Role of ultrasonography, computed tomography and diagnostic peritoneal lavage in abdominal blunt trauma

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ABSTRACT

Objective: To compare the diagnostic accuracy of diagnostic peritoneal lavage (DPL), ultrasonography and computed tomography in the management of blunt abdominal trauma.

Methods: A retrospective review of the charts of 233 patients with blunt abdominal trauma necessitating admission to Riyadh Medical Complex, Riyadh, Kingdom of Saudi Arabia was carried out over a 2 year period (January 2000 to December 2001). The diagnostic yields of DPL, ultrasound and computed tomography were analyzed. The results were compared with findings on subsequent laparotomy or ultimate outcome, which continued in hospital observation and conservative management.

Results: Mean age was 23 years and 79% patients were male. Road traffic accident remained the most common cause (70%) and 56% patients had multisystem injuries. The sensitivity for DPL, ultrasound and computed tomography scans was found to be 98%, 96% and 98% with an overall accuracy rate of 92%, 95% and 99%. Diagnostic peritoneal lavage showed false positive results with retroperitoneal injuries and missed one small bowel injury and a pancreatic injury, and resulted in one catheter related bowel injury. Computed tomography scan was able to grade, quantify and localize the injury and helped in devising a successful management plan in 76.5% cases.

Conclusion: Diagnostic peritoneal lavage is a promising bedside investigation, but is invasive with low accuracy for retroperitoneal injuries and high probability of nontherapeutic laparotomy with false positive results. The high sensitivity and accuracy rates of computed tomography justify its use in quantifying and estimating the grade of injury in order to select the appropriate management of trauma victims. Computed tomography is recommended as the initial investigation of choice in hemodynamically stable patients with blunt abdominal trauma.

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Management of blunt abdominal trauma is a complex undertaking that requires a coordinated and timely approach. Prior to 1960, serial physical examinations were used to make the diagnosis of intraabdominal blunt trauma. Reliance upon "clinical judgment" resulted in many disasters leading to, in some instances, unnecessary morbidity and even mortality.[1] In 1965 Root et al[2] described diagnostic peritoneal lavage (DPL), and this still remains the diagnostic study of choice for assessing blunt abdominal trauma (BAT) in many institutions around the globe. With its introduction, the abdominal computed tomography (CT) established its place in diagnosis of BAT especially in the assessment of hemodynamically stable patients. Diagnostic peritoneal lavage and CT became gold standard for

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diagnosis of BAT but only recently the Ultrasonography (USG) has come up as another promising tool for assessment of BAT.[3] In spite of all these modern technological advances the BAT still remains a hard nut to crack for treating surgeons, occasionally putting them in real diagnostic dilemmas. Riyadh Medical Complex is a tertiary referral center with a busy emergency department. The hospital caters a major share of the trauma victims, both direct admissions and referrals from peripheral hospitals. This retrospective study was carried out to review the diagnosis of blunt abdominal trauma at this center comparing the 3 diagnostic modalities, DPL, USG and CT scan. The study will help to evolve a diagnostic protocol for best and efficient care of blunt abdominal trauma patients.

Methods. A retrospective chart review was performed on all patients presented with abdominal trauma in Riyadh Medical Complex emergency room (ER) in last 2-years (January 2000 through to December 2001). The charts of all patients admitted with diagnosis of blunt abdominal trauma (BAT) were reviewed for initial assessment and results of diagnostic modalities were correlated with findings on laparotomy and success or failure of conservative management. Inclusion criteria were all patients who sustained BAT and were initially evaluated clinically and by using any of diagnostic modality like DPL, CT and ultrasound (US). All patients with penetrating injuries to abdomen, patients with minor injury and discharged home after receiving only ER treatment or patients who had their initial evaluation at other hospitals were not considered eligible for this study, as were the patients, dead on arrival or who died during resuscitation without further evaluation or treatment. The BAT patients with clear indications for surgical intervention like peritonitis, free air under diaphragm or unstable patients without any obvious cause posed less diagnostic dilemma and were considered for emergent laparotomy. The hemodynamically stable patients or patients having altered mental status, central nervous system injury and an equivocal physical examination were subjected to DPL or CT or US. The decision to perform either investigation was taken by the consultant or specialist in charge in the surgical emergency room. Sometimes a combination of diagnostic modalities was utilized in case of equivocal findings on any one investigation or if suggested by the radiologist. Diagnostic peritoneal lavage was not carried out in patients being considered for ultrasonography or CT scan. Diagnostic peritoneal lavage was performed using a closed technique, except in patients with pelvic fractures, where an open method was employed. Diagnostic peritoneal lavage was considered positive if introduction of catheter revealed frank blood or lavage aliquot on analysis showed more than 100,000 red blood cells/mm3, white blood cells >500/mm3 or serum amylase over 250 IU/100ml. Ultrasound was performed using standard protocol of viewing upper quadrants, pelvis and solid organs. A positive US was defined as showing free fluid in these areas or solid organ injury. Computerized tomography scan was performed with oral and intravenous contrast, using 10 mm cuts through the abdomen and pelvis and considered positive in case of solid organ injury, viscus perforation or presence of significant amount of free fluid (>200 ml).

