AIM OF THE WORK

The aim of the work is to assess the role of FAST and CT in the emergency department for the management of intra-abdominal injuries in pediatric patients with blunt abdominal trauma.

PATIENTS

This prospective study was conducted on all patients in pediatric age group less than 18 years with blunt abdominal trauma admitted to Alexandria Main University Hospital within 6 months from 1st of May 2013 to 30th of October 2013 with a total of one hundred and fifty patients.

Patients with penetrating trauma were excluded. And patients above 18 years also were not included.

METHODS

Study Design

Prospective observational study.

Study Setting

Emergency Department of Alexandria Main University Hospital, Egypt.

Patient selection

Eligible to our study, we included children aged less than 18 years at risk for intra-abdominal injury following blunt abdominal trauma. Admission and primary assessment of patients were made in emergency department. Full history with special emphasis on mode of trauma and time between trauma and presentation was taken from all patients who underwent abdominal ultrasound examination while in the ED. We excluded patients with penetrating abdominal trauma as well as adults.

Patients were considered at risk for intra-abdominal injury if they had any one of the following in association with blunt torso trauma:

1) A significant mechanism of injury (motor vehicle collision, ejection from a motor vehicle, automobile versus pedestrian, falls over 10 feet)
2) A decreased level of consciousness according to Glasgow coma scale (GCS)
3) Extremity paralysis or multiple bone fractures
4) Physical examination suggestive of intra-abdominal injury.

Each patient was enrolled prospectively by the ED physician caring for the patient. Data collected included mechanism of injury and initial physical examination findings. The pediatric or trauma surgical resident on the trauma team determined the need for laparotomy.

Patient assessment

1- Physical examination

All patients were managed according to ATLS 9 guidelines by the American College of Surgeons [32]. Examination included primary survey and secondary survey. The primary survey included airway, breathing, circulation, disabilities and exposure. The secondary survey was done via examining all the body from head to toe with special consideration to the abdominal examination.[67]

A. <u>Primary Survey and Resuscitation:</u> that includes management of life threatening conditions, it includes ABCDE approach:

➢ ***Airway maintenance with cervical spine protection:***

Airway was assessed for patency and clearance. If the patient was able to talk or cry, the airway was likely to be clear and this patient cervical spine was protected only. If the patient was unconscious, he/she may would not have been able to maintain his/her own airway. In a spontaneously breathing child with a partially obstructed airway, the airway was opened by jaw thrust maneuver (Fig.11) combined with bimanual inline spinal immobilization. Airway adjuncts might be required up to endotracheal tube (ETT) insertion. An oral airway was avoided as possible unless a child was unconscious, since vomiting is likely if the gag reflex is intact. Nasopharyngeal airways was avoided if there was any suspicious of fractured base of skull.

If it was not clear because of secretions (e.g. by blood or vomit), the fluid was cleaned out of the patient's mouth by the help of suctioning.

Endotracheal intubation with adequate cervical immobilization was done for injured children in a variety of situations, including severe brain injury requiring controlled ventilation, if airway cannot be maintained, signs of ventilatory failure, significant hypovolemia, and depressed sensorium. Full preoxygenation was crucial in each step to establish an airway.

Cervical spine protection was done by placement of a 1-inch-thick layer of padding beneath the infant's or toddler's entire back to preserve neutral alignment of the spinal column. Neck collar with appropriate size was used for children with suspected cervical spine injury.

- ***Breathing: Ventilation and Oxygenation:***

The neck and chest were exposed while ensuring immobilization of the head and neck. The rate and depth of respirations were determined. The respiratory rate in children decreases with age. An infant breathes 30 to 40 times per minute, whereas an older child breathes 15 to 20 times per minute. Normal, spontaneous tidal volumes vary from 4 to 6 mL/kg for infants and children, although slightly larger tidal volumes of 6 to 8 mL/kg, and occasionally as high as 10 mL/kg, may be required during assisted ventilation.

The neck and chest for tracheal were examined deviation, unilateral and bilateral chest movement, use of accessory muscles, and any signs of injury like flail segments or wounds. Palpation was done for assessment of fracture ribs, sites of tenderness. Percussion of the chest was done for presence of dullness or hyper resonance, Auscultation of the chest bilaterally was done for air entry assessment and additional sounds. High-concentration oxygen was administered, the patients were ventilated with a pediatric bag-mask device if was needed, relief of tension pneumothorax by needle thoracentesis and tube thoracostomy were carried out. The patients were monitored by pulse oximetry.

- ***Circulation and hemorrhage control***

Identification of any source of external hemorrhage; where direct pressure was applied; or potential source(s) of internal hemorrhage was done.

We examined the pulse for Quality, rate, and equality. Abnormal values for vital signs were determined by the patients age and included systolic blood pressure (abnormal < 70+2(age) for 0–10 years old and < 90 for ages over 10 years old) and heart rate (abnormal > 180 for 0–1 year old, > 150 for 1–3 years old, > 135 for 4–8 years old, and > 110 for 9–16 years old) according to APLS [68].The patients were stratified into four grades of hypovolemic shock mentioned in (Table 1).

Two wide pore IV lines were inserted peripherally. IV fluid therapy with warmed crystalloid and cross matched blood product replacement were initiated. Interosseous line insertion was needed in some cases in the anteromedial portion of the tibia.

Failure to improve hemodynamic abnormalities following the first bolus of resuscitation fluid raises the suspicion of continuing hemorrhage, prompts the need for administration of a second and perhaps a third 20 mL/kg bolus of crystalloid fluids. Vasopressors were needed if no response to fluids only.

- ***Disability: Brief neurologic examination***

Determine the level of consciousness using the GCS was determined according to age mentioned in (Tables 2 and 3). The pupils were checked for size and reaction. Lateralizing signs and spinal cord injury were assessed. Exclusion of other causes of coma rather than TBI was done via RBS, identification of toxicological state or alcohol intake also was done.

- ***Exposure/Environmental control***

Completely undress the patient, but segmentally with prevention of hypothermia via warm blankets and warm solutions.

- ***Adjuncts to primary survey and resuscitation***

Insertion of urinary and gastric catheters were done unless contraindicated to monitor the patient's hourly output of urine. Attachment of ECG, and pulse oximetry monitors was done. Performance of FAST for the cases was done sonographers from the radiology department.

B. Secondary Survey and Management

When the patient was well resuscitated, the secondary survey began. The secondary survey is a head-to-toe examination with special consideration to the abdominal examination. If at any time during the secondary survey the patient deteriorates, another primary survey was carried out as a potential life threat may be present. The person should be removed from the hard spine board and placed on a firm mattress as soon as reasonably feasible as the spine board can rapidly cause skin breakdown and pain while a firm mattress provides equivalent stability for potential spinal fractures (96). This included:

- ***AMPLE history and mechanism of injury***

Full history including **S**igns and symptoms, **A**llergies, **M**edications, **P**ast history or pregnancy, **L**ast meal, and **E**vents or environment. (37) The patients were stratified according to the mechanism of trauma.

- ***Physical examination,*** including the reassessment of all vital signs. Each region of the body was fully examined.
- ***Head and neck***

Inspection and palpation of the entire head and face for lacerations, contusions, fractures, and thermal injury. Pupils were reevaluated, level of consciousness and GCS score were reevaluated. Cranial-nerve function were examined. Inspection of ears and nose for cerebrospinal fluid leakage.

- ***Chest examination***

Assessment for signs of chest injuries, pattern of breathing, palpation for fractures and surgical emphysema, Auscultation of breath and heart sounds. Tube thoracostomy under water seal drainage was done when indicated. Open chest wounds were covered with sterile dressing till cardiothoracic surgeon assessment. FAST examination reviewed pericardial fluid by Subxiphoid view.

- ***Abdominal and perineal examination***

The initial clinical assessment of patients with blunt abdominal trauma is often difficult and notably inaccurate. Associated injuries often cause tenderness and spasms in the abdominal wall and make diagnosis difficult. Lower rib fractures, pelvic fractures, and abdominal wall contusions may mimic the signs of peritonitis. So, clinical evaluation alone has an accuracy rate of only 65% for detecting the presence or absence of intra-peritoneal blood.

The abdominal examination must be systematic by inspection, palpation and auscultation and the patients were stratified according to the abdominal signs:

1- **Inspection:** for abrasions or ecchymosis (e.g. lap belt abrasions, steering wheel–shaped contusions). Inspection for abdominal distention that may be due to pneumoperitoneum, abdominal collection.
2- **Palpation and percussion:** We considered abdominal tenderness present if the conscious child stated that palpation caused pain, if the patient grimaced on palpation, or if there was voluntary guarding. But it was not considered present if there was DLC. Palpation signs revealed, lax abdomen, local or generalized tenderness, guarding, rigidity, or rebound tenderness, which suggests peritoneal injury. Fullness and doughy consistency on palpation may indicate intra-abdominal hemorrhage.
3- **Auscultation:** Auscultation of bowel sounds or abdominal bruit
4- **Perineal and Rectal pelvic examinations:** Positive signs include evidence of bony penetration, the rectal tone, and palpation of a high-riding prostate in male patients. The genitals and perineum were examined for soft tissue injuries, bleeding, and hematoma. PR was avoided in children unless indicated due to its traumatic effect.
5- A nasogastric tube was placed routinely (in the absence of contraindications, e.g., basilar skull fracture) to decompress the stomach and to assess for the presence of blood. If the patient has evidence of a maxillofacial injury, an orogastric tube is preferred.
6- Urinary catheter was inserted when was needed to follow the patient urine output in all cases with hypovolemic shock.
7- Insertion of central venous catheter in children with hypovolemic shock non responsive to fluids only and vasopressors used when were needed.

- ***Musculoskeletal examination***

Extremities were examined for contusions, lacerations, deformities, fractures, bleeding. Palpation was done for tenderness, crepitation, abnormal movement, and sensation. The peripheral pulses were examined. The pelvis was assessed for fractures. The Spine was assessed. Immobilization was done using splints for the limbs until further fixation to be done.

