BASE DEFICIT AS AN INDICATOR OF SIGNIFICANT BLUNT ABDOMINAL TRAUMA AT KENYATTA NATIONAL HOSPITAL

This dissertation is submitted in part fulfillment for the award of Master of Medicine in General Surgery degree of the University of Nairobi

By
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DECLARATION

I declare that this study is my original work and has not been presented for the award of any degree at any other institution or university.

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This research Dissertation was presented at the Department of Surgery meeting held on 6/11/2014 and approved for presentation to the Kenyatta National Hospital/ University of Nairobi Ethics and Research Committee.

Sign………………………………Date………………………………

Chairman,
Department of Surgery,
University of Nairobi.
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UNIVERSITY OF NAIROBI

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Registration Number _____________________________________________________________
College ____________________________________________________________
Faculty/School/Institute _________________________________________________________
Department _________________________________________________________________
Course Name _________________________________________________________________

Title of the work

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Date ________________________________________________________________
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LIST OF ABBREVIATIONS

AI           Abdominal injury
BAT   Blunt abdominal injury
BD         Base deficit
CT        Computed tomography
DPL       Diagnostic peritoneal lavage
FAST     Focused abdominal sonography for trauma
KNH    Kenyatta National Hospital
UON    University of Nairobi
ROC   Receiver operator curve.
NPV    Negative predictive value
PPV    Positive predictive value
DEDICATION:

First and foremost I would like to thank Almighty God for giving me the strength and wisdom to pursue my dreams.

Special thanks go to my supervisors, Prof. Peter Mungai and Dr. Daniel Ojuka whose contribution to development of this Dissertation is unrivalled.

Deep gratitude goes out to my family for offering me time and moral support to develop this Dissertation.
Base deficit as an indicator of significant blunt abdominal trauma at Kenyatta National Hospital

ABSTRACT

Background:
Blunt abdominal trauma (BAT) is an important cause of morbidity and mortality among all age groups. Early recognition of significant BAT is of utmost importance in preventing adverse outcomes. Focused Abdominal Sonography for Trauma (FAST) is the screening method of choice while CT scan is currently the ideal method for haemo-dynamically stable patients. Base deficit (BD) has been proposed as an early available tool alongside FAST in the screening of patients suspected to have BAT and also to help guide the selective use of CT scan. However studies regarding the utility of BD as an indicator of BAT are few and there is no such study in our local set up.

Objective: To determine the use of BD as an indicator of significant BAT

Study Design: A Prospective observational Study.

Setting: Kenyatta National Hospital, Nairobi Kenya

Methodology: Ethical approval was sought and obtained from KNH\UON ERC. Data was collected from February 2015 to May 2015. Anon-randomized series of 134 patients (110 Males and 24 Females) with suspected BAT admitted into Accident & Emergency and who met the inclusion criteria were enrolled. History, physical examination findings and vital signs were noted. Arterial blood samples were analyzed for BD. FAST, CT scan, and or laparotomy were performed according to need to find intra-abdominal injury. Following clinical evaluation and investigations 81 patients were discharged from (A&E), 7 patents were discharged from the wards in 48 hrs after ruling out abdominal injury, 32 patients were managed conservatively for abdominal injury while 14 patients underwent explorative laparatomy. For those who were discharged from A&E or shortly from the wards without operation, follow up phone interviews were done after 7 days to find out their progress. 132 patients (108 males and 24 females) were analyzed. 2 patients were excluded from the study
because one had a negative laparotomy while the other who had been discharged from (A&E) did not answer calls when he was contacted.

**Data analysis:** Data was collected using a structured questionnaire and analyzed using SPSS 17.0 program. Receiver operating characteristic (ROC) curves were drawn and comparison of mean values of BD between different groups of patients (discharged from A&E, managed conservatively and operated) were performed using ANOVA.

**Results:** BD values were significantly lower in patients who had abdominal injury compared to patients who had no abdominal injury (p=0.037). Similarly BD values were significantly lower in patients who had abdominal injury and underwent explorative laparotomy compared to those who had abdominal injury but were managed conservatively (p=0.029). For patients who had abdominal injury versus those who did not the cut-off value at which the greatest sum of sensitivity 82.98% and specificity 65.91 % was obtained for base deficit was -4.15. The PPV was 56.52% and the NPV was 87.88 %. For those who underwent explorative laparotomy versus those who did not the cut-off value was -6.85 with a sensitivity of 73.33% and specificity 58.06. The PPV was 45.83% and the NPV was 81.82 %.

**Conclusion**

The findings of our study show that BD is an early available tool that can be used to predict presence of AI as well as significant AI (injuries requiring exploratory laparotomy). At a cut-off of -4.15, the likelihood of abdominal injury is so high that an objective evaluation using imaging is warranted. On the other hand a normal BD, though an important indicator of absence of injury does not rule out presence of injury, however our findings show that a patient with significant intra-abdominal injuries requiring surgical intervention is unlikely to have a BD> -6.85 Meq/L
Introduction

Trauma is the most frequent cause of death in the first four decades of life worldwide and remains a public health problem in all countries, regardless of the level of socio-economic development. \(^1\), \(^2\), \(^3\)

Injuries of the abdomen are classified as either blunt or penetrating. \(^3\), \(^4\), \(^5\). Studies done in many centres around the globe put the prevalence of intra-abdominal injury(any injury to intraperitoneal and retroperitoneal organs including the presence of hemoperitoneum) in BAT at about 13% with 4.7% requiring therapeutic surgery or angiographic embolization to stop bleeding. \(^6\) In South Africa the incidence of BAT is estimated to be 9.8% while locally Musau et al puts the ratio of penetrating to BAT at 2:1. \(^3\), \(^7\), \(^8\), \(^9\) Not all intra-abdominal injuries have significant clinical consequences. Most investigators define patients with significant intra-abdominal injuries as those requiring therapeutic surgery or angiographic embolization to stop hemorrhage. \(^6\)

Evaluation of patients with BAT has significant diagnostic challenges even to the most experienced trauma surgeon. \(^10\), \(^11\), \(^12\) Patients with severe injuries and ongoing loss of blood need immediate identification and treatment while those with seemingly less severe trauma or have unequivocal clinical signs on initial physical examination may still have significant intra-abdominal injuries, and delayed recognition may be responsible for preventable morbidity and mortality. \(^6\)

The most widely used algorithms for hemody-namically unstable patients involve diagnostic modalities such as FAST or diagnostic peritoneal lavage (DPL) to determine the need for urgent surgical intervention. \(^10\), \(^11\), \(^13\) Studies have shown that BD is a laboratory investigation that can aid in the screening of patients with suspected BAT alongside FAST. Some authors have emphasized the importance of obtaining it early during the evaluation of blunt trauma patients as it can reliably predict not just ongoing haemorrhage but significant intra-abdominal injury and the need for surgical intervention. \(^14\) In most studies a BD of $-6$ Meq/L or less has been shown to be predictive of significant intra-abdominal injury in BAT. \(^6\)

Abdominal CT scan is the most commonly used modality for diagnostic evaluation of patients with BAT who are haemo-dynamically stable. However, less than 20% of abdominal CT scans obtained in these patients are positive for intra-abdominal injury and less than 3%
have injuries that require surgical intervention or angiographic embolization. Deunk et al. proposed a selective criterion in victims of blunt trauma, based on clinical, radiological, laboratory and ultrasound exam to guide use of CT scan. Among the laboratory investigations, he proposed a BD of <-3Meq/L as predictive of the need for evaluation by CT scan. However there is still paucity of data on the usefulness of BD in BAT. There is no such study in our local set up. This study seeks to validate the usefulness of BD in BAT as an indicator of significant intra-abdominal injury.

**Literature review**

BD is defined as the amount of base (in mmol) needed to titrate a liter of whole arterial blood to the normal pH of 7.40 at partial pressure of carbon dioxide (PaCO$_2$) of 40 mmHg. This value is not affected by acute changes in PaCO$_2$, is always elevated in the presence of all pathological changes that lead to metabolic acidosis, and as such is a reliable indicator of the severity of an underlying metabolic state. It was first described by Anderson and Engel in 1960 as a measure of metabolic acidosis and has been shown to correlate with severity of injury and degree of hemorrhage. BD is calculated from blood gas analyzer using the values of PaCO$_2$, pH, and HCO$_3$ as applied to a standard nomogram. It is assessed in a fast, reliable and easy manner and therefore is available within a short time after admission to A&E. Normal values vary from institution to institution, but generally tend to be greater than 2mmol/l.

BD as a marker of severity of injury is based on the fact that trauma patients suffer from loss of blood and hypo-perfusion which diminishes oxygen delivery to tissues. Moreover, the state of shock and hypoperfusion that occurs in blunt trauma is not attributed to loss of blood alone. Even simple hemorrhage accompanied by soft tissue injuries that is commonly seen in blunt trauma induces pro-inflammatory activation that results in many cellular changes similar to those seen in septic shock thereby impairing tissue perfusion. The ensuing anaerobic metabolism results in accumulation of lactic acid (formed from pyruvate by the action of lactate dehydrogenase) which creates a BD in order to keep pH within normal range. Lactate is a biochemical marker sensitive to the presence and extent of anaerobic metabolism. BD measured in the setting of trauma correlates very well with lactic acid and has been recommended as a surrogate marker for lactate and acidosis because of the strong correlation between the initial BD and lactate in trauma patients.
Alterations in the BD usually precede changes in other hemodynamic parameters in hemorrhagic shock. Whereas normal physiological mechanisms come into play to maintain blood pressure, urine output, and pH, hemorrhage causes early changes in both arterial and venous BD. Factors that may confound the use of the BD in estimating hypoperfusion are the administration of bicarbonate, hypothermia, heparin, alcohol and keto-acidosis. However BD remains one of the most widely used tool in estimating O\textsubscript{2} debt because of its clinical relevance, accuracy, and availability.

There is plenty of literature on several relationships that have been confirmed between injury severity and base BD. BD has been shown to predict mortality of trauma patients. It also correlates with trauma score and has been linked to hypotension and resuscitation. Large retrospective human studies have established that severity of BD on admission and response of BD to resuscitation are important predictors of morbidity and mortality after trauma. The admission BD has also been shown to correlate well with the development of multiple organ failure, length of intensive care, hospital stay, and need for blood transfusions. S. Cheddie et al has also demonstrated the use of BD as a marker of the onset of coagulopathy in trauma as measured by the INR.

Studies have shown that BD is an early laboratory investigation that can be used to identify intra-abdominal injury in patients who have sustained BAT. In 1989, Mackersie et al identified Base Excess less than -5 mEq/L in arterial blood gases, hypotension at admission or at the accident site and the presence of associated injuries as early indicators of significant intra-abdominal injury. Eleven years later, Deunk et al identified among other factors a base excess less than -3 mEq/L in arterial blood gases as an independent predictor of significant intra-abdominal injury.

Davis JW et al carried out a study on BAT patients between January 1985 and July 1988 to determine indicators of significant intra-abdominal injury. In their analysis, a BD less than or equal to -6mEq/l was the single most significant indicator of AI (P less than or equal to .0001), and the odds ratio for AI increased with each category of increasing severity of BD. They also noted that admission hypotension, major chest injury, pelvic fracture, and field hypotension (in odds ratio order) also were significantly associated with AI. In conclusion they stated that BD is a strong indicator of AI. Although a normal BD does not exclude AI, a BD less than or equal to -6mEq/l should prompt objective evaluation of the abdomen in blunt trauma.
In another study whose aim was to evaluate the accuracy of BD in the diagnosis of significant intra-abdominal injury, 400 patients with BAT were evaluated between September 2007 to September 2008. The cutoff point of −6mEq/l was obtained with sensitivity and specificity of 88.2% and 95.2% and with 22 seventy-six patients had a BD of -6mEq/l or less while sixty eight had intra-abdominal injury with a BD of approximately -8.7 ± 3.2mEq/l. Patients without intra-abdominal injury had a BD of -0.4 ± 0.1mEq/l. Patients with a BD of -6mEq/l or lower achieved more laparotomy and blood transfusion compared with patients who had a higher BD. Positive and negative predictive values of 79% and 97.5%, respectively were noted.25

In as far as normotensive patients who have sustained trauma are concerned, controversy still continues regarding the prognostic value of BD. However in a subgroup of patients over 65 years of age with penetrating trauma studies have shown that lactate and BD levels predict mortality fairly well.14

In a study done to evaluate the usefulness of BD and lactate in predicting the outcome in normotensive trauma patients over 65yrs of age, the following findings were made; BD was more abnormally altered in those who died compared with those who lived (-2.3 mEq/L +/- 5.2 mEq/L vs. 0.28 mEq/L +/- 1.0 mEq/L, p < 0.001). Normal(>0mEq/l), moderate (0 to -6mEq/l) and severe(<-6mEq/l) BD were associated with mortality rates of 14%, 27% and 40% respectively. Correlated with the normal BD group, patients in the severe group had 4.1 increased odds of death.26

Arriving at a diagnosis in BAT should be based on the sum of information derived from physical examination, circumstances of trauma, laboratory investigations and imaging.12 The presence or absence of peritonitis in BAT does not reliably rule out or confirm intra-abdominal injury. However clinical findings of rebound tenderness, abdominal distention, