DIAGNOSTIC ACCURACY OF COMPUTED TOMOGRAPHY ABDOMEN WITH SURGICAL FINDINGS FOR BLUNT ABDOMINAL INJURY CASES

ABSTRACT

Aims: Computed tomography (CT) has become a widely used imaging modality for evaluating Blunt abdominal injury (BAI) due to its ability to provide detailed anatomical information. This study aims to investigate the correlation between CT abdomen findings with surgical findings in cases of BAI, to assess the accuracy and reliability of CT in diagnosing and guiding surgical intervention. **Study design and methodology:** A retrospective study was conducted on a cohort of patients (n=100), clinically suspected of BAI who underwent CT abdomen and surgical procedure. The sensitivity, specificity, positive predictive value (PPV) and negative predictive values (NPV) of each solid organ were calculated. **Results:** Most of the organs involves are liver (37%) followed by kidney (29%) and spleen (19%). Patient with pancreas and adrenal injuries were low, 8% and 7% each other. CT revealed great sensitivity for the liver (98%), kidneys (98%) and adrenal (89%), and moderate sensitivity for the spleen (85%) and pancreas (80%). All the solid organs have high positive predictive value (PPV) and negative predictive value (NPV), with kidneys having the largest range (PPV: 100% and NPV: 98%). The overall validity of CT was excellent in evaluating BAI cases. The results of this study indicate a strong correlation between CT abdomen findings and surgical findings in BAI cases. CT also showed abnormal findings like contusion, hematoma, laceration and vascular injury in most BAI cases. **Conclusion:** The accuracy and reliability of CT highlight its significance, guiding appropriate surgical intervention and optimizing patient outcomes.

Keywords: blunt abdominal injury, computed tomography, surgical findings, diagnostic accuracy.

1. INTRODUCTION

Trauma is a leading cause of morbidity and mortality worldwide, with abdominal injuries being a significant consequence of blunt trauma. According to Karaki (2015), missed blunt abdominal injuries (BAI) still result in avoidable fatalities. BAI is a significant cause of morbidity and mortality, accounting for a considerable portion of trauma cases worldwide. Prompt and accurate diagnosis is crucial for timely intervention and improved patient outcomes. BAI typically happens after assaults, falls, traffic accidents, and other mishaps while out having fun. Men are typically impacted slightly more frequently than women. Epidemiological studies have demonstrated the high incidence of blunt abdominal injuries in trauma patients. For instance, a study by Morrison et al. (2021) reported that abdominal injuries accounted for approximately 15% of all trauma cases. Blunt abdominal trauma can cause a wide range of injuries, including solid organ injuries (such as liver, spleen, and kidney). The impact of trauma can lead to various intra-abdominal injuries, ranging from minor contusions to severe organ damage, necessitating immediate and accurate diagnosis for appropriate management.

The management of patients with blunt abdominal injuries requires a multidisciplinary approach, involving accurate diagnosis, appropriate resuscitation, and timely surgical intervention when indicated. However, imaging modalities, particularly computed tomography (CT), are crucial for accurate diagnosis. CT plays a crucial role in the initial assessment of these patients, providing detailed anatomical information to guide clinical decision-making (Scalea et al., 2021). CT imaging allows for the identification and characterization of various intra-abdominal injuries, such as solid organ lacerations, bowel perforations, and the presence of intra-abdominal hemorrhage. It provides valuable information regarding the extent and severity of injuries, facilitating the decision-making process for surgical intervention (Demetriades et al., 2022). Evidence from a study by Smith et al. (2022) demonstrated that the integration of CT findings with surgical procedures resulted in improved patient outcomes in cases of blunt abdominal injuries. The study reported that the use of CT-guided surgical intervention led to reduced operative times, decreased rates of unnecessary laparotomies, and improved overall survival rates compared to traditional surgical approaches.

However, it is important to note that not all patients with blunt abdominal injuries require immediate surgical intervention. In cases where CT findings do not indicate the need for immediate surgery, a non-operative management approach can be considered. BAI cases be a clinical challenge because of its subtle and nonspecific clinical findings, especially in identifying an isolated traumatic injury to the bowel or mesenteric. This issue could ultimately cause a delay in identification and treatment, which would raise the related morbidity and death (Vailas et al., 2015).