- ***Neurological examination***

Assessment for level of consciousness, the pupils, motor and sensory functions of the limbs and cranial nerves, and presence of lateralizing signs.

- ***Adjuncts to secondary survey***

The diagnostic imaging tests were done as the patient's condition permitted these included: chest, spine and pelvis X-rays, and long bones according to clinical examination, CT scan of the head for TBI.

2- Laboratory investigations

Which include:

- Complete blood count (CBC) to have an idea about the blood loss.
- Liver Profile including (AST, ALT)
- Renal functions including (Urea and Creatinine)
- Coagulation profile including prothrombin time (PT), partial thromboplastin time (PTT) and INR (international normalized ratio).

3- Abdominal imaging examinations and definitions

a) Ultrasonography

Ultrasound examinations were performed in the ED by sonographers from the department of radiology who were trained in trauma ultrasonography. A portable ultrasound scanner was used with 3.5 MHz and 5.0 MHz probes of Toshiba Nemio 20 device, Toshiba Corporation, Otawara, Japan. (Fig. 23 and 24).

The ultrasound blunt trauma protocol for the detection of intraperitoneal fluid (hypoechoic area) included views of subdiaphragmatic areas, Morison's pouch (hepatorenal interface), bilateral paracolic gutters, suprapubic region, and the splenorenal fossae. The examinations occurred during the initial evaluation of the patient in the ED (Fig. 16).

Bedside interpretations for the presence of intraperitoneal fluid were made at the time of ultrasound scan. Ultrasound scans were classified as positive if intraperitoneal fluid was identified and negative if no such fluid was identified. The protocol did not include dedicated ultrasound imaging of solid organs for potential injury.

The minimum fluid that ultrasound can detect has been estimated at 70-250 cc depending on the study. Four basic planes have been used in trauma ultrasound to constitute the FAST exam (Focused Abdominal Ultrasound for Trauma). The right upper quadrant (RUQ or right lateral/ longitudinal plane) is located near the rib margin on the upper right side. This view can demonstrate right hepatic lobe lesions, subhepatic fluid, retroperitoneal fluid, right kidney lesions, and intrathoracic fluid.

The Subxiphoid view (or transverse epigastric plane) reveals the pancreas, left hepatic lobe injuries, intra-abdominal gas, pericardial fluid/ tamponade, and gross cardiac motion. The left upper quadrant view (LUQ or left lateral/longitudinal view) is located opposite the right view. This view depicts splenic lesions, Perisplenic fluid, intra-thoracic fluid, left kidney injuries, and retroperitoneal fluid. Finally, the suprapubic/transverse view can reveal fluid behind the bladder in what is called Douglas' Pouch.

For the current study, the bedside interpretations were used to calculate the accuracy of ultrasound for detecting intraperitoneal fluid associated with intra-abdominal injury. A senior resident radiologist confirmed the ultrasound scans as positive if intraperitoneal fluid was identified and negative if no such fluid was noted.

Fig. (23): Toshiba Nemio 20 Ultrasound device.

Fig. (24): Ultrasound probes.

b) Computed tomography

A single experienced radiologist was asked to give all clinical data including initial ultrasound interpretations and abdominal CT scan. Computed tomography of the abdomen were obtained using a16 slice MX 16 Philips device (fig. 25). Scans were performed using 2.5-mm slice thickness collimation (pitch = 1.375) for patients with body weight of 10 kg or less, and 5-mm collimation (pitch =1.375) for body weight higher than 10 kg with or without intravenous contrast. No oral contrast was administered. The radiologist identified all injuries visualized on abdominal CT including the presence or absence of intraperitoneal fluid. Hemoperitoneum on CT was identified by its density which was determined by Hounsfield units (HU) and divided in low (up to 15 HU), intermediate (N15 and b50 HU), and high (≥50 HU). Intra-abdominal injury was defined as the presence of an injury to the spleen, liver, pancreas, or gastrointestinal (GI) tract. The presence or absence of intra-abdominal injury was determined by abdominal CT scanning, laparotomy, or the patients' clinical courses.

CT of the abdomen was not performed routinely for FAST-negative patients who showed no clinical sign of intra-abdominal trauma, which suggests that performing CT in this group would incur unnecessary cost and risk from radiation, while showing no benefit to the patient. Some patients required light pharmacological sedation during the procedure.

c) X-ray abdomen

The abdominal x-ray can be unreliable in underlying intra-abdominal injury. Nevertheless, review of the abdominal part of a pelvic x-ray screening for pelvic fracture is of potential use, but may be used for detection of traumatic perforated gut which appear on plain erect x-ray as air under diaphragm.

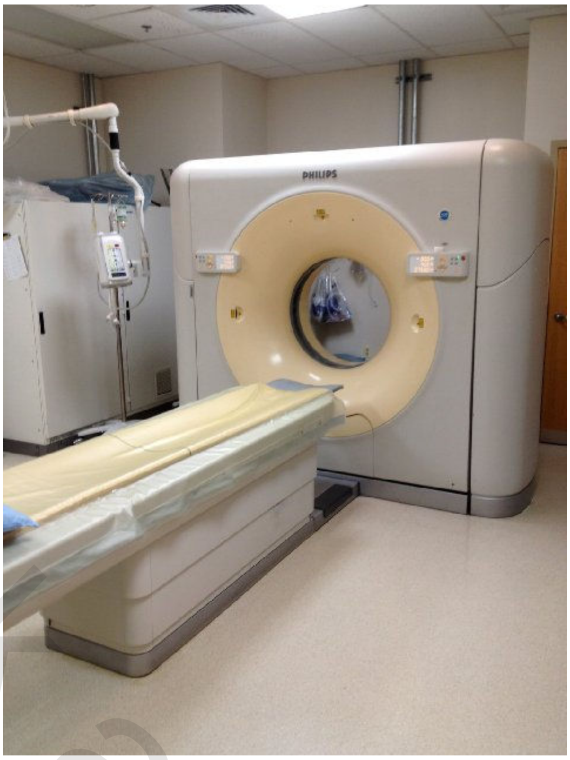

Fig. (25): Phillips MX 16 slice computerized tomographic scanner device.

4- Patient follow up

Patients underwent follow-up through their hospitalizations by serial ultrasonography for cases with minor intra-abdominal injuries, for the purpose of identifying those who ultimately had intra-abdominal injuries as well as to identify the need for therapy (blood transfusion or laparotomy).

Patients who were discharged home from the ED were telephoned 1 week after their ED visits. And patient who were still hospitalized were reached in their wards. Both were asked if any complications occurred, if conservative management was failed or if any further management was needed. Clinical course was rated negative if no intervention was performed, no failure occurred during hospital admission and/or after discharge. Patients receiving an intervention (surgery), patients who clinically deteriorated (defined as the need for ≥2 packed cells, decreasing systolic blood pressure below standard value for age or drop in hemoglobin)

Ethical considerations

Approval of Alexandria Faculty of Medicine ethics committee and the administration of the main university hospital were obtained. Radiation exposure, pharmacologic sedation and contrast administration (if was needed) was considered during abdominal CT scans and X-ray on all patients.

Statistical analysis

Data were fed to the computer and analyzed using IBM SPSS software package version 22.0. Qualitative data were described using number and percent. Quantitative data were described using Range (minimum and maximum) mean, standard deviation and median. Comparison between different groups regarding categorical variables was tested using Chi-square test. When more than 20% of the cells have expected count less than 5, correction for chi-square was conducted using Fisher's exact test or Monte Carlo correction. Significance of the obtained results was judged at the 5% level.(69,70)

Agreement of the different predictives with the outcome was used and was expressed in sensitivity, specificity, positive predictive value, negative predictive value and accuracy. Univariate and Multivariate logistic regression was assessed with exact binomial 95% confidence intervals (CI), of ultrasound scan for identifying children with intraperitoneal fluid from an intra-abdominal injury.

These calculations were based on the initial, bedside interpretation of the ultrasound scan. In addition, the accuracy of abdominal ultrasound scan in identifying children undergoing operative intervention or blood transfusion for an intra-abdominal injury as well as identifying those hypotensive children with hemoperitoneum from an intra-abdominal injury.

RESULTS

This study was conducted on 150 pediatric patients subjected to blunt abdominal trauma presenting to the emergency department at Alexandria University Hospital to study the role of abdomen ultrasonography and Computerized tomography in their management.

1- Distribution of studied cases according to demographic data

I) Distribution of studied cases according to age:

The age of the patients ranged from 3 days to 17 years with a mean age ± Standard Deviation (SD) of 8.8 ± 4.93 years. The mean age for male patients was 7.5 ± 4.89 years, while that for females was 9.3 ± 4.89 years. The highest incidence of blunt abdominal trauma was in age group >5 years where 100 cases 66.7%. Distribution of studied cases according to gender: (Table 4, and Fig. 26, 27).

Our sample included a total of 150 patients, of them 109 were males representing 72.7%, and 42 females representing 27.3% of total number of cases.

