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Original Article

Radiology Section

Role of Ultrasonography and CT in the Evaluation of Blunt Abdominal Trauma- A Prospective Study

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ABSTRACT

Introduction: Blunt Abdominal Trauma (BAT) is leading to most causes of death under 45 years of age. Ultrasonography (US) is useful in the evaluation of patients with BAT. Helical CT examination can produce more definitive diagnostic information in about the same time, it takes to perform a complete US examination. CT is accurate in the evaluation of abdominal visceral organ injuries and assessment of the retroperitoneum.

Aim: To assess the role of US and CT in the evaluation of BAT and to compare operative findings or clinical follow-up in conservatively managed patients.

Materials and Methods: This prospective study was conducted in the Department of Radiology from March 2017 to September 2018 on 64 patients with BAT. All patients underwent US and CT abdomen. The patients with haemoperitoneum or abdominal visceral injury or both were considered as positive for intra abdominal injury. The detection of organ injuries and haemoperitoneum on US were correlated with CT findings. Sensitivity, Specificity, PPV, NPV was used to find the correlation of US and CT scan with operative findings.

Results: The overall sensitivity of US in the detection of solid organ injuries was 83.3% and specificity was 87.5%.The PPV was 93.7%, NPV was 70% and accuracy was 84%. The overall sensitivity and specificity in this study with respect to detection of solid organ injuries by CT was 94.7% and 100% respectively. The PPV was 100%, NPV 87.5% and accuracy of this study was 96%.

Conclusion: US may be used as the initial diagnostic modality for suspected BAT. CT is accurate in the detection and quantification of haemoperitoneum and more sensitive in the detection of solid organ injury which is useful in the management of most patients.

Keywords: Bowel and mesenteric injury, Haemoperitoneum, Solid organ injury, Ultrasonogram

INTRODUCTION

BAT is leading to most causes of morbidity and mortality under 45 years of age. The most common causes of BAT includes motor vehicular accidents, blows and kicks over abdomen, fall from height, fall of heavy objects over abdomen, crush and blast injuries. Assessment of the abdomen for possible sustained intra abdominal injury due to blunt abdominal trauma is a common clinical challenge for surgeons and emergency medicine physicians. Physical findings may be unreliable because of decreased patient consciousness, neurologic deficit, medication, or other associated injuries [1]. The most important decision in the management of patients with BAT is to assess the need for surgery. So the screening test must be quick and most sensitive.

US appears to be useful in the evaluation and management of patients with BAT. US is quick, easy to perform, non-invasive, no ionizing radiation or contrast material is required, cost-effective and can be repeated as and when required [2].

Helical CT is the best diagnostic modality in providing information at the same time it takes for a complete US Abdomen. CT is the sole modality for haemodynamically stable patients with BAT or patients who stabilise after initial resuscitation [3]. CT has become imaging of choice in patients with BAT due to high accuracy in abdominal visceral injuries and retroperitoneal injuries in haemodynamically stable patients.

In literature many studies compared either US or CT with operative findings [4,5], but only few studies correlated with operative findings or clinical outcome of patients with BAT [6]. In our study we compared US and CT in the evaluation of BAT and to assess with operative findings or clinical follow-up in conservatively managed patients.

MATERIALS AND METHODS

Prospective study was conducted in the Department of Radiology, Government Medical College and General Hospital in association with Department of Surgery for a period of 18 months from March 2017 to September 2018 on 64 patients with BAT.

Data for the study was collected from patients referred to the Department of Radiology with history of BAT.