An accurate diagnosis of BAI is essential for appropriate management and improved patient outcomes. CT has become the imaging modality of choice, providing crucial information for prompt and accurate diagnosis. Understanding the relationship between CT findings helps guide clinical decision-making to surgical procedures and findings in the context of optimizing patient care. Therefore, the purpose of this study is to review the correlation or association between CT findings and surgical findings for BAI by determining the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of CT findings on spleen, liver, pancreas, adrenal and kidney as a baseline for surgical findings.

2. MATERIALS AND METHOD

A retrospective data analysis was performed in all adult patients who underwent CT abdomen examination and reported blunt abdominal injuries and attempts by the surgical team from January 2021 to December 2022. This study was carried out at Radiology Department, Hospital Pulau Pinang (HPP), Malaysia to determine the correlation of the CT findings with the surgical findings for BAI cases. The overall sensitivity, specificity, PPV and NPV were determined.

2.1 Computed Tomography (CT) scan of abdomen

CT abdomen examination was scanned using 128 Slices Multidetector CT Scanner SIEMENS Somatom Definition AS (Siemens Sector Healthcare, Forchheim, Germany). The data of the patient’s report was collected from picture archiving and communication system (PACS) obtained from Radiology Department, HPP. After going over the reports, patients with incomplete data were excluded, and only patients who had reported with blunt abdominal injuries through CT findings and attempted by the surgical team were included in this study. A standard template for the CT abdomen report was taken from the Radiological Society of North America (RSNA).

2.2 Data collection

The data collection forms used in this study consist of two sections. Section A is on demographic data that consist of 4 items while Section B which has 6 items adopted from Cinquantini et al., 2017. This data collection form was used as the tool to collect all patient's data in this study. Patient's reports on solid organs; spleen, liver, pancreas, adrenal and kidney in BAI cases were obtained from picture archiving and communication system (PACS) for CT findings which were reported by the Radiologist and data of the surgical findings were obtained from Hospital Information System (HIS).

Demographic data, mechanism of trauma, management and outcomes were studied retrospectively reviewed the records of patients with BAI cases including the operative surgical reports and the CT findings. This study considered the PPV and NPV through the collected data. These data determined the validity of the CT examination and compared it with surgical findings or clinical outcomes.

2.3 Diagnostic accuracy measures

This study quantified two measures for diagnostic accuracy, sensitivity and specificity; and positive and negative predictive values (PPV, NPV). These measures are related to two main categories of issues; classification of patients between those who have and those who do not have diseases (discrimination); and estimation of the probability of a disease (prediction).

Decisions about health policy are primarily concerned with discrimination, but once test results are known, predictive measures are most helpful in estimating a person's likelihood of developing a disease. These diagnostic accuracy measures are therefore not interchangeable. Most of the measures are sensitive to the range of diseases in the population under study, and several of them rely heavily on the prevalence of the disease (V.M. Montori et al,. 2005).

The cutoff value in a test will show if a person is positive (beyond/beyond the cutoff) or negative (beyond/beyond the cutoff). The gold standard, also known as the reference method, tells us if the same person is healthy or sick. The population of studied patients with and without disease is thus divided into four subgroups by the cutoff, as shown in table 1.

- true positive (TP) = patients with the disease with the value of a parameter of interest above/below the cutoff; It is the total counts having both predicted and actual values are Dog.

- false positive (FP) = patients without the disease with the value of a parameter of interest above/below the cutoff;

- true negative (TN) = patients without the disease with the value of a parameter of interest below/above the cutoff;

- false negative (FN) = patients with the disease with the value of a parameter of interest below/above the cutoff

Table 1: 2 × 2 table reporting cross-classification of patients by index and reference test result

Index text	**Reference test**		**Total**
	Patients with the disease	**Patients without the disease**	
Positive	TP	FP	TP + FP
Negative	FN	TN	FN + TN
Total	TP + FN	FP + TN	

Sensitivity = [TP / (TP + FN)] x 100

Specificity = [TN / (TN + FP)] x 100

Figure 1: Formula to calculate sensitivity and specificity

2.3.1 Sensitivity and Specificity

Sensitivity is generally expressed in percentage and defines the proportion of TP subjects with the disease in a total group of subjects with the disease: TP/(TP + FN). Sensitivity estimates the probability of getting a positive test result in subjects with the disease. Hence, it relates to the ability of a test to recognize the ill (D.G. Altman, J.M. Bland, 1994)

