3%) non traumatic and 39 (55.7%) traumatic.

Table 16: Correlation between GCS score and midline shift

Correlations			
		MIDLINESHIFT (mm)	GCS score
MIDLINESHIFT (mm)	Pearson Correlation	1	-.876**

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	Sig. (2-tailed)		.000
	N	70	70
GCS score	Pearson Correlation	-.876**	1
	Sig. (2-tailed)	.000	
	N	70	70
**. Correlation is significant at the 0.01 level (2-tailed).			

Table of correlation between midline shift and GCS score, demonstrating (r = −0.876, p < 0.001) which means that patients having severe midline shift showing on CT scan had lower GCS score. This indicate the statistically significant association between midline shift and GCS score.

Table 17: ANONA test of GCS score

ANOVA					
GCS score					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	249.395	35	7.126	2.413	.006
Within Groups	100.390	34	2.953		
Total	349.786	69			

One way ANOVA statistical test conducted to compare the GCS score between the different age group patients. The results demonstrated that significant difference in mean Glasgow coma score among different age groups F (35, 34) = 2.41, p = 0.006. These values indicate that the consciousness significantly varied among the children, adult and elderly patients on the basis of their characteristics. Patients having severe intracranial hemorrhage and associated findings demonstrated lower GCS scores.

Table 18: ANOVA test of midline shift

ANOVA					
MIDLINESHIFT (mm)					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	228.568	35	6.531	3.993	.000
Within Groups	55.607	34	1.635		
Total	284.175	69			

One way ANOVA test conducted for midline shift as well which indicating that statistically significant difference in mean midline shift among the different age groups F(35, 34) = 3.99, p < 0.001. These results demonstrating that the midline shift on CT scan significantly different in children, adult and elderly patients.

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DISCUSSION

The aim of this study to compare the different types of intracranial hemorrhage in patients of different age group such as pediatric, adult and elderly on computed tomography. In this study we also compare the radiological feature with clinical markers of hemorrhagic patients such as midline shift with Glasgow comma score (GCS) score among different age group patients. The results of this study demonstrated that there is statistically significant difference in CT imaging characteristics and clinical outcomes among from different age group. Also the cause of hemorrhage and type of hemorrhage play crucial role in evaluating the severity and patterns of intracranial hemorrhage.

According to this study the most common or predominant cause of intracranial hemorrhage is trauma as results demonstrated that out of total 70 patient presented with intracranial hemorrhage 31 (44.3%) were non traumatic and 39 (55.7%) were traumatic patients. These results consistent with research study of Porcari et al (2018), who concluded in their research studies that trauma and vascular malformation are the leading etiologies of intracranial hemorrhage particularly in pediatric and adult patients whereas hypertension and microvascular cerebral amyloid angiopathy are the most common causes in elderly patients for intracranial hemorrhage. [50]

The types of intracranial hemorrhage differs significantly among the patients of different age groups. Results demonstrating that SAH, SDH and EDH more commonly seen in adult patients while pediatric patients only demonstrated the SAH, IPH, SDH and EDH in which IPH more commonly seen in this group of patients. Furthermore, SAH, IPH and ICH more commonly seen in elderly patients as compare to other groups. The similar age related ICH variation also demonstrated in a research study by van Asch et al. (2010) and Feigin et al. (2022), they concluded that occurrence and mortality rate of intracranial hemorrhage increasing with age mainly due to vascular changes. [12, 49]

Glasgow comma score (GCS) also observed in this study which demonstrated that the mean GCS score 13.21 with minimum 4 and maximum 15 within 70 patients presented with intracranial hemorrhage indicating the moderate neurological deficit in patients with ICH. One way ANOVA statistical test conducted to compare the GCS score between the different age group patients. The results demonstrated that significant difference in mean Glasgow coma score among different age groups F (35, 34) = 2.41, p = 0.006. These values indicate that the consciousness significantly varied among the children, adult and elderly patients on the basis of their characteristics. Patients having severe intracranial hemorrhage and associated findings demonstrated lower GCS scores. The elderly patients indicating lower GCS score as compare to adults which shows the severe neurological deterioration. These findings are consistent with the results of Qureshi et al. (2020) who demonstrated that advance age and large size of hematoma due to ICH strongly associated with the lower GCS which causes worse outcomes. Similarly charidimou et al. (2022) demonstrated in their research results that elderly patients indicating more severe bleeding and clinical outcomes particularly those with microvascular cerebral amyloid angiopathy or on anticoagulant therapy.