Table (4): Distribution of the studied cases according to demographic data (n=150)

	No.	**%**
Sex		
Male	109	72.7
Female	41	27.3
Age		
<1 month	1	0.7
1 month - 1 year	2	1.3
>1 year to 5 years	47	31.3
> 5 years	100	66.7
Min. – Max.	3 days - 17 years	
Mean ± SD.	8.8 ± 4.93	
Median	9.0	

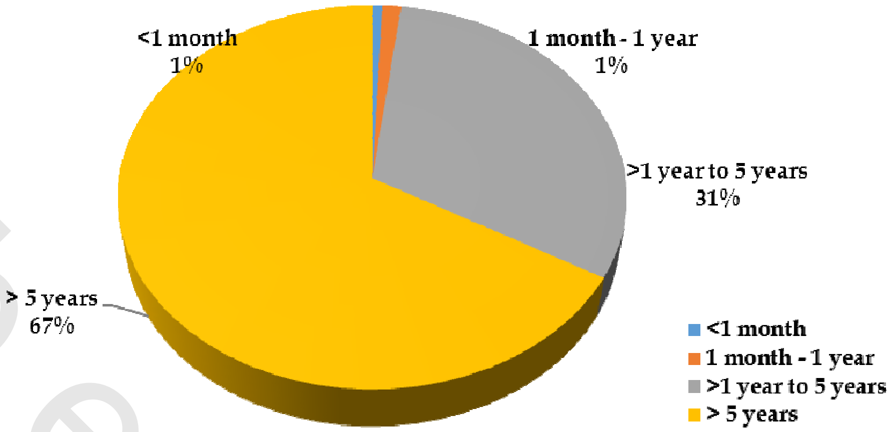

Fig. (26): distribution of cases according to age group.

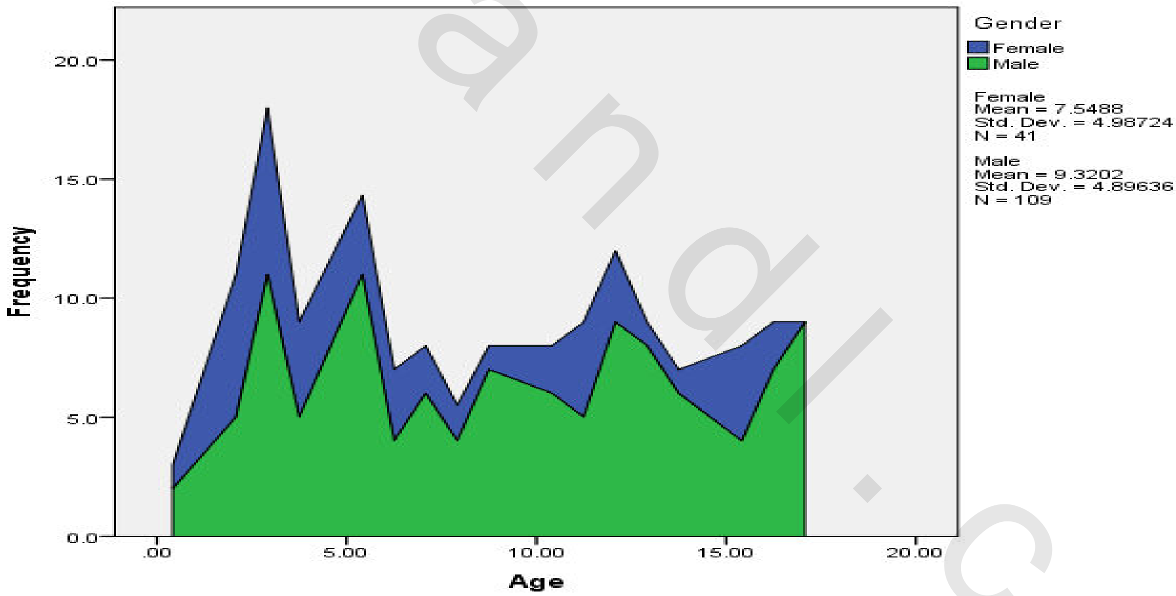

Fig. (27): Area chart showing distribution of age frequency.

1) Relation between gender and age group

Both male and female gender showed the same distribution (fig. 27) as the highest incidence of trauma was in the age group above 5 years where in males 77 cases from total 109 cases (51.3%) from the total 72.2% and in females 23 cases of total 41 cases (25 %) from total 27.3%. Again in the age group less than 1 month both showed the least distribution, in males there was only one case (0.7%) but no cases where found in females. In the age group from 1 month to 1 year showed the same distribution 1 case for each (0.7%). 17 cases (11.3%) of females were found in the age group above 1 year and less than 5 years but 30 cases (20%) were found in males. So male sex showed more distribution in all age groups than female sex (table 5, fig. 28).

Table (5): Distribution of age groups compared to gender (n=150)

Age Group	Gender			
	Female		Male	
	n	%	*n*	%
<1 month	0	0.0%	1	0.7%
1 month - 1 year	1	0.7%	1	0.7%
>1 year to 5 years	17	11.3%	30	20.0%
> 5 years	23	15.3%	77	51.3%
Total	**41**	**27.3%**	**109**	**72.7%**

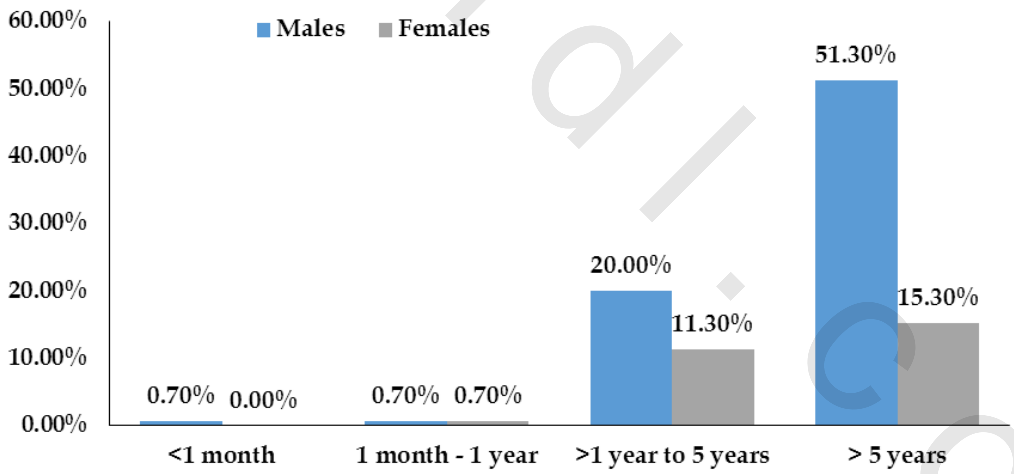

Fig. (28): Bar graph showing distribution of age groups compared to gender.

2) Distribution of the studied cases according to MOT

The analysis of the mechanism of trauma in this study (table 6, fig. 29) revealed that road traffic accident (RTA) was the commonest mode of trauma in 82 patients representing 54.7%. Falling from a height (FFH) in 59 patients representing 39.3%, Localized abdominal trauma in 6 patients representing 4% and Assault in 2 patients representing 1.3% of patients in this study. Lastly was the child abuse in 1 case (0.7%).

Table (6): Distribution of the studied cases according to MOT (n=150)

MOT	**No.**	**%**
RTA	82	54.7
FFH	59	39.3
Localized trauma	6	4.0
Alleged Assault	2	1.3
Child abuse	1	0.7

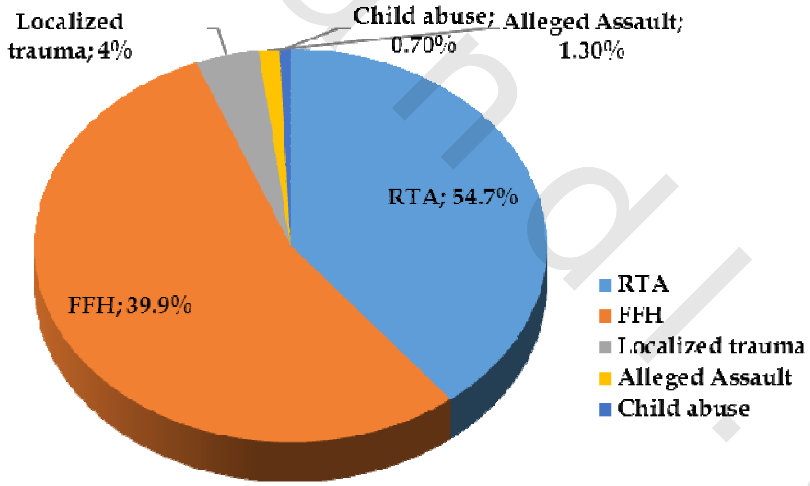

Fig. (29): Distribution of cases according to mode of trauma

3) Relation between age and MOT

Comparing the different modes of trauma to the age group (table 7, fig. 30), we had only one case of RTA in a 3 day old newborn and 2 cases aged from 1 month and below I year; one with RTA and another with FFH. There was no statistical significance among both age groups below 1 month and from 1 month till below 1 year even when we excluded them from the comparison, so both groups were joined. But in age groups from 1-5 years and above 5 years we found a statistically significant relation between the mode of trauma and the age in which the RTA and FFH we predominant with a *P* <0.001.

Table (7): Relation between age and MOT.

	Age						χ^2	^{MC}p
	<1 month – 1year (n = 3) #		>1 year to 5 years (n = 47)		> 5 years (n = 100)			
	No.	%	No.	%	No.	%		
MOT								
FFH	1	0.7	6	4.0	52	34.7	18.709*	<0.001*
RTA	2	1.4	41	27.3	39	36.0	32.437*	<0.001*
Localized trauma	0	0.0	0	0.0	6	4.0	3.269	0.274
Alleged Assault	0	0.0	0	0.0	2	1.3	2.071	1.000
Child abuse	0	0.0	0	0.0	1	0.7	2.627	1.000
χ^2 (^{MC}p)	35.246* (<0.001*)							

χ^2: value for Chi square test
MC: Monte Carlo test
*: Statistically significant at $p \leq 0.05$
#: two aged groups were joined

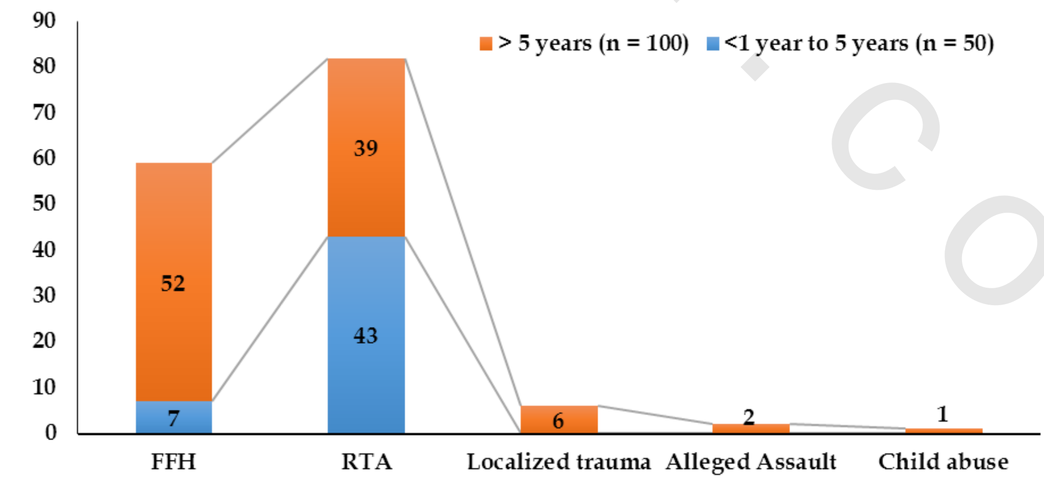

Fig. (30): Relation between age and MOT

II- Distribution of cases according to clinical examination

1) According to GCS

DLC in cases was either due to traumatic brain injuries associated with abdominal trauma in polytraumatized patients or due to severe shock. It was assessed by GCS. 30 cases out of 150 total patients had GCS < 15.