Specificity is defined as the proportion of subjects without the disease with a negative test result in a total group of subjects without the disease: TN/(TN + FP). In other words, specificity estimates the probability of getting a negative test result in a healthy subject. Therefore, it relates to the ability of a diagnostic procedure to recognize the healthy (D.G. Altman, J.M. Bland, 1994)

Both sensitivity and specificity are not dependent on disease prevalence, meaning that results from one study could easily be transferred to some other setting with a different prevalence of the disease in a population. Nonetheless, sensitivity and specificity may largely depend on the spectrum of the disease. In fact, both sensitivity and specificity benefit from evaluating patients with more severe disease. Sensitivity and specificity are good indices of a test's discriminative ability; however, in clinical practice a more common line of reasoning is to know how good the test is at predicting illness or health: How confident can we be about the disease status of a subject if the test has yielded a positive result? What is the probability that the person is healthy if the test is negative? These questions need predictive values to address them.

2.3.2 Predictive values

PPV define the probability of being ill for a subject with a positive result. Therefore, a PPV represents a proportion of patients with a positive test result in a total group of subjects with a positive result: TP/(TP + FP) (D.G. Altman, J.M. Bland, 1994).

NPV describe the probability of not having a disease for a subject with a negative test result. An NPV is defined as a proportion of subjects without the disease and with a negative test result in a total group of subjects with a negative test result: TN/(TN + FN) (D.G. Altman, J.M. Bland, 1994).

Unlike sensitivity and specificity, both PPV and NPV depend on disease prevalence in an evaluated population. Therefore, predictive values from one study should not be transferred to some other setting with a different prevalence of the disease in the population. PPV increase while NPV decrease with an increase in the prevalence of a disease in a population. Both PPV and NPV increase when we evaluate patients with more severe disease.

Positive predictive value (PPV) = [TP / (TP + FP)] x 100

Negative predictive value (NPV) = [TN / (TN + FN)] x 100

Figure 2: Formula to calculate Positive Predictive Value (PPV) and Negative Predictive Value (NPV)

2.4 Data analysis

The sensitivity, specificity, positive predictive value (PPV) and negative predictive values (NPV) of each solid organ were calculated. Descriptive data were presented as mean ± standard deviation. Data analysis was performed by using Microsoft Office Excel, Statistical Package for Social Sciences (SPSS) version 22.0 (SPSS V22.0, Chicago, USA) and MedCalc statistical software. A *p* value of less than 0.05 was considered statistical significance. Pearson's Chi-square test was used to determine the association between CT findings and surgical findings. The independent variable (IV) is surgical findings and dependent variable (DV) is CTfindings (Radiologist’s reports).

3. RESULTS

Out of 100 data of patients collected for this study, 59% were male and 41% were female. The age of patients ranged from 5 to 85 years (mean age 46.16 years). Each patient was scrutinized and relevant information was determined. The sociodemographic data are shown in Table 2.

Table 2: Sociodemographic

Variable		**Frequency**	**%**
Sex	Male	59	59
	Female	41	41
Age	0-20	4	4
	21-40	68	68
	41-60	25	25
	61-80	2	2
	81-100	1	1

From table 3 below it is noted that 59% of the 100 BAI patients had only one organ injury while 41% of the BAI patients had more than one organ injury in their abdomen. 38% of them underwent surgery while 62% of them were non-surgery cases. These cases were treated as conservative that is did not undergo any surgery and 95% of patients were alive while 5% of them died while warded and treatment was going on. Most of the BAI were diagnosed and treated promptly on arrival or obtained the appropriate treatment in time, decreasing the mortality rate for cases from BAI.

Table 3.: Injury of organs reported by the patients

Variable		**Percentage (%)**
Number of organs injured	Only one organ	59
	More than one organ	41
Treatment	Surgery	38
	Non - Surgery	62
End Result	Alive	95
	Death	5

From the statistics, figure 3 shows that out of the 100 BAI patients, 37% of the injuries were from the liver, 29% from the kidneys, 19% from the spleen, and 8% and 7% from the pancreas and adrenal. From here we can derive that most of the BAI involves the liver followed by kidneys and spleen. Patients with pancreas and adrenal injuries were low.

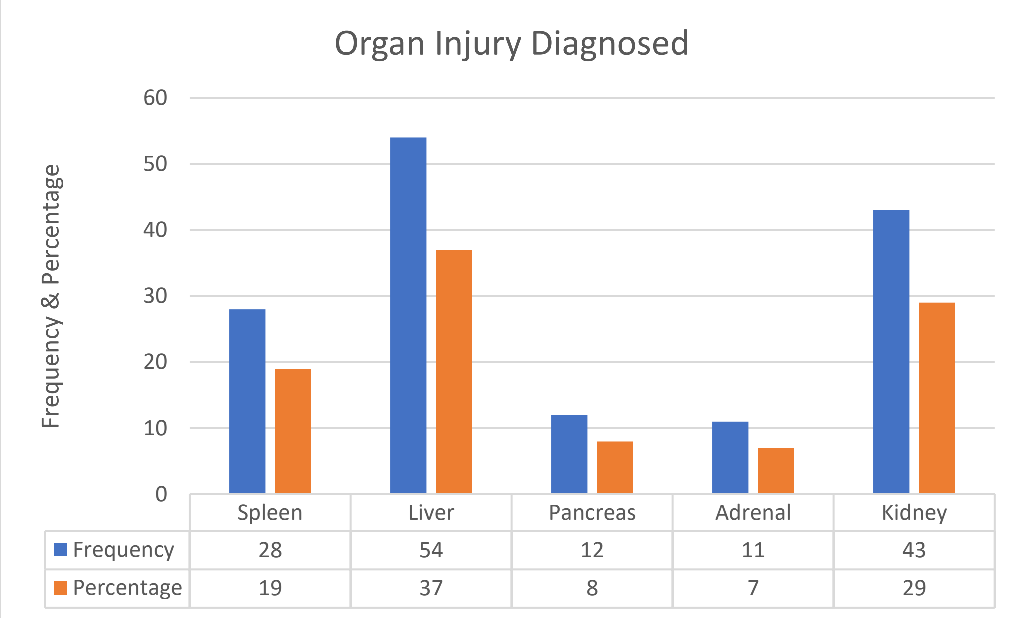

Figure 3.: Organ Injury Diagnosed

3.2 Preliminary Analysis

Several analyses were performed after going through the various data collected in this present study. The nature of variables to each question in the data collection form was explored through Microsoft Excel software, SPSSversion 22 and MedCalc software.

Table 4: Blunt Mechanism of The Patients

Variable	Frequency	Percentage (%)
Motor Vehicle Collision	89	89
Assaults	4	4
Fall from Height	3	3
Pedestrians struck by vehicles	2	2
Crush Injury	2	2

3.2.1 To determine the blunt mechanism for BAI cases at HPP.

From Table 4, motor vehicle collision (89%) is the most common reason for BAI, followed by assault 4%, fall from height 3%, and pedestrians struck by vehicles and crush injury 2% respectively. This also could indicate that the number of vehicles on the road has increased and there were a lot of road accidents resulting in BAI.

3.2.2 To determine the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of CT findings on spleen, liver, pancreas, adrenal and kidney as a baseline for surgical findings.

Before determining the sensitivity, specificity, PPV and NPV of CT findings on the five organs using the surgical findings as the baseline, the true positive (TP), false negative (FN), false positive (FP) and true negative (TN) including the present (TP+FN) and absent (FP+TN) of the injury were demonstrated on all the five organs individually. This was done using SPSS version 22 and MedCalc statistical software. The surgical findings were used as the gold standard to determine the values.

Table 5 and Figure 4 below demonstrate the estimates of diagnostic accuracy of each organ that had been analyzed. Liver had the highest true positive (51 patients) while the lowest was pancreas and adrenal (8 patients each) respectively. Spleen and kidneys had 22 patients and 42 patients respectively. Pancreas and Adrenal had the highest true negative (89 patients each). Kidney cases were more accurate where the false negative and false positive were the lowest. Liver (52%) had the highest percentage of present findings (had injuries) while adrenal (91%) had the highest percentage of absent findings (no injuries).