For the purpose of analysis, the results of laparotomy or conservative management were recorded carefully. The results were identified as true positive, true negative, false positive and false negative. The true positive result of any diagnostic modality was one that was later confirmed by operation or successful conservative therapy. False positive was one, which on exploration did not reveal any positive finding. Similarly, true negative result was one that continued to have negative physical examination during observation, conservative therapy or confirmed by other radiographic study, while false negative was one which later on required exploration due to missed injury or other imaging modality showed an injury. Statistical analysis was carried out employing exact Fisher test, chi-square test, and analysis of variance for comparative analysis of the data using IBM-compatible personal computer utilizing Statistical Package for Social Sciences 10.0 for Windows (SPSS Inc., Chicago, IL).

Results. A total of 387 patients with abdominal trauma were evaluated in the ER of Riyadh Medical Complex over 2 years period. Fifty-two patients (13.4%) had penetrating injuries and were excluded from the study. Another 31 patients (8%) who had minor injuries were discharged without further evaluation and were excluded from study. Seventy-one patients (18.3%) having clear indications of laparotomy, like peritonitis, free gas under diaphragm or hemodynamically unstable without any obvious cause, were subjected to laparotomy and were not considered eligible for study. The remaining 233 patients (60.2%) were analyzed further for the study. Males were the main victims, 184 (79%) whereas 49 (21%) females were involved in trauma with male to female ratio of 3.8:1. The age distribution is shown in **Table 1**. Age ranged from 7-80 years, with mean age of 23-years. Most (70%) of trauma victims belong to 20-50 years of age, the most productive years of life. Mode of injury is depicted in **Table 2**, which shows road traffic accidents being the most frequent (70%), followed by falls (17%) and assault (13%). Majority, 130 (56%)of patients had polytrauma. Abdominal trauma was associated with long bone fractures, thoracic, pelvic, head and spine and any combination of above. The

Table 1 - Distribution of patients according to age (n=233).

Age range	n (%)
0-10	19 (8)
>10-20	28 (12)
>20-30	79 (34)
>30-40	51 (22)
>40-50	33 (14)
>50-60	12 (5)
>60-70	7 (3)
>70-80	4 (2)

n - number

Table 2 - Distribution of patients according to the mode of injury (n=233).

Mode of injury	n (%)
RTA	163 (70)
Fall	40 (17)
Assault	30 (13)

n - number, RTA - road traffic accident

Table 3 - Results of diagnostic peritoneal lavage, abdominal ultrasound and computed tomography (n=233).

Diagnostic modality	n of patients	True positive	False positive	True negative	False negative
Diagnostic peritoneal lavage	141	103	9	27	2
Ultrasound	67	52	1	12	2
Computed tomography	81	62	0	18	1

Some patients had a combination of tests

Table 4 - Comparison of specificity, sensitivity and accuracy of diagnostic peritoneal lavage, ultrasonography and computed tomography.

Comparison	DPL*	US*	CT*	*P value* DPL/US	*P value* DPL/CT	*P value* US/CT
Sensitivity	98	96	98	NS	NS	NS
Specificity	75	92	100	<0.05	<0.05	<0.05
Accuracy	92	95	99	NS	NS	<0.05

* - values are in percentages of total patients
DPL - diagnostic peritoneal lavage, US - ultrasonography
CT - computed tomography, NS - non significant

isolated abdominal trauma was seen in 103 (44%) of cases. Diagnostic peritoneal lavage was used as a primary diagnostic tool in this study and was performed in 141 (60.5%) cases. Out of these 141 patients, DPL yielded positive results in 112 (79.4%) cases and negative in 29 (20.6%) cases. In this group 11 patients also had US and 19 cases had CT scan as well. Laparotomy was carried out in 112 cases, which revealed positive result in 103 (92%) and turned out to be negative in 9 (8%) cases. Among 29 cases with negative DPL, 3 (10.3%) developed positive clinical signs of acute abdomen within 24 hours. These 3 patients who on further investigation (CT) and laparotomy proved to have missed small bowel injury in one case and pancreatic injury in other case whereas the 3rd case had iatrogenic small bowel injury with DPL catheter (through and through puncture of small bowel).