Table (8): Distribution of the studied cases according to vital signs (n=150).

	Frequency	Percent
GCS		
<15	30	20.0
15	120	80.0

2) According to hemodynamic state and grade of shock

Eighty five cases (56.7%) showed no evidence of hypovolemic shock that was assessed as regard blood pressure and pulse according to age, capillary refilling time, level of consciousness, central venous pressure (CVP) if central venous catheter was inserted after fluid challenge according to age was started (20 ml/kg loading and maintenance 100ml/kg for the 1st 10 kg, 50 ml/kg for the 2nd 10 kg and 20 ml/kg for each kg above 20 kg). Grade I hypovolemic shock in twenty three cases (15.3%). Grade II hypovolemic shock in fifteen cases (10.0%. Grade III hypovolemic shock in seventeen cases (11.3%). Ten cases (6.7%) had severe hypovolemic shock grade IV.

Table (9): Distribution of cases according to grading of hypovolemic shock (n=150).

	Frequency	Percent
No evidence of Hypovolemic shock	85	56.7
Grade 1 hypovolemic shock	23	15.3
Grade 2 hypovolemic shock	15	10.0
Grade 3 hypovolemic shock	17	11.3
Grade 4 hypovolemic shock	10	6.7

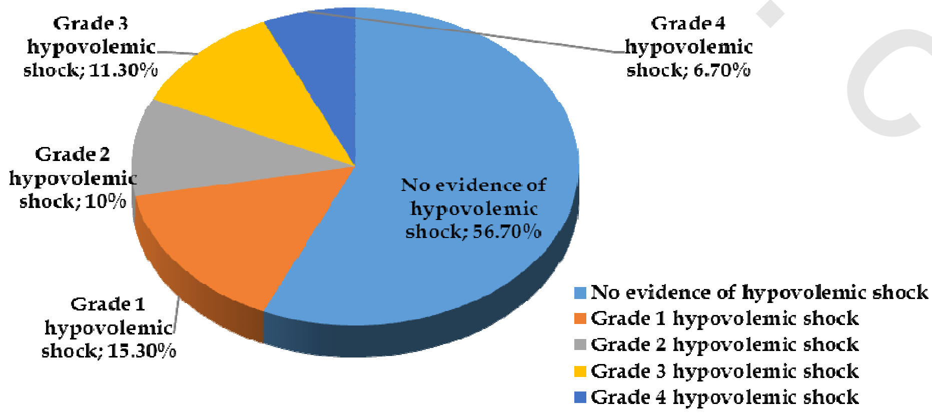

Fig. (31): Distribution of cases according to grading of hypovolemic shock.

3) Distribution of cases according to abdominal examination:

Abdominal examination is important in the examination of children with blunt abdominal trauma although it may be irrelevant in certain cases as in child with disturbed level of consciousness, very young children, irritable child and if there was a distracting cause of pain as fracture bone, so it can't be the only way to assess a child with abdominal examination but in 107 cases (71.3%) it was normal as there was no tenderness, distension or ecchymosis. In 17 cases (11.3%) it was tender but lax and no echymosis. It was rigid abdomen with no pain or pain can't be assessed but no ecchymosis in 9 cases (6%). In 17 cases (11.3%) it was surgical abdomen i.e. very tender and rigid, distended with or without ecchymosis.

Table (10): Distribution of cases according to abdominal examination.

Abdominal examination	No.	%
Normal abdominal examination or unreliable	107	71.3
Localized tenderness	17	11.3
Guarding, rigid, echymosis	9	6.0
Surgical abdomen	17	11.3
Total	150	100.0

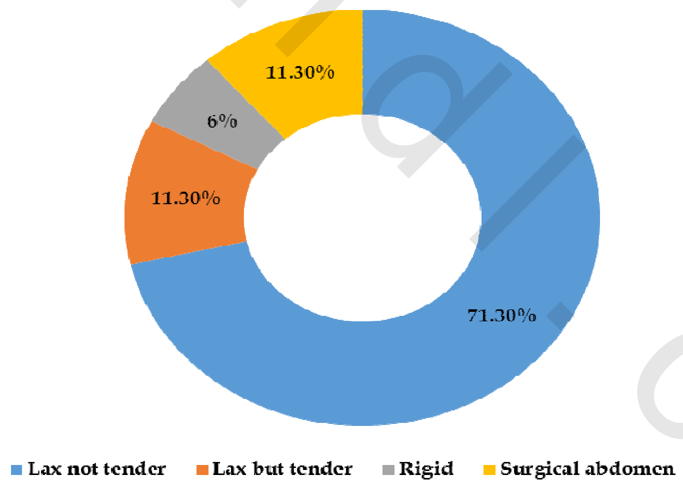

Fig. (32): Distribution of cases according to abdominal examination.

4) Distribution of cases according to their outcome:

From 150 cases, we had 69 (64%) of cases were discharged from ED after being investigated for polytrauma in general and BAT specifically. 6 (4%) cases died 5 of them due to TBI and one due to severe trauma and irreversible hypovolemic shock. 15 (10%) cases were operated for IAIs with different organs injury as discussed below. Conservative management was the commonest decision taken in children with IAIs in 50 patients (33.3%). 10 (6.7%) cases were discharged against medical advice and refused to continue management

Table (11): Distribution of the studied cases according to outcome (n=150)

Patient outcome	No.	%
Discharged ED	69	46.0
Died	6	4.0
OR	15	10.0
Conservative	50	33.3
DAMA	10	6.7
Total	150	100

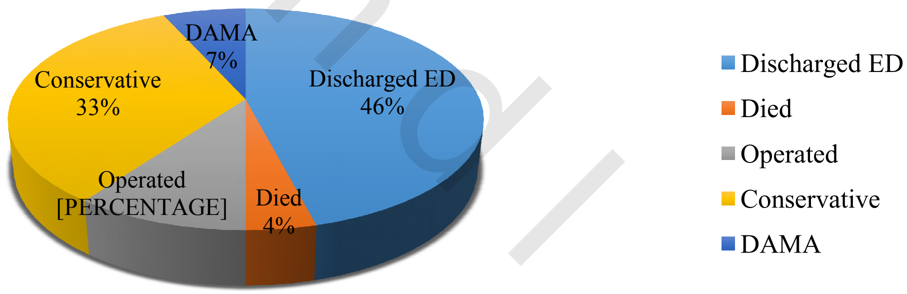

Fig. (33): Distribution of the studied cases according to patient outcome.

5) Relation between abdominal examination and patient outcome:

There was a statistical significant relation between abdominal examination and patient outcome with **p <0.001** for all cases after exclusion of patient who were discharged against medical advice.

Table (12): Relation between abdominal examination and patient outcome

Patient outcome	**Abdominal examination**				χ^2	**P**
	Positive		**Negative**			
	No.	**%**	**No.**	**%**		
Discharged from ED	2	1.3	67	44.7	61.811*	**<0.001***
Operated	14	9.3	1	0.7	81.11*	
Conservative management	20	13.3	30	20.0	31.745*	
Died	4	2.7	2	1.3	30.208*	

χ^2value for Chi square test

* Statistically significant at $p \leq 0.05$

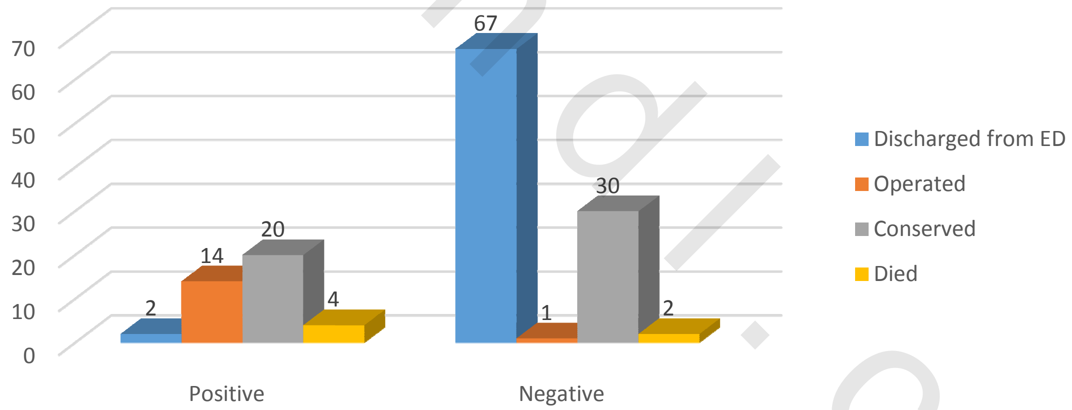

Figure (34): relation between abdominal examination and patient outcome

III- Distribution of cases according to laboratory investigations

Out of 150 patients, we found 32 cases (21.4%) with low haemoglobin according to weight and age, as well as elevated liver enzymes in 13 patients (8.6%).

Table (13): Distribution of cases according to laboratory investigations.

Laboratory test	positive		negative	
	No.	%	No.	%
Low Heamoglobin	32	21.4%	118	78.6%
Elevated Liver enzymes	13	8.6%	135	91.4%

IV- Distribution of cases according to radiological investigations:

The diagnosis and management of BAT in adults or children depends mainly on the needed investigations. The choice of each modality depends on many factors as MOT, hemodynamic stability of the patient, availability of the diagnostic procedure, the ability of patient transportation and the suspected injury.

In 23 cases (15.3%) performance of standing X-ray abdomen was difficult due to hemodynamic instability and the disturbed level of consciousness and the need for mechanical ventilation. But it was positive in 4 cases (2.7%) as regard pneumoperitonium and was negative for it in 123 case (82%).

FAST was done as the only diagnostic modality done in all cases. It was positive for detection of free fluid collection in 77 cases (51.3%) and was negative in 73 cases (48.7%).

CT abdomen with I.V contrast was significant in 38 positive cases (25.3%) for free fluid collection, negative in no case but wasn't done in 112 cases (74.7%) due to difficult of transportation or not needed as no evidence of severe abdominal injury either clinically or with FAST and stability of the patient condition. Plain CT abdomen for detection of pneumoperitonium when there was no evidence of hypovolemic shock and negative FAST and clinical evidence of surgical abdomen was done in 4 cases (2.7%) but was negative for it in 0 cases and wasn't done in 146 cases (97.3%). So total positive cases with FAST were 77 cases and total negative cases were 73 cases but total positive cases with CT either with or without contrast was 41 cases but not cases needed CT.

Table (14): Distribution of the studied cases according to radiological investigations (n=150).

	X-ray		CT with I.V contrast		CT without I.V contrast (plain)		U/S (FAST)	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Negative	123	82.0	0	0	0	0	73	48.7
Positive	4	2.7	38	25.3	3	2.7	77	51.3
Not done	23	15.3	112	74.7	147	97.3	0	0
					NO.		**%**	
FAST Positive					77		51.3	
CT Positive					41		27.3	

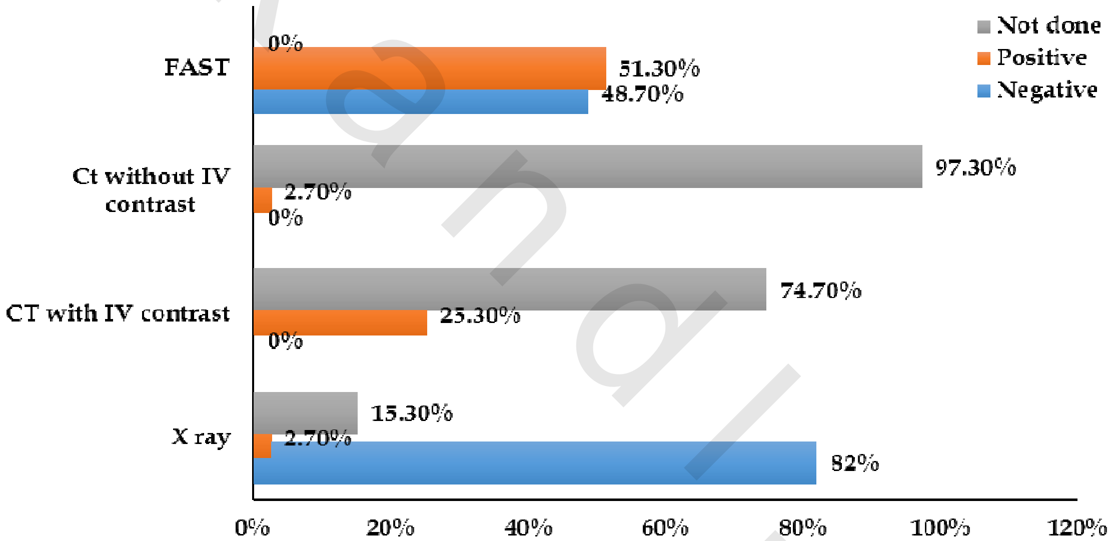

Fig. (35): Distribution of the studied cases according to radiological investigations.

A) Ultrasound findings

1) Grade of Collection and follow up

FAST was found to be negative for fluid collection in 73 cases (48.7%) and positive in 77 cases (51.3%). Of the positive cases we had 53 (35.5%) cases with minimal fluid collection, 19 cases (12.7%) with mild collection and 5 (3.3%) of moderate collection. No cases of massive collection.

Follow up FAST was done for cases who needed it if there was deterioration in the clinical condition of the patient, suspicion of increase of fluid collection and patient was under observation for conservative management. So, 96 (64%) of cases had no follow up even if was free from the start or no need for it. In 52 (34.7%) there was no interval changes. 1 (0.7%) case was free and became with minimal collection in follow up. And one (0.7%) case was mild became moderate on follow up.

Table (15): Distribution of the studied cases according to FAST initial and follow up findings (n=150).

	No.	%
FAST		
Negative	73	48.7
Positive	77	51.3
FAST fluid grade		
Free	73	48.7
Minimal	53	35.3
Mild	19	12.7
Moderate	5	3.3
Follow up FAST in ED		
Not done	96	64.0
No interval changes	52	34.7
Minimal	1	0.7
Moderate collection	1	0.7

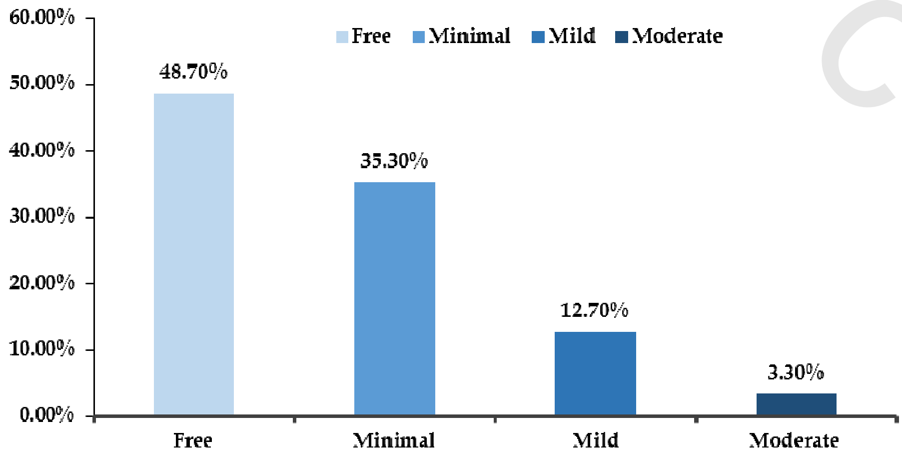

Fig. (36): Percentage distribution of initial FAST screening findings (n=150).

1) Site of collection

We recorded the site of fluid collection which was of less importance as all cases having non loculated fluid which is variable according to the position of the patient. We had 73 cases with no abdominal collection. The distribution of 77 positive cases was: 35 cases (23.3%) with pelvic collection, subhepatic in 16 (10.7%), perisplenic in 12 (8%), Subhepatic associated with pelvic collections in 10 (6.7%), and 14 cases (9.3%) had collection all over the abdomen.

Table (16): Distribution of the studied cases according to FAST site of collection (n=150).

	No.	% of total
FAST site of collection		
No collection	73	48.7
Pelvic	35	23.3
Subhepatic	16	10.7
All over	14	9.3
Perisplenic	12	8

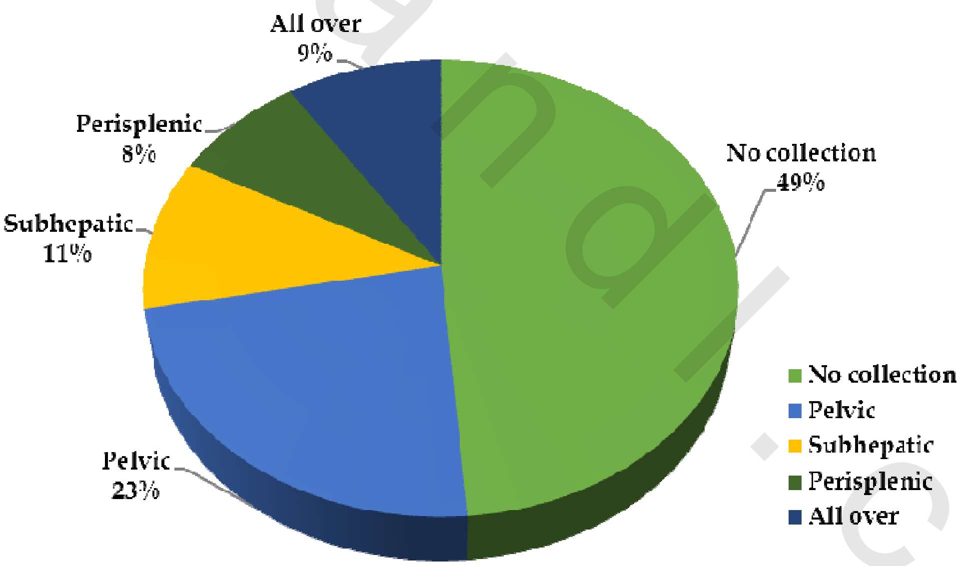

Fig. (37): Distribution of the studied cases according to FAST site of collection (n=150).

2) Relation between Grade of shock and FAST fluid grade

The study of the relation between fluid grade on FAST examination and grade of hypovolemic shock according to age there was statistically significant relationship in all grades of intra-abdominal fluid collection and grade of shock of $p < 0.001$.