Table 5: Estimates of Diagnostic Accuracy

Variable	**True Positive (TP)**	**False Negative (FN)**	**False Positive (FP)**	**True Negative (TN)**	**Present Findings (%)**	**Absent Findings (%)**
Spleen	22	4	1	73	26	74
Liver	51	1	3	45	52	48
Pancreas	8	2	1	89	10	90
Adrenal	8	1	2	89	9	91
Kidneys	42	1	0	57	43	57

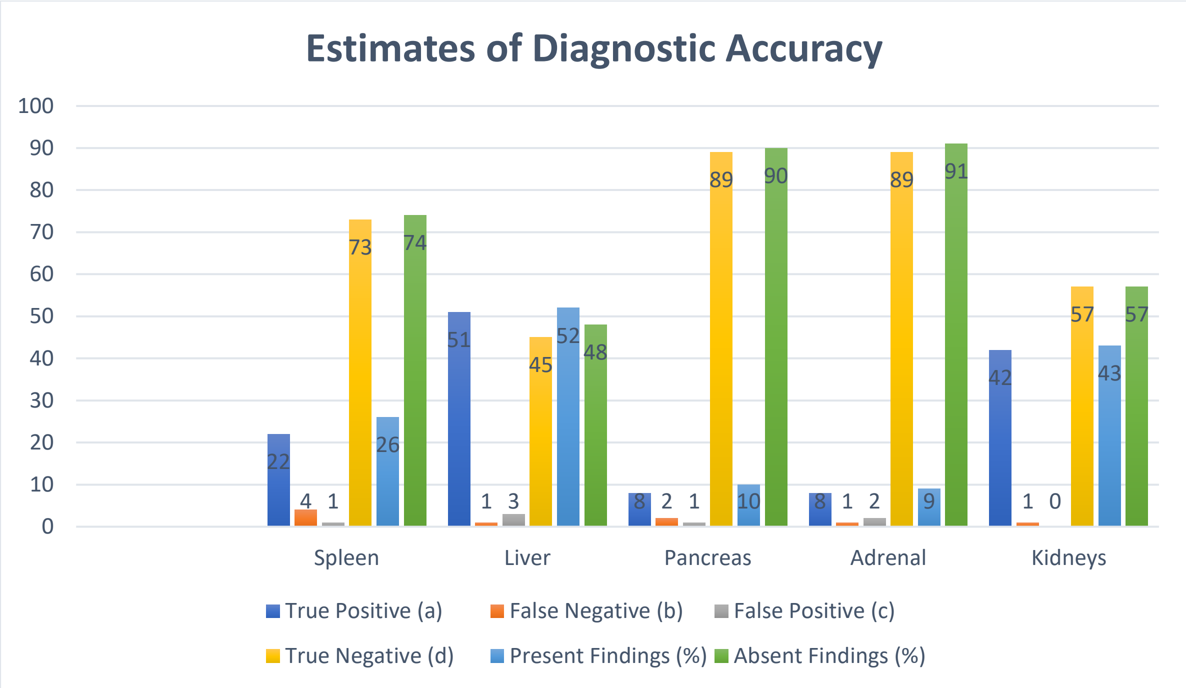

Figure 4: Estimates of Diagnostic Accuracy of the five solid organs

After identifying the estimated diagnostic accuracy in the five organs, Table below shows the sensitivity, specificity, PPV and NPV. With the aid of Table 1 above, the sensitivity, specificity, PPV and NPV were determined. Using the formulae in fig 1 and 2 above, all the parameters in Table 5 were calculated from the result of the CT findings and surgical findings in each of the five organs and expressed as percentages to obtain the values.

Table 6-

Sensitivity, Specificity, PPV and NPV

Variable	**Sensitivity (%)**	**Specificity (%)**	**Positive Predictive Value (PPV) (%)**	**Negative Predictive Value (NPV) (%)**
Spleen	85	99	96	95
Liver	98	94	94	98
Pancreas	80	99	89	98
Adrenal	89	98	80	99
Kidneys	98	100	100	98

3.2.2.1 The sensitivity and specificity.

Even though the sensitivity of all the organs are 80% and above, the highest sensitivity among the five organs are liver and kidneys which amount to 98% respectively. The lowest sensitivity organ is pancreas (80%).

Figure 5 illustrates the sensitivity and specificity of each organ. The specificity of all organs ranges from 94% to 100%. The liver has the lowest specificity with 94% while the kidneys were very accurate with 100%.

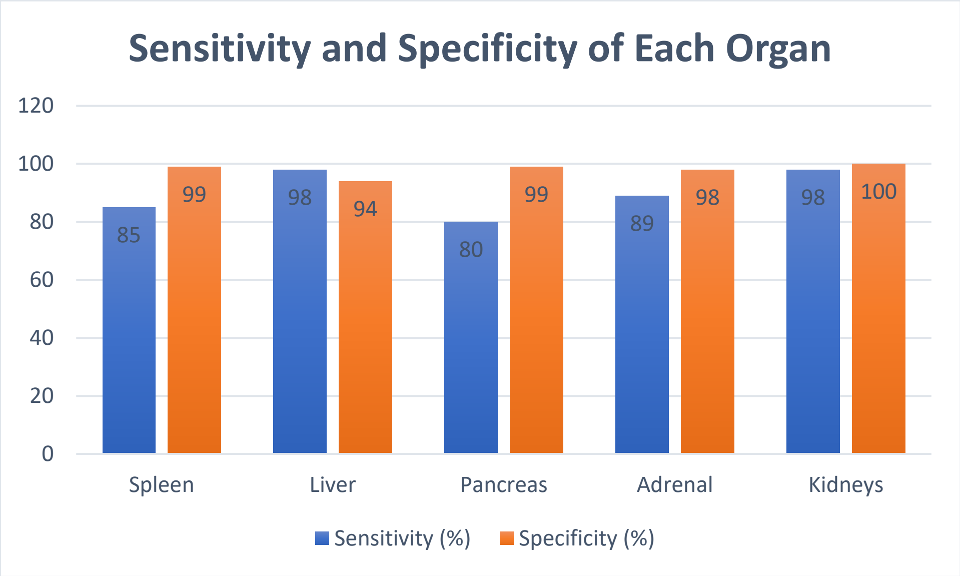

Figure 5: Sensitivity and Specificity of Each Organ

3.2.2.2 The PPV and NPV

The PPV of all the organs ranged from 80% to 100%, however, the highest PPV among the five organs is kidneys which amount to 100%. The lowest PPV organ is adrenal (80%). The NPV of all organs is 95% and above. The adrenal has the highest with 99% while the spleen was the lowest (95%).The data regarding PPV and NPV are illustrated in Figure6 below.

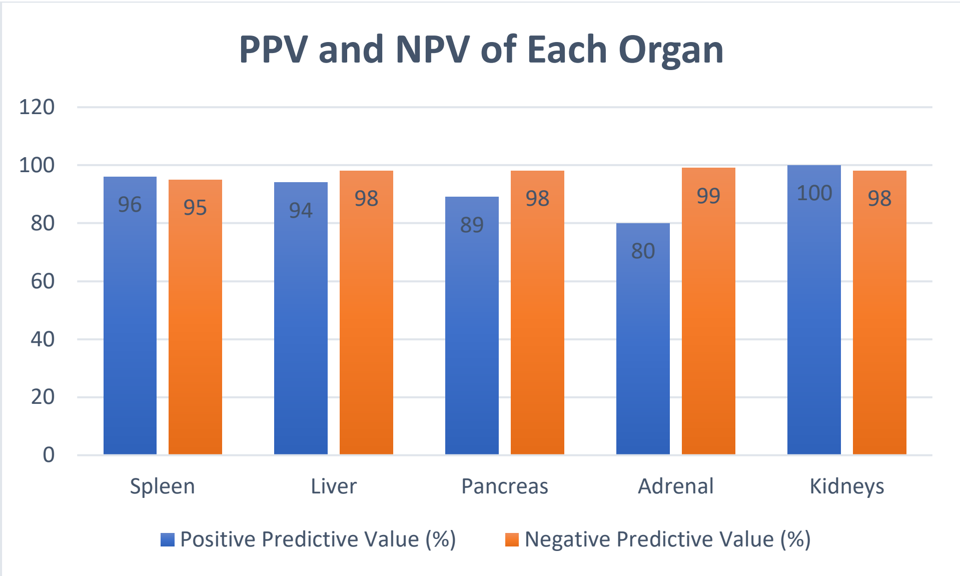

Figure 6: Positive and Negative Predictive Value of Each Organ

4. DISCUSSION

The mean age of the patients was 46 years old. 59% were male and 41% were female. Most of these patients were Malays. From the statistics itwas shown that most of the BAI injuries were from liver among the five solid organs. 59% had injured only one organ while 41% had injured more than one organ. Out of the 100 patients, 38 of them underwent surgery while 62 of them were treated conservatively (admitted, treated and discharged). Eventhough there were five deaths, most of the BAI were treated promptly which in turn decreased the mortality rate for cases from BAI.