Ultrasonography was performed in 67 (28.8%) cases, with positive result in 53 (79.1%) and negative in 14 (20.9%) cases. Out these 67 cases, CT scan was also performed in 37 cases; most of these cases (n=28) were candidates for conservative therapy. Laparotomy was carried out in 39 cases, all were positive except one which did not revealed any intra-abdominal injury, other than small non-expanding retroperitoneal hematoma. Out of 14 negative cases on USG, later on 2 cases proved to have bowel injury and required laparotomy.

The CT was used in 81 (34.8%) patients, with positive finding in 62 (76.5%) and negative in 19 (23.5%) cases. Out of the 62 cases found to have some positive finding on CT, conservative management was adopted in 29 (46.8%) and 33 (53.2%) underwent laparotomy, with no negative result in any patient. Among 19 negative cases one patient developed signs of peritonitis during observation and proved to have missed bowel injury on laparotomy. The compiled results of DPL, US, CT are shown in **Table 3** and the statistical significance is compared in **Table 4**. The table depicts that DPL is highly sensitive but less specific. Ultrasonography seems very promising technique, readily available, cheap, and noninvasive with bedside ER availability. CT, performed only selectively, was found nearest to an ideal diagnostic tool in this study.

Discussion. The diagnosis of intra-abdominal injury following blunt trauma continues to challenge surgeons. Evaluation requires modalities that are both

accurate and readily available. In addition to inherent advantages and drawbacks of each modality, availability also governs its use in various hospitals. While not all hospital have round the clock rapid access to CT or US, the surgeon or even the surgical resident can readily perform a DPL. Same condition exist in Emergency Department of Riyadh Medical Complex admitting at least 7-10 trauma victims, belonging to various specialties everyday.

Since its introduction, DPL has become a standard method for evaluation of BAT and being the most common modality in use, it is true for this study as well.[4,5] The advantages of DPL are availability, good accuracy and low complication rate but with limitation of over sensitivity, leading to non-therapeutic laparotomy. The present study has an accuracy rate of 92% and has a low complication rate, which correlates well with many international studies.[6,7] The high sensitivity of DPL, however, exacts a price in form of non-therapeutic laparotomy, 8% incidence is within the rates of 1.2-16%.[8-10] False positive DPL may result from retroperitoneal hematoma, bleeding from catheter insertion and minor lacerations of liver or spleen.[5,7] In addition to this, failure to recognize injured organ, retroperitoneal or diaphragmatic injuries and low sensitivity in detecting hollow viscus injuries are other limitations.[5,6] The ability of CT to detect parenchymal injuries and their categorization, retroperitoneal injuries, vascular integrity and hemoperitoneum, has made it an attractive option.[3,7] Computed tomography has highest specificity and accuracy, this was depicted in present study as no false positive and only one false negative (1.2%).[11,12] Furthermore, hemoperitoneum resulting from retroperitoneal hematoma due to pelvic fracture can be recognized and in the absence of other solid visceral injuries, laparotomy may be avoided.[2,13] Majority of patients are polytrauma cases (56% in this study), simultaneous head, chest and abdominal CT, may be expeditious.[9,11] Although results of CT scan seem compelling but it is not without its own shortcomings. Allergic reactions to intravenous contrast are well known. In addition to risk of aspiration, the oral contrast requires 2-3 hours transit time for adequate opacification, avoiding this delay may result in missing of GIT injuries and intragastric precipitation of contrast results in scan of poor quality.[14] Patient's movement which may be unavoidable in some cases (head injury, intoxicated patient) will lead to degradation of images and ultimately compromise the result. In Frame's study of 15 initially false-negative CT scan, 9 were considered uninterpretable due to movement artifact and in order to ensure complete motionless CT, use of sedatives or neuromuscular blocking agent were found to have their own hazards.[8] Finally, the main concern and perhaps of greatest fear for both clinician and radiologist, a potentially unstable patient is shifted from best place for resuscitation to unsuitable place. In the present study, CT was postponed half way in 2-cases due to deterioration of patient's condition. Davis et al[15] reports preventable mortality resulting from delay in operative therapy while obtaining CT scans, and states that much of the "golden hour of resuscitation" may be expended in Radiology Department when scans are obtained.