Midline shift is crucial CT imaging marker to indicate the mass effect and intracranial pressure. In this study One way ANOVA test conducted for midline shift as well which indicating that statistically significant difference in mean midline shift among the different age groups $F(35, 34) = 3.99$, $p < 0.001$. These results demonstrating that the midline shift on CT scan significantly different in children, adult and elderly patients. Results showing that the mean midline shift measures 0.591 mm with minimum 0 and maximum 10 mm among 70 patients of ICH. Total 9 pediatric patients presented with ICH out of which 1 (11.1%) with midline shift, 40 adults patients presented out of which 3 (7.5%) with midline shift and 21 elderly patients presented out of which 4 (19.0%) with midline shift. Overall out of 70 patients 8 (11.4%) with midline shift and 62 (88.6%) without midline shift presented. Patients with IPH and SDH showing severe midline shifts. These findings support the previous results by Wintermark et al. (2019) and Wardlaw & smith (2014) who demonstrated the CT role for hematoma size and midline shift markers in acute intracranial hemorrhage management. [3, 1]

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According to this study correlation between midline shift and GCS score demonstrating ($r = -0.876$, $p < 0.001$) which means that patients having severe midline shift showing on CT scan had lower GCS score. This indicate the statistically significant association between midline shift and GCS score. Similarly comparable association between radiological features such as mass effect and clinical outcome like GCS score demonstrated by Qureshi et al (2020) and Li et al. (2024) which make sure this correlation is reliable. [16, 24]

The results of this study emphasize the role of computed tomography, which is not only a diagnostic tool but also it provide the prognostic marker in all types' pf intracranial hemorrhage among different age groups. Some CT parameters such as midline shift measurement play a crucial role by providing crucial information for patient management when compare with the clinical outcomes such as Glasgow comma score (GCS). Understanding ICH CT imaging features according to different age group surely guide in patient monitoring, management and treatment plan in emergency settings.

This study completed with smaller sample size in limited region which may not completely shows the population level differences. Other than that various variables which may provide the in depth understanding regarding prognosis such as hematoma size, management plan and clinical outcomes at follow up not included in this study. Future researches with large sample sizes from multiple regions with advance CT imaging techniques such as CT brain perfusion with inclusion of other clinical and radiological variables recommended to validate these results.

Overall this study indicated that the age, etiologies and ICH types significantly influence the radiological characteristics and clinical features in patients who presented with intracranial hemorrhage. Elderly patients showed the lower GCS score and severe midline shift which reflected the poor prognosis. The negative correlation between midline shift and GCS indicate the importance of radiological features and clinical presentations for evaluating the clinical outcomes and improving the management plans for patients present with ICH.

CONCLUSION

The findings showed that trauma was the predominant cause of intracranial hemorrhage in children and adults, whereas non-traumatic causes such as hypertension and cerebral amyloid antipathy were more common in the elderly. Extra-axial hemorrhages (subdural and epidural) were mainly observed in adults, while Intraparenchymal hemorrhage was more frequent in elderly patients. Significant differences in midline shift and Glasgow Coma Scale (GCS) scores across age groups indicated increased radiological severity and poorer neurological status with advancing age. A negative correlation between midline shift and GCS highlighted that greater mass effect was associated with worse clinical outcomes, underscoring the pivotal role of CT in diagnosing, classifying, and prognosticating intracranial hemorrhage in emergency settings.

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