The study was approved by Institutional Ethical Committee-IEC/RIMS/2017/59 and guidelines of the committee were followed in the study. Patients with clinical suspicion of Intra-abdominal injury, haemodynamically stable and polytrauma patients were included in the study. Haemodynamically unstable patients were excluded from the study. All patients included in the study were first subjected to Transabdominal Ultrasonography using Toshiba Xario-100, Japan. Then CECT abdomen was performed with Toshiba Asteion 16 Slice CT Equipment. For intravenous contrast enhancement non ionic water soluble iodinated contrast Iohexol (Omnipaque) was given in the dose of 1 mL/kg. To compare US and CT, the time gap between them was kept to the minimum. All 64 patients underwent US and CT, No diagnostic peritoneal tapping was performed. The patients with haemoperitoneum or abdominal visceral injury or both were taken up for the study. US was performed by Senior Resident who was blinded to the patients condition. CT images were reviwed by Second Radiologist who was blinded to the ultrasound results and unaware of the study.

Haemoperitoneum was detected on US and grading of Haemoperitoneum was done on CT. Grading of Individual organ injuries on CT was done based on OIS system proposed by Moore EE et al., [7].

Parameters studied were Haemoperitoneum, Solid organ injury, Bowel/Mesenteric injury and Bladder Injury. A 500 mL of water-

soluble oral contrast was given for suspected bowel perforation and delayed (5-7 minutes) scanning was performed in cases of renal or bladder injuries.

STATISTICAL ANALYSIS

The diagnostic accuracy of Helical CT and US were analysed statistically by using computer based Epi Info and SPSS software version 22. CT is taken as reference test when US findings are compared with CT and diagnostic statistics such as p-value, kappa value has been used to correlate US and CT findings. Operative findings were taken as Gold standard and diagnostic statistics such as Sensitivity, Specificity, PPV, NPV was used to find the correlation of US and CT scan with operative findings.

RESULTS

In this study, there were 46 male and 18 female patients. The patients age ranged from 10 years to 67 years. The peak incidence of 37.5% was present in the 3rd decade and a second peak of 28.1% in the 4th decade of life. The Mean age was 33.05 years and SD was 11.85.

The road traffic accidents were the most common cause of BAT (68.7%), followed by history of fall (20.3%) and Assault (11%) in our study.

Injury Characteristics

Out of 64 patients, 67.2 % (43 patients) were positive for abdominal injury and 32.8% (21 patients) were negative. Based on CT findings, clinical condition, surgeons choice and haemodynamic stability 26 patients were taken up for surgery. Rest of the 17 patients were managed conservatively and followed-up.

Out of the 43 patients who were positive for intra abdominal injury, 40 patients had haemoperitoneum, and 3 patients had visceral injury without hemoperitoneum. US and CT detected haemoperitoneum in all positive cases except in 3 cases [Table/Fig-1].

Positive intra abdominal injuries	No.of cases (n=43)	Percentage (%)
Visceral injuries with hemoperitoneum	38	88.3
Visceral injuries without hemoperitoneum	3	7
Isolated haemoperitoneum	2	4.7
Total	43	100

[Table/Fig-1]: Distribution of positive intra abdominal injuries.

Haemoperitoneum

Forty patients with haemoperitoneum on US were divided into two groups as described by Huang MS et al., [8]. One score was given for free fluid in each intra-abdominal region (Douglas pouch, Morrisons pouch, perisplenic and paracolic gutters). Two points were given if free fluid more than 2 mm was seen in the Morrisons pouch and Douglas pouch or floating bowel loops were seen. Intra abdominal fluid is at least 1000 mL when US score is 3 or more [Table/Fig-2].

US scoring of hemoperitoneum	No. of patients	No. of patients managed conservatively	No. of patients operated
US Score <3	9	6	3
US Score >3	31	8	23
Total	40	14	26

[Table/Fig-2]: Management of patients based on hemoperitoneum (US).

In this study, cases of haemoperitoneum showed a density of about 45 to 65 Hounsfield units on CT. Forty patients with haemoperitoneum were divided into three groups as proposed by Federle MP et al., [9]. These were Small (Fluid in one space), Moderate (Fluid in two or more spaces) and Large (Fluid in all spaces or Pelvic fluid anterior or superior to bladder) [Table/Fig-3].

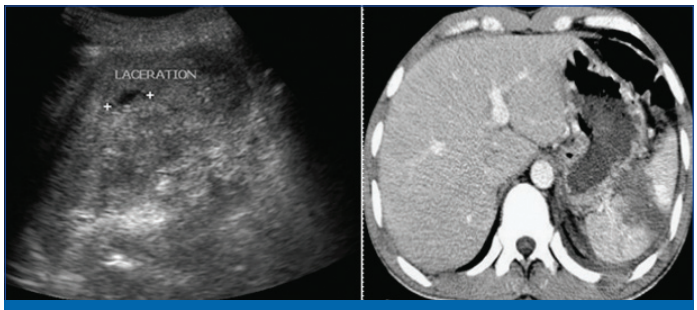
Splenic injury: In the present study, Spleen was the commonest organ injured. Spleen was injured in 17 cases (39.5%) [Table/Fig-4,5]. US missed laceration in one case of splenic injury which was confirmed with CT and surgery. Out of 17 cases 8 cases were managed conservatively and 9 cases were taken up for surgery.

CT quantification of hemoperitoneum	No. of patients	No. of patients managed conservatively	No. of patients operated
Small	8	7	1
Moderate	21	7	14
Large	11	0	11
Total	40	14	26

[Table/Fig-3]: Management of patients based on hemoperitoneum (CT).

Abdominal viscera involved	Number of injuries	Percentage (%)
Liver	11	25.5
Spleen	17	39.5
Pancreas	3	6.9
Renal	5	11.6
Bowel/Mesentery	4	9.3
Bladder	3	6.9
Total	43	100

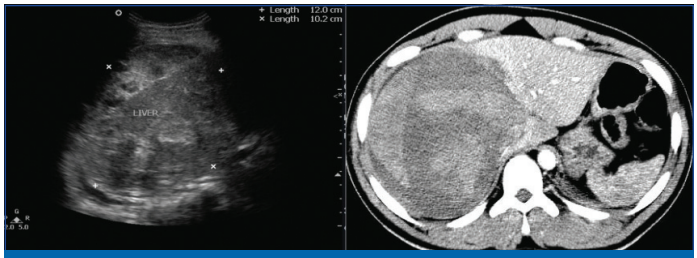
[Table/Fig-4]: Distribution of visceral injuries.



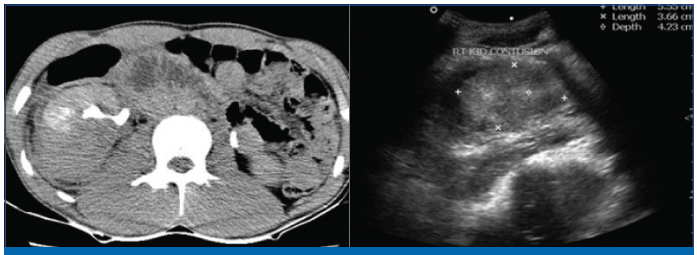
[Table/Fig-5]: US Abdomen shows a large contusion with laceration in the mid and inferior poles of spleen. CECT abdomen shows a large laceration with contusion in the mid-pole causing transection of spleen- Grade IV Splenic Injury.

Hepatic injuries: Hepatic injuries were demonstrated in 11 patients (25.5%). US was not able to detect laceration in one case of liver injury which later was confirmed with CT and surgery. Out of 11 cases 6 cases were managed conservatively and 5 cases were taken up for surgery [Table/Fig-6].

Renal injuries: In our study, 5 patients had renal injuries (11.6%). Ultrasound was able to detect all cases of renal injuries which were confirmed with CT and surgery [Table/Fig-7].

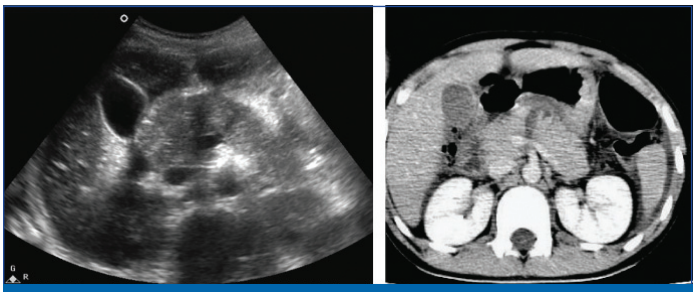


[Table/Fig-6]: US Abdomen shows contusion with hematoma in right lobe of liver. Subcapsular hematoma was also noted. CECT Abdomen shows Sub capsular, Intraparenchymal hematomas and infaction of entire right lobe of the liver-- Grade IV Liver Injury.



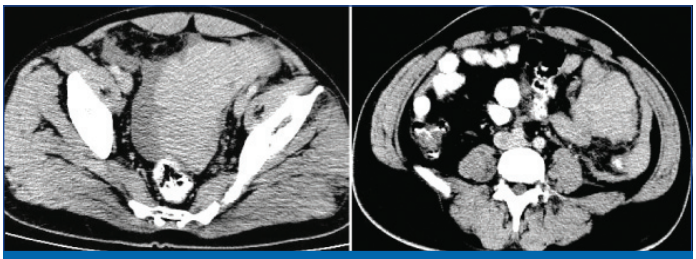
[Table/Fig-7]: USG Abdomen and CECT Abdomen shows an ill-defined contusion with laceration in lower pole of right kidney along with Perinephric hematoma. Grade III Injury Right Kidney.

Pancreatic injury: In our study, 3 cases (6.9%) of pancreatic injuries were detected. US was not able to detect laceration in one case of pancreatic injury which later was confirmed with CT and surgery. These two cases underwent surgery [Table/Fig-8].



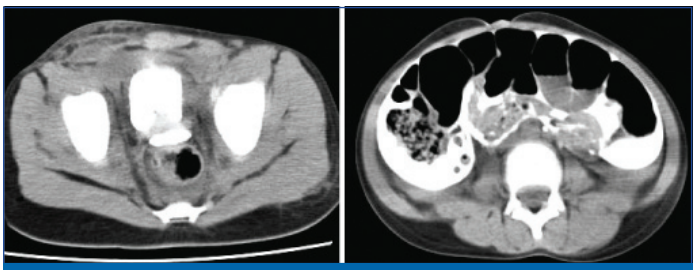
[Table/Fig-8]: USG Abdomen shows a large linear hypoechoic area s/o laceration in the body of pancreas. CECT Abdomen shows large laceration in the body of pancreas with intact splenic vein posteriorly. Grade III pancreatic injury.

Bowel and mesenteric injuries: In this study, there were 4 cases of bowel and mesenteric injuries. In this study, we could detect only 50% of bowel (2 out of 4) injuries. The rest 2 cases of bowel injury were diagnosed in the cases of isolated haemoperitoneum taken up for surgery [Table/Fig-9].



[Table/Fig-9]: CECT Abdomen shows hyperdense area seen in close opposition to the junction of sigmoid and descending colon s/o bowel haematoma. Mesenteric stranding noted adjacent to bowel hematoma s/o mesenteric oedema.

Bladder injuries: This study had 3 bladder injuries. 2 were intraperitoneal and 1 was extraperitoneal. All cases of bladder injuries were diagnosed with US and CT. Intraperitoneal bladder injury cases were operated. Extraperitoneal rupture of bladder was conservatively managed [Table/Fig-10].



[Table/Fig-10]: Intraperitoneal rupture of bladder- CT cystogram shows contrast filled bladder with tear in the posterior aspect causing extravasation of contrast into peritoneal cavity and outlining bowel loops and paracolic gutters.

Majority of the visceral injuries were Grade II injuries. There were no grade V injuries (complete devascularization following transection at hilum) in this study. Most of the visceral injuries which were operated upon belonged to Grade III and IV. None of the injuries graded I to II required surgery. Hence, visceral injuries graded I to II can be managed conservatively and only rarely require surgical intervention. [Table/Fig-11]. Comparisons of CT with US and CT with operative findings in detection of solid organ injury are described in [Table/Fig-12].