The most common blunt mechanism for BAI cases was motor vehicle collisions (89%). There was also other blunt mechanism which total to 11% such as assaults, fall from height, pedestrians struck by vehicles and crush injury.

Spleen with the low sensitivity (85%) and a moderate specificity (99%) but has a high PPV and NPV of (98%) and (95%) respectively. This shows that the accuracy of the CT finding and surgical findings can be considered accurateand accepted.

Liver with a higher sensitivity (98%), high specificity (94%) and NPV which was higher than the PPV (98%) and (94%) shows that the CT findingsand surgical findings have errors but the error margin is small and acceptable.

Pancreas with a lowest sensitivity (80%), low specificity (99%), lower PPV (80%) and higher NPV (98%) shows that this organ is difficult to detect in the CT findings but in the surgical findings, the injury can be noted.

Adrenal with a high sensitivity (98%), high specificity (98%), lowest PPV (80%) and highest NPV (99%) shows that the injury of the adrenal in the CT findings and surgical finding cannot be noticed and diagnosis is very difficult to decide. It could be because that the organ is very tiny.

Kidneys with a higher sensitivity (98%) and highest specificity (100%) shows that the diagnosis of kidneys injury in BAI cases are accurate in accordance to the surgical findings and CT findings. The results are accurate giving the highest PPV (100%).

This study found CT to be highly sensitive (80% - 98%) and strongly specific (94% - 100%), thus it is likely to identify most patients in whom there is solid organs injury for BAI cases. It had a very high PPV ranging from 80% till 100%, resulting in only a few patients with no solid organinjury will be subjected to surgery. The NPV was high, ranging from 95% till 99% i.e. the probability that a respondent does not have solid organ injury giventhat CT scan is negative. The level of agreement between CT and surgical findings wasdetermined by using Chi-square testing for statistical analysis. A *p* value of 0.000% was considered statistically significant. Regarding the Chi-Square test finding, CT Scan is the most appropriate modality for detecting injuries from BAI cases.

The statistical hypotheses formulated for all solid organs in this investigation posited a null hypothesis (no correlation or association between CT and surgical findings) and an alternative hypothesis (a significant correlation exists). With a stringent alpha level of 0.01, the analysis yielded a *p*-value of 0.000, which is substantially lower than the predefined significance threshold. Consequently, the null hypothesis was rejected, indicating a statistically significant correlation between CT imaging results and surgical observations specifically for BAI cases. This robust finding ($p < \alpha$) underscores the reliability of CT scans in diagnosing BAI and aligning with intraoperative assessments, which holds critical implications for clinical decision-making and reinforces the utility of CT as a non-invasive diagnostic tool in trauma settings. The results highlight the importance of integrating imaging findings with surgical evaluation to enhance diagnostic accuracy and patient outcomes in BAI management.

5. CONCLUSION

This study proves that the CT and surgical findings as the gold standard examinations are similar and accurate. CT is considered the diagnostic test of choice (100% sensitive) in stable patients with BAI and providesappropriate anatomical detail of the spleen, liver, pancreas, adrenal and kidney organs. It also showed abnormal findings in patients with contusion, hematoma, laceration and vascular injury can be identified. In most BAI cases only one organ is involved. In this present study liver is the most injurious organ in BAI cases. CT scan is helpful in diagnosis and decision making for surgery in cases of BAI. CT scan should be the gold standard in identifying injuries in BAI cases which in turn helps the surgical team in administering the appropriate treatment and managing together with after care of all BAI cases. It is concluded that CT despite of its high radiation exposure and higher cost delineates the severity of BAI and provides information and assistance for the surgeon in managing the treatment. Hence, CT findings correlate with surgical findings for BAI cases.

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