Table (17): Relation between Grade of shock and FAST fluid collection grade.

FAST fluid grade	Grade of shock										χ^2	p
	No chock (n = 85)		Grade 1 (n = 23)		Grade 2 (n = 15)		Grade 3 (n = 17)		Grade 4 (n = 10)			
	No.	%	No.	%	No.	%	No.	%	No.	%		
Free	70	46.7	2	1.3	0	0.0	1	0.7	0	0.0	41.938*	<0.001*
Minimal	15	10.0	21	14.0	11	7.3	4	2.7	2	1.3	23.402*	<0.001*
Mild	0	0.0	0	0.0	4	2.7	10	6.7	5	3.3	4.655*	$^{MC}p=0.046^*$
Moderate	0	0.0	0	0.0	0	0.0	2	1.3	3	2.0	2.423	$^{MC}p=0.126$
χ^2 (^{MC}p)	145.124* (<0.001*)											

χ^2: value for Chi square test, MC: Monte Carlo test,
*: Statistically significant at $p \le 0.05$

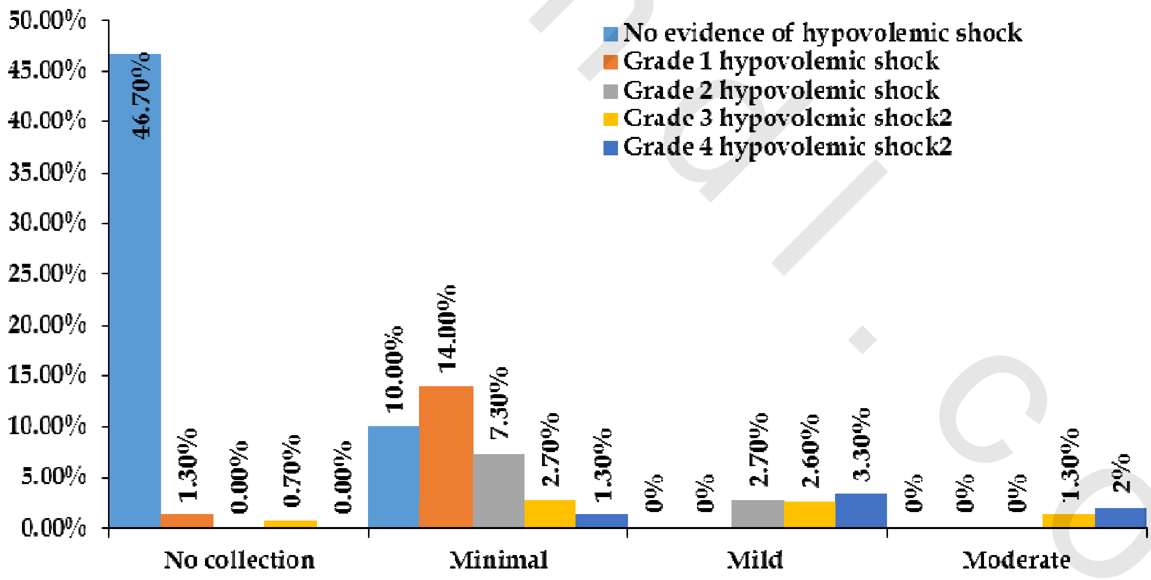

Fig. (38): Relation between Grade of shock and FAST fluid grade.

3) *Relation between FAST fluid grade and patient outcome*

There was significant statistical relation between the FAST result regarding the fluid collection and patient outcome with significant statistical relationship with ^{MC}**p <0.001** in all patients who discharged immediately from ER, patient who was managed conservatively, patient who was operated and the patient who died. So, FAST is a reliable tool for decision making regarding the patient fate and it can save time and lives.

Table (18): Relation between FAST fluid grade and patient outcome (n=150).

Patient outcome	FAST fluid grade								χ^2	^{MC}p
	No collection (n = 73)		Minimal (n = 53)		Mild (n=19)		Moderate (n=5)			
	No.	%	No.	%	No.	%	No.	%		
Discharged Immediately										
No	5	3.3	52	34.7	19	12.7	5	3.3	151.394*	**<0.001***
Yes	68	45.3	1	0.7	0	0.0	0	0.0		
Conservative										
No	72	48.0	12	8.0	13	8.7	3	2.0	90.578*	**<0.001***
Yes	1	0.7	41	27.3	6	4.0	2	1.3		
OR										
No	72	48.0	51	34.0	9	6.0	3	2.0	36.469*	**<0.001***
Yes	1	0.7	2	1.3	10	6.7	2	1.3		
Died										
No	73	48.7	50	33.3	17	11.3	4	2.7	9.603*	**0.014***
Yes	0	0.0	3	2.0	2	1.3	**1**	0.7		

χ^2: value for Chi square test
MC: Monte Carlo test
*: Statistically significant at $p \leq 0.05$

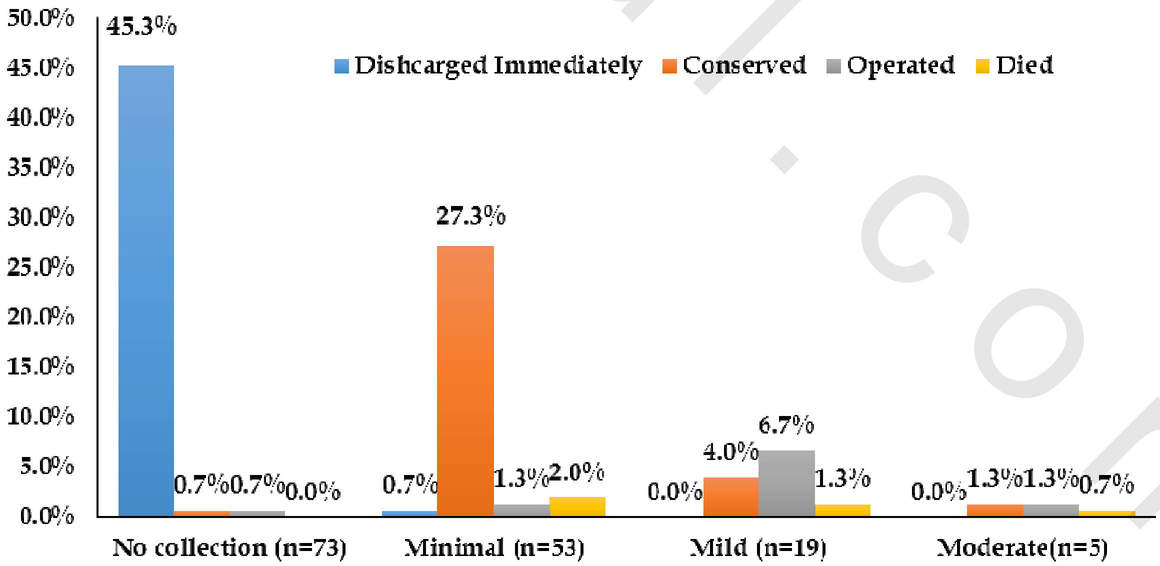

Fig. (39): Relation between FAST fluid grade and patient outcome.

B) CT Findings

CT which was not always available and need transportation of the mechanically ventilated or shocked patient for a distance of 50 meters. So, the need for stabilization of the patient general condition before transfer for CT made the least time needed was 20 minutes up to 115 minutes with a Mean ± SD 54.72 ± 23.77 minutes and a median 50.0 minutes.

1) Distribution according to CT abdomen and pelvis

CT abdomen with or without contrast were done for selected cases where suspicion for severe organ injury, active internal bleeding, retroperitoneal collection as can't be detected by FAST of bowel injury. So we have 109 (72.6%) cases where no need for CT. In 17 (11.4%) patients there was minimal fluid collection and mild in 20 (12.8%). There were 4 (2.7%) cases of moderate. There were no cases with massive collection.

Table (19): Distribution of the studied cases according to CT Abdomen and pelvis fluid grading (n=150).

CT fluid grade	No.	%
Not done	109	72.6
Minimal	17	11.4
Mild	20	13.3
Moderate	4	2.7
Massive	0	0.0

2) Distribution according to organ injury in CT

In the 41 cases who needed CT abdomen either with contrast or without, splenic injuries were the most common and they represented 16 cases (10.7%). The liver injuries were 13 cases (8.7 %). Psoas muscle injury was found in 4 cases (2.7%) kidney was injured in 2 cases (1.3%) and bladder in 3 cases (2%). 3 cases had bowel injuries forming 2% of cases with organ injuries.

Table (20): Distribution of the studied cases according to CT findings (n=150).

CT organ injury	No.	%
Not done	109	72.6
Spleen	16	10.7
Liver	13	8.7
Psoas muscle	4	2.7
Kidney	2	1.3
Bladder	3	2
Bowel	3	2

3) Distribution according to relation between CT results & patient outcome:

Statistically significant relationship was found between CT findings and the patient outcome whether CT was or was not needed for all cases to diagnose the fluid collection in patients who was discharged immediately from ER, patients who were operated and patients managed conservatively.

Patients who were died there was no significant relationship as most cases were died due to associated injuries not abdominal injuries.

Table (21): Distribution according to relation between CT results & patient outcome.

Patient outcome	CT						χ^2	p
	Not done (n = 109)			Positive (n = 41)				
	No.	% from total cases (n=150)	% from cases CT not done	No.	% from total cases	% from casa had CT		
Discharged Immediately							48.063*	**<0.001***
No	40	26.7	36.7	41	27.3	100.0		
Yes	69	46.0	63.3	0	0.0	0.0		
Conservative							8.123*	**0.004***
No	80	53.3	73.4	20	13.3	48.8		
Yes	29	19.3	26.6	21	14.0	51.2		
OR							29.541*	**^{FE}p<0.001***
No	107	71.3	98.2	28	18.7	68.3		
Yes	2	1.3	1.8	13	8.7	31.7		
Died							1.617	^{FE}p=0.346
No	106	70.7	97.2	38	25.3	92.7		
Yes	3	2.0	2.8	3	2.0	7.3		

χ^2: value for Chi square test
FE: Fisher Exact test
*: Statistically significant at $p \le 0.05$

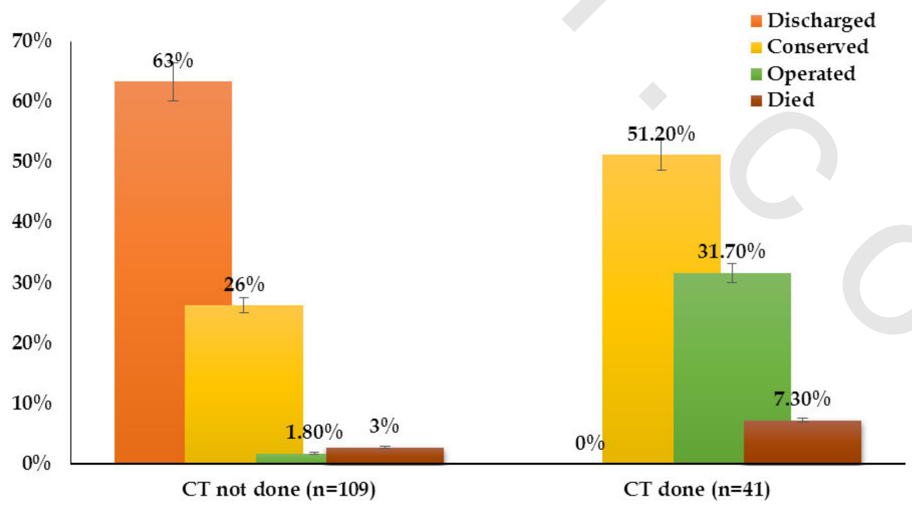

Fig. (40): Relation between CT and patient outcome.

C- Comparisons between FAST and CT

1) FAST versus CT according to timing

FAST as a bed side diagnostic tool where no need for patient transportation. The least time needed was 4 minutes and maximum time was 20 minutes, with mean ± SD 11.29 ± 4.23 and median 11.0. CT which was not always available and need transportation of the mechanically ventilated or shocked patient so, the need for stabilization of the patient general condition before transfer for CT made the least time needed was 20 minutes up to 115 minutes. With Mean ± SD54.72 ± 23.77 and median 50.0. So, there is significant difference between both modalities of investigations in timing. FAST is rapid, time saving and bed side diagnostic tool, bed side and need no transportation with a strong statistically significance towards FAST <0.001

N.B: total number of cases is 118 cases (the positive cases of FAST and CT)

Table (22): Comparison between the FAST and CT according to timing: (n=118).

Timing	FAST (n=77)	CT (n=41)	t	*p*
Min. – Max.	4.0 - 20.0	20.0 – 115.0	11.466*	<0.001*
Mean ± SD	13.01 ± 3.77	54.72 ± 23.77		
Median	11.0	50.0		

t: Student t-test

*: Statistically significant at p ≤ 0.05

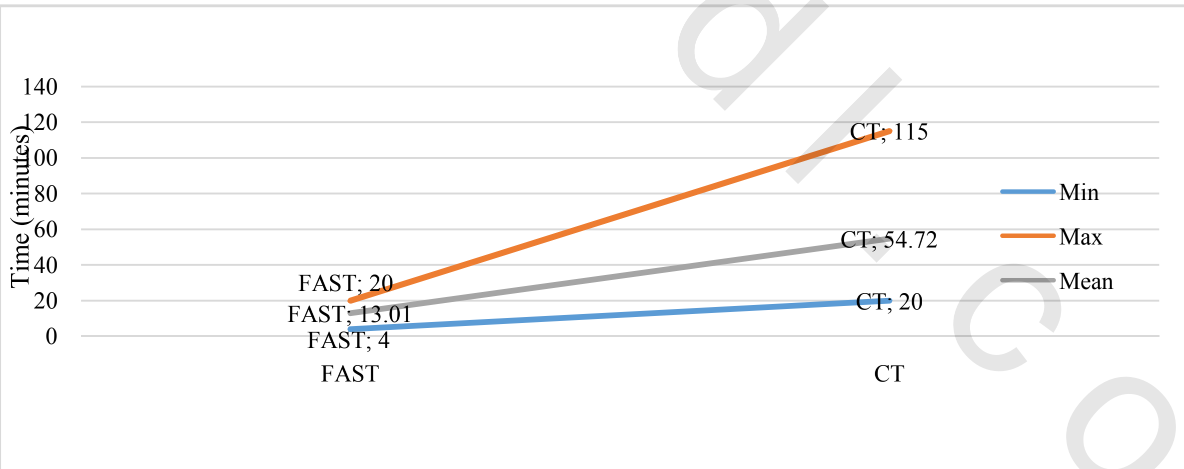

Fig. (41): FAST Versus CT regarding timing.

2) *FAST versus CT according to free fluid collection*

In all positive cases with FAST (77 case), minimal fluid collection was found in 53 cases (68.8%), mild collection in 19 cases (24.7%) and moderate collection in 5 cases (6.5%). 41 total cases had CT. Minimal collection was found in 17 cases (41.4%), mild in 20 cases (48.8%) and 4 cases (9.7%) showed moderate collection. In both groups there was no cases with massive collection.

N.B: not all cases with positive FAST underwent CT.

Table (23): Comparison between FAST and CT according to grade of collection.

Grade of collection	FAST (n=77)		CT (n=41)		χ^2p	^{MC}p
	No.	%	No.	%		
Minimal	53	68.8	17	41.4	12.784*	0.004*
Mild	19	24.7	20	48.8		
Moderate	5	6.5	4	9.7		

χ^2: value for Chi square
MC: Monte Carlo test
*: Statistically significant at $p \leq 0.05$

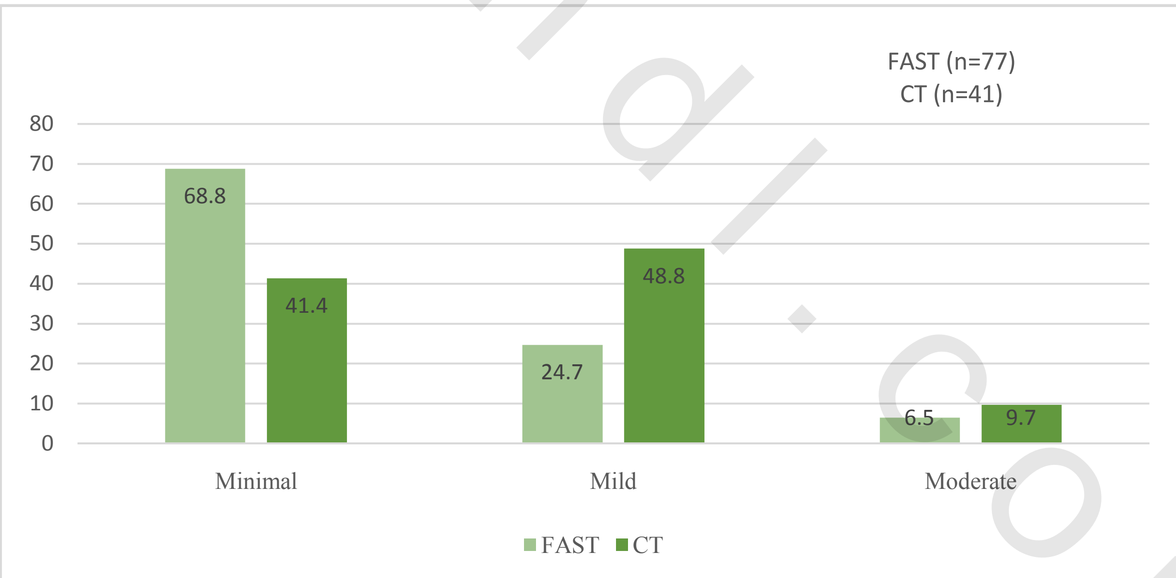

Fig. (42): Comparison between FAST and CT according to grade of collection.

3) Sensitivity and specificity of FAST judged by CT

In 41 cases underwent CT scan, FAST results were compared with CT. One case was false negative on FAST with splenic contusion on CT and no fluid collection and another case underwent immediate operative management upon FAST results only, as the patient was hemodynamically unstable with moderate intraperitoneal fluid collection. FAST showed sensitivity for detection of intra-abdominal free fluid collection of 95.12% with positive predictive value (PPV) of 100% and negative predictive value (NPV) of 0% Specificity was 100%.

Table (24): Test parameters for FAST in detection of hemoperitoneum compared to CT as a gold standard

Detection of hemoperitoneum by FAST as confirmed by CT (Gold standard)	**FAST (n=150)**	**CT (n=41)**
	N	**N**
True positive (TP)	40	41
False Positive (FP)	0	0
True negative (TN)	110	0
False negative (FN)	1	0
Total	150	41
FAST test parameters		
Sensitivity (TP/(TP+FN))	95.12%	-
Specificity (TN/(TN+FP))	100%	-
Positive predictive value	100%	-
Negative predictive value	0%	-
Accuracy (TP+TN)/(TP+TN+FP+FN)	96.2%	-

4) FAST versus CT according to organ injury

Evidence of organ injury not always associated with free fluid collection as it may be due to small intra-abdominal blood vessels and it was mainly very few amount. In FAST, no organ injury was found in 40 cases (51.9%) and there were 41 cases (27.33%) with organ injury i.e. FAST missed one case. Spleen was the most common injured organ in children in both investigation tools where in FAST 15 cases (19.5%) had splenic injury versus 16 cases (39%) with CT. the second most common injured organ was the liver where 13 cases (18.2%) where detected by both FAST and CT. Psoas muscle injury can be detected by FAST and CT in 4 cases. Kidney injury also was detected in 2 cases by both FAST and CT and also bladder injury was the same in them in 3 cases. Bowel injury couldn't be detected by FAST where no cases was diagnosed by it and 3 (7.3%) cases where diagnosed by CT. So, CT was superior to FAST in detection of bowel injury, but both had the same ability to diagnose solid organ injuries.