DISCUSSION

The challenge in imaging abdominal trauma is to identify injuries that require early operative intervention and at the same time to decide cases that can be managed conservatively.

In this study, the youngest patient was 10-year-old, and the oldest was aged 67 years.This is in agreement with study by Mallik K et al., in which the youngest was 4 years and the oldest patient was 45 years [6].

The maximum percentages of patients (38.4%) were in the age range of 21 to 30 years. This is comparable with study by Kala SK et al., where the maximum percentage of patients was 34.6% [10].

In our study, majority of the patients (59.6%) were involved in motor vehicle accidents. This correlates with findings made by Visrutaratna P et al., who reported that most percent of cases is caused by car accidents (more than 75%) [11].

There were more male patients (71.1%) with blunt injury to abdomen than female patients and male patients outnumbered the female patients in all modes of injury. Kala SK et al., in their study reported that majority of the patients were males (85.5%) [10].

In our study, 40 patients with haemoperitoneum on US, 33% of patients with a score of less than 3 are conservatively managed. In contrast 74% of patients with score of 3 or more required surgical management. Our findings are comparable with the observations made by Mallik K et al., [6]. In their study, 11% of patients with a score of less than 3 are likely to receive conservative management. 60% of patients with score 3 or more need surgery.

Huang MS et al., found that 96% of patients required therapeutic laparotomy with US score 3 or more and with a US score less than 3 laparotomy was required in only (38%) [8].

Regarding CT quantification of haemoperitoneum, the results in our study was in accordance with Mallik K et al., in which all eight patients with small fluid were conservatively managed and similarly all three patients with large fluid required surgical exploration [6]. Approximately, half of the patients with moderate fluid were explored.

We found good correlation of CT quantification of haemoperitoneum with management approach (r value-0.82). Thus in this study, CT quantification devised by Federle MP et al., was a reliable indicator for operative management [9].

This is in comparison with study done by Mallik K et al., which reported good correlation of CT quantification of hemoperitoneum with management (r value-0.53) [6].

Spleen was the single most common organ injured in BAT in the present study. All patients with Grade IV and 3 out of 4 with Grade III required surgical exploration. This correlates well with the study by Kumar MM et al., in which 4 patients, two belonging to grade I and one each belonging to grades II and III were managed conservatively and the rest underwent laparotomy [12].

Injury grade	Liver		Spleen		Pancreas		Kidney		Total (n=36)
	Conservative	Operative	Conservative	Operative	Conservative	Operative	Conservative	Operative	
I	_	_		_	_	_	_	_	_
II	5	_	7	_	1	_	1	_	14
III	1	1	1	3	_	2	_	2	10
IV	_	4	_	6	_	_	_	2	12
V	_	_	_	_	_	_	_	_	_
Total	6	5	8	9	1	2	1	4	36

[Table/Fig-11]: CT grading of solid organ injury with management.

No	Comparison of CT and US in detection of solid organ injuries	Significance
1	Difference in accuracies of CT and US in the detection of solid organ injuries	Statistically significant (p<0.05).
2	The performance of CT and US in the detection of solid organ injury denotes substantial agreement.	Kappa value 0.66
No	**CT and operative findings in detection of solid organ injury**	**Significance**
1	Difference in accuracies of CT and operative findings in the detection of solid organ injury	Statistically significant (p<0.05).
2	The performance of CT and operative findings in the detection of solid organ injury denotes perfect agreement.	Kappa value 0.9

[Table/Fig-12]: Mc nemar test and kappa value for statistical significance.

In our study, hepatic injuries with Grade I and II were managed conservatively. All patients with Grade IV required surgical exploration. Study done by Jeffrey RB Jr et al., showed that CT Grading of liver injuries has little discriminatory value in management of haemodynamically stable patients [13].