Ultrasonography has gained a rapid popularity in the last 2 decades, offering many advantages; portable, non-invasive, rapid and repeatable and has no known complication. It can be used in cases where DPL is contraindicated, previous laparotomy, and pregnancy or clotting disorders.[6] However, results are operator dependent and may be compromised by obesity, dilated gut loops and ascites. In present study, US has proved very promising, showing comparable sensitivity, accuracy but significantly better specificity (92% versus 75%) as compared to DPL, these findings are comparable to those reported by many investigators.[16,17] All these studies recommend its use in the Emergency Department, ensuring bed side round the clock availability which avoids dangers inherent to transfer to other places, can be repeated if required and is being performed by trauma surgeons or residents and even radiologists. There is ample evidence regarding the potential of this modality to replace DPL.[16-18] Although sensitivity and accuracy of all 3 examinations, DPL, US and CT were comparable (98%, 96%, 98% and 92%, 95%, 99%) but 2 pathologies, bowel injury and retroperitoneal hematoma were the main reasons for difference in the out come of these diagnostic modalities.[5,6] Isolated bowel injury following BAT may be difficult to diagnose especially in early period, as inflammatory response takes some time to established. In present study DPL and US missed 2 each and CT one intestinal injury. Delayed (4-10 hours post injury) DPL may improve the diagnosis rate, allowing enough time to make the diagnosis using criteria of white blood cells >500/mm^3. But purposeful delay is neither feasible nor recommended. This limitation may be countered by complete assay of lavage fluid including amylase, bilirubin, bacteria and particulate matter in lavage aliquot.[2,6] The same is true for US (2 missed small bowel injuries), which rely on detection of free fluid, it takes time for intraperitoneal fluid to accumulate, minimal fluid or inconclusive results are indication for subsequent repeat examination.[5] Computed tomography has its own limitations, needs proper visualization with contrast but even then results are not guaranteed, as evident by one missed bowel injury in the present study. Retroperitoneal hematoma is another area of concern; wrong diagnosis cost a non-therapeutic intervention. It is leading cause for false positive DPL (5/9 in present study), US is better than DPL but CT remains a gold standard in this regard.[2,13] Overall comparison in the

present study depicts that the results of DPL and US are comparable except US is more specific (P=<0.05) that is why DPL is still the most frequent method in practice.[16,17] The added advantages of US, like being non-invasive, bedside availability and feasibility to be performed even in hemodynamically unstable patients while being resuscitated, makes this an attractive option. For this reasons US is rapidly becoming a screening method of choice in many trauma centers around the globe.[6,18] The sensitivity of CT is similar to DPL and US but specificity and accuracy is significantly better than the other 2 modalities. Additional benefits of CT include categorization of parenchymal injuries, retroperitoneal structures and hematoma and vascular injuries.[19] In polytrauma cases, combining head or chest with abdominal scan would have been more expeditious. With emergent role of conservative management of splenic and hepatic injuries in stable patients, CT scan is rapidly gaining popularity as an ideal investigation. One step forward to reduce the incidence of non therapeutic laparotomies and missed injuries, may be the use of diagnostic laparoscopy for evaluation of stable equivocal cases and patients under going surgical exploration.[20] Although we have no personal experience as this facility is not available in our emergency but there are sporadic reports with favorable and non favorable results of this diagnostic modality in evaluation of blunt abdominal trauma. The potential advantages of laparoscopy include its ability to directly visualize injured organ, assess ongoing hemorrhage and detect a hollow viscus injury and in this way can reduce non-therapeutic explorations and missed injuries to a negligible level.[20,21] However, the procedure has its own limitations and must be applied cautiously. Limitations clearly are in terms of visualization of retroperitoneal structures like duodenum, pancreas, where CT scan remains standard noninvasive diagnostic tool.[22,23] Evaluation of the small bowel by laparoscopy is tedious, unreliable and even missed injuries has been reported.[23,24] In addition to cost and risks of general anesthesia, a small but definite risk of serious complications does exist, like trocar related complications, potential fatal tension pneumothorax in presence of diaphragmatic injuries and certainly the possibility of gas embolism from pneumoperitoneum is there in case of venous injuries.[25] Up to 6% incidence of such complications has been reported, which is quite significant as compared with 9.3% complications from negative laparotomies.[26] The current role of diagnostic laparoscopy in evaluation of blunt abdominal trauma is still unclear. Increased clinical experience and more clinical trails will define the future role of this modality.[22,24]

In conclusion, DPL remains gold standard investigation in management of blunt abdominal trauma, being most sensitive test available for detection of intra-abdominal injury although not very specific. Ultrasonography performed by a surgeon or emergency physician in emergency room is rapidly becoming an examination of choice for screening the blunt abdominal trauma and is being used in most major trauma centers instead of DPL. Computed tomography appears to be an important diagnostic tool because of its high specificity especially in hemodynamically stable patients who are candidate for non-operative therapy. Computed tomography is also indicated in stable polytrauma cases requiring evaluation of head and chest trauma and in selected cases to confirm the diagnosis following DPL and US. In the authors' opinion the best diagnostic strategy for blunt abdominal trauma may be ultrasonography as initial screening test followed by CT for further categorization and precise diagnosis of injury to select the most appropriate therapy for a particular patient.

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