Table (25): Comparison between FAST and CT according to organ injury.

CT organ injury	FAST (n=77)		CT (n=41)		χ^2p	p
	No.	%	No.	%		
Spleen	15	19.5	16	39.0	5.276*	0.022*
Liver	13	18.2	13	34.1	3.422	0.064
Psoas muscle	4	5.2	4	9.8	0.881	$^{FE}p = 0.446$
Kidney	2	2.6	2	4.9	0.425	$^{FE}p = 0.609$
Bladder	3	3.9	3	7.3	0.649	$^{FE}p = 0.417$
Bowel	0	0	3	7.3	5.781*	$^{FE}p = 0.040^*$

χ^2: value for Chi square
FE: Fisher Exact test
*: Statistically significant at $p \le 0.05$

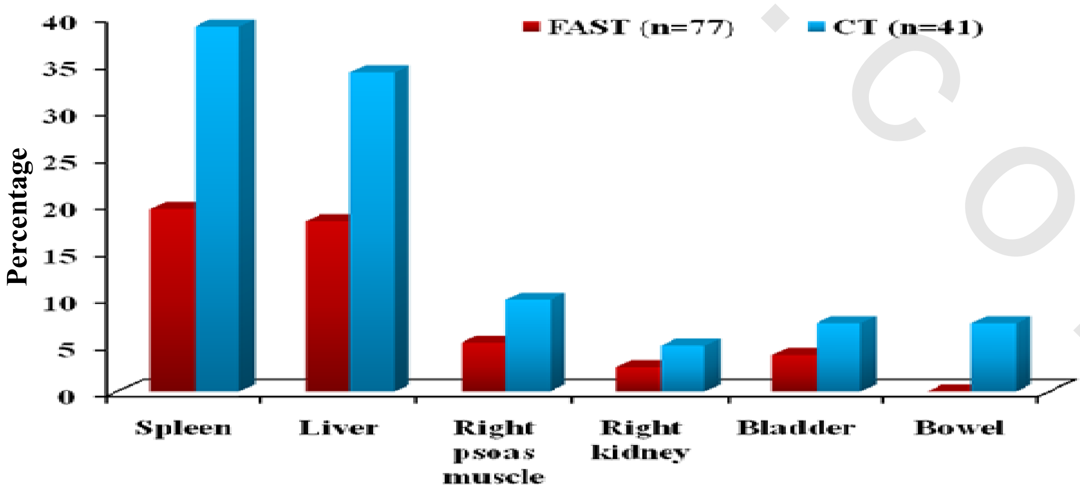

Fig. (43): Comparison between FAST and CT according to organ injury

5) FAST versus CT according to Patient outcome and follow up

FAST was very helpful tool in evacuation of the overcrowded ED and rapid decision making in all our cases.

A) Conservative management

There was no change in decision making for the conservative management in the patients had FAST or CT. i.e. the CT did not add any change on the decision for managing the patient conservatively. Where 49 cases of total 77 positive cases with FAST (63.6%). One case was failed to be managed conservatively and was operated after follow up FAST.

Table (26): Comparison between FAST and CT according to conservative management.

Patient outcome	FAST (n=77)		CT (n=41)		χ^2p	p
	No.	%	No.	%		
Conservative						
No	28	36.4	20	48.8	1.709	0.191
Yes	49	63.6	21	51.2		

B) Operative management

Again the CT did not add any more for taking a decision to operate a patient. One case was operated upon FAST finding which was so diagnostic with moderate free intraperitoneal fluid collection with grade 4 shock, so the patient was operated immediately giving the FAST an advantage upon CT for saving the patient life and a trustable tool of examination.

Table (27): Comparison between FAST and CT according to operative management.

	No.	%	No.	%	χ^2p	p
Operative management						
No	63	81.8	28	68.3	2.774	0.096
Yes	14	18.2	13	31.7		

χ^2: for Chi square test

The details of 15 operated cases are mentioned in (table 28). We tested the impact of different parameters against operative management using Univariate and Multivariate binary logistic regression (tables 29,30), where we found significant relations with the grade of shock, abdominal examination in both analyses, presence or absence, and grade of fluid collection detected by FAST only in univariate analysis.

Table (28): Description of operated cases.

NO.	Age	Sex	MOT	Grade of shock	Abd. exam.	FAST findings (All Positive)	Grade of fluid collection	Site of fluid collection	CT findings	OR Intervention	Outcome One week
7	6	M	RTA	3	surgical	Minimal to mild all over, splenic and hepatic hypodense area	Mild	Subhepatic and splenic	Minimal to mild all over, shuttered spleen and liver laceration	Splenectomy and liver packing	Cured
9	14	M	RTA	3	lax but tender	Mild, Subhepatic and pelvic collection	Mild	Subhepatic and pelvic	Mild collection, Liver laceration Splenic laceration, RT kidney laceration, RT adrenal hematoma, Intraperitoneal rupture urinary bladder with active extravasation	Splenectomy and repair of rupture bladder	Cured
26	3	M	RTA	3	surgical	minimal all over	Minimal	Minimal	Minimal all over, mild pneumoperitonium, Subhepatic, minimal retroperitoneal hematoma related to RT posoas muscle	Resection anastomosis of small intestine	Cured
30	2.2	F	FFH	3	surgical	minimal Subhepatic, mild perinephric hematoma	Mild	perinephric	Minimal Subhepatic, mild to moderate pelvic hematoma ….. Intraperitoneal rupture bladder	repair of bladder rupture	Cured
69	11	M	RTA	4	surgical	mild Subhepatic	Mild	Subhepatic	Mild Subhepatic with active extravasation	Repair of liver tear	Cured
72	6	M	Localized abd. trauma	3	surgical	mild Subhepatic	Mild	Subhepatic	Pneumoperitonium, mild Subhepatic, hepatic laceration with active extravasation	hepatic packing, small intestine resection anastomosis	Cured
81	7	M	RTA	3	surgical	mild allover	Mild	All	Mild all over, hepatic laceration with active extravasation	hepatic packing	Died due to brain injury
84	12	F	child abuse	1	N/A	minimal pelvic and Perisplenic	Minimal	Perisplenic	Mild Perisplenic splenic contusion with active extravasation	splenectomy	improved with no complications
96	3	F	RTA	4	Surgical	moderate Perisplenic and pelvic	Mod.	Perisplenic	Not done	splenectomy	Died due to sepsis
116	13	M	RTA	3	Rigid	free	None	None	Not done	resection anastomosis of small intestine	Cured
119	6 M	M	RTA	3	Surgical	moderate Perisplenic, minimal pelvic	Mod.	Perisplenic	Not done	splenectomy	Cured
121	13	F	RTA	4	Surgical	mild pelvic	Mild	Pelvic	Mild pelvic, intraperitoneal rupture bladder mild right perinephric, right kidney laceration	repair of ruptured bladder, conservative management of kidney	Sepsis
130	10	F	RTA	4	Surgical	mild all over	Mild	All	Mild all over, hepatic laceration with active extravasation	died intraoperative	Died
137	3	M	RTA	4	Surgical	mild Perisplenic and pelvic	Mild	Perisplenic	Mild Perisplenic collection, splenic laceration and contusion	splenectomy	Died due to brain injury
143	16	M	FFH	3	Rigid	mild allover	Mild	All	Mild all over with hepatic laceration with active extravasation	hepatic packing	Cured

Analysis of operated cases:

Studying the operated cases reveled that clinical examination in association with FAST results were very reliable for operative decision cases in all operated cases.

Table (29): Univariate analysis for operated cases with different parameters

	Operative management				p
	No		Yes		
	No.	%	No.	%	
MOT					0.037*
Localized abdominal trauma	7	5.2	1	6.7	
child abuse	0	0.0	1	6.7	
RTA	80	59.3	11	73.3	
FFH	48	35.6	2	13.3	
Grade of hypovolemic shock					<0.001*
No evidence of hypovolemic shock	85	63.0	0	0.0	
Grade 1	22	16.3	1	6.7	
Grade 2	15	11.1	0	0.0	
Grade 3	8	5.9	9	60.0	
Grade 4	5	3.7	5	33.3	
Abdominal examination					<0.001*
Normal abdominal examination or unreliable	106	70.7	1	6.7	
Localized tenderness	16	10.7	1	6.7	
Guarding, rigidity or echymosis	6	4.0	2	13.3	
Distended surgical abdomen	6	4.0	11	7.3	
Grade of fluid collection					<0.001*
Free	72	53.3	1	6.7	
Minimal	51	37.8	2	13.3	
Mild	9	6.7	10	66.7	
Moderate	3	2.2	2	13.3	

*: Statistically significant at $p \le 0.05$

Table (30): Multivariate analysis for operated cases with different parameters

	B	SE	Sig.	OR	95% CI	
					LL	UP
Grade of shock	1.081	0.43	0.011*	2.947*	1.281	6.779
Abdominal examination	0.882	0.39	0.022*	2.415*	1.134	5.141
Presence of fluid collection	-2.270	1.76	0.197	0.103	0.003	3.261
Grade of fluid collection	0.759	0.65	0.244	2.136	0.596	7.652
Mode of trauma	-0.508	0.45	0.260	0.602	0.249	1.456

Distribution of patients according to follow up with FAST

After 1 week of follow up for all patients either discharged or still hospitalized and either had conservative management or was operated, no cases died but there was 3 cases had complications as sepsis and elevated liver enzymes. 5 cases died 2 of them due to TBI brain injury and 3 due to septicemia.

Table (31): Distribution of the studied cases according to follow up.

Follow up 1week	**No.**	**%**
Improved and discharged with no complications	133	88.7
Improved but still hospitalized	9	6.0
Worsened	3	2.0
Died	5	3.3