Ilahi O et al., in their study reported that that CT scan was 68% accurate moderately sensitive and in detecting pancreatic injury [14]. Though there are numerous studies in the literature comparing either CT or US with surgical findings [Table/Fig-13,14] [4,12,15-22], but there are very few studies comparing CT and US with operative findings in the literature Mallik K et al., [6].

Authors	Sensitivity (%)	Specificity (%)	*PPV (%)	*NPV (%)	Accuracy
Richards JR et al., [4]	68	97	82	91	92
Grussner R et al., [18]	84	–	89	–	86
Michele A et al., [16]	89	96	61	99	96
Hoffmann R et al., [17]	89	97	94	95	94
Dolich MO et al., [15]	86	98	87	98	97
Yoshii H et al., [19]	94.6	95.1	–	–	94.9
Present study	83.3	87.5	93.7	70	84

[Table/Fig-13]: Comparison of validity and predictive values of US with previous studies [4,15-19].
*PPV: Positive predictive value; NPV: Negative predictive value

Authors	Sensitivity (%)	Specificity (%)	*PPV (%)	*NPV (%)	Accuracy
Kumar MM et al., [12]	93	100	100	–	–
Wing VW et al., [20]	100	96.8	–	–	97.6
Liu M et al., [21]	97.2	94.7	–	–	96.4
Pietzman AB et al., [22]	–	–	–	–	98.3
Present study	94.7	100	100	87.5	96

[Table/Fig-14]: Comparison of validity and predictive values of CT with previous studies [12,20-22].
*PPV: Positive predictive value; NPV: Negative predictive value

In this study, we could detect only 50% of bowel (2 out of 4) injuries. Bowel and mesenteric injuries were not detected with US. The sensitivity of bowel injury detection by CT was 50%.

This is in comparison with Kumar MM et al., who in their study reported that CT sensitivity of bowel (41.6%) and bladder (50%) injuries [12].

Out of 43 cases with positive intra-abdominal injury, 26 cases (60.4%) were taken up for surgery. All the 17 cases managed conservatively (39.6%) had uneventful recovery during subsequent clinical observation or follow up period. There was one death in this study which was related to postoperative complications.

In the overall detection of intra abdominal injuries we observed similar findings on US and CT in 26 patients. The present study demonstrates the superiority of CT over US, that in many of our patients CT altered the choice of management or influenced the extent of surgery.

Hence, in the overall CT analysis of visceral injuries in this study, Organ Injury Scaling (OIS) grading in isolation, appeared to predict the management protocols in most patients, except in cases of bowel injuries.

Kumar MM et al., also concluded that the CT OIS is a reliable system that helps in deciding patient management [12]. This is in contrast to the study done by Mallik K et al., who did not find the OIS grading useful in guiding the management of their patients [6].

LIMITATION

As the diagnostic yields in our study was relatively low, large clinical trials are required to suggest protocols to be followed. Another pitfall includes smaller sample size which can have an effect over the overall outcome of the study.

CONCLUSION

To conclude from our study, Ultrasonography may be used as the initial diagnostic modality for suspected BAT. US is accurate in the detection of haemoperitoneum but less sensitive in the detection of solid organ injury. Bowel and mesenteric injuries were not detected with US. CT is accurate in the detection and quantification of haemoperitoneum and more sensitive in the detection of solid organ injury CT is less sensitive in the detection of bowel and mesenteric injuries. The overall CT analysis of visceral injuries in this study, OIS grading in isolation, appeared to predict the management protocols in most patients, except in cases of bowel injuries. Compared with US, CT is extremely accurate and valuable in predicting occult bowel injuries, Retroperitoneal haemorrhage in the form of traumatic perforations even without the use of contrast opacification of bowel. CT has additional advantage in the depiction of associated bony injuries of Spine and Pelvis.

REFERENCES

[1] Lingawi SS, Buckley AR. Focused abdominal US in patients with trauma. Radiology. 2000; 217:426-29.
[2] Healey MA, Simons RK, Winchell RJ. A prospective evaluation of abdominal ultrasound in blunt trauma: is it useful? J Trauma. 1996;40:875-83.
[3] Shuman WP.CT of blunt abdominal trauma in adults. Radiology. 1997;205:297-306.
[4] Richards JR, Knopf NA, Wang L, McGahan JP. Blunt abdominal trauma in children: evaluation with emergency US. Radiol. 2002; 222:749-54.
[5] Hamidi MI, Aldaoud KM, Qtaish I. The role of computed tomography in blunt abdominal trauma. Sultan Qaboos Univ Med J. 2007;7(1):41-46.
[6] Mallik K, Vashisht S, Thakur S, Srivastava DN. Comparative evaluation of ultrasonography and CT in patients with abdominal trauma: A prospective study. Indian J Radiol Imaging. 2000;10:237-43.
[7] Moore EE, Cogbill TH, Malangoni M, Jurkovich GJ, Champion HR. Scaling system for organ specific injuries. Current Opinion in Critical Care. 1996;2(6):450-62.
[8] Huang MS, Liu ML, Wu JK, et al. Ultrasonography for the evaluation of hemoperitoneum during resuscitation: a simple scoring system. J Trauma. 1994;36:173-177.
[9] Federle MP, Jeffrey RB Jr. Hemoperitoneum studied by computed tomography. Radiology. 1983;148:187-92.
[10] Kala SK, Mathur RK, Singh SP. A clinical study of blunt abdomen trauma. Int J Recent Trends Sci Technol. 2015;5(3):626-30.
[11] Visrutaratna P, Na-Chiangmai W. Computed tomography of blunt abdominal trauma in children. Singapore Med J. 2008;49:352-58.
[12] Kumar MM, Venkataramanappa M, Venkataratnam I, Kumar NV, Babji K. Prospective evaluation of blunt abdominal trauma by computed tomography. Ind J Radiol Imag. 2005;15:2:167-73.

[13] Jeffrey RB Jr. CT diagnosis of blunt hepatic and splenic injuries: A look to the future (editorial). Radiology. 1989;171:17-18.
[14] Ilahi O, Bochicchio GV, Scalea TM. Efficacy of computed tomography in diagnosis of pancreatic injury in adult blunt trauma patients: A single institutional study. Am Surg. 2002;68:704-08.
[15] Dolich MO, McKenny MG, Varela JE, Compton RP, McKenney KL, Cohn SM. 2,576 ultrasounds for blunt abdominal trauma. J Trauma. 2001;50:108-12.
[16] Michele A, Brown MD, Casola G, Sirlin CB, Patel NY, Hoyt DB. Hoyt. Blunt abdominal trauma: Screening US in 2,693 patients. Radiology. 2001;218:325-58.
[17] Hoffmann R, Nerlich M, Muggia-Sullam M. Blunt abdominal trauma in cases of multiple traumas evaluated by ultrasonography: A prospective analysis of 291 patients. J Trauma. 1992;32(4):452-58.
[18] Gruessner R, Mentges B, Duber Ch, Ruckert K, Rothmund M. Ultrasonic and lavage in polytraumatized patients with blunt abdominal trauma. J Trauma. 1989;29(2):242-44.
[19] Yoshii H, Sato M, Yamamoto S et al. Usefulness and limitations of ultrasonography in the initial evaluation of blunt abdominal trauma. J Trauma. 1998;45:45-51.
[20] Wing VW, Federle MP, Morris JA. The clinical impact of CT for blunt abdominal trauma. AJR. 1985;145:1191-94.
[21] Liu M, Lee CH, P'eng FK. Prospective comparison of diagnostic peritoneal lavage, CT scanning, and ultrasonography for the diagnosis of blunt abdominal trauma. J Trauma. 1993;35(2):267-70.
[22] Peitzman AB, Makaroun MS, Slasky BS, Ritter P. Prospective study of computed tomography in initial management of blunt abdominal trauma. J Trauma. 1986;26:585-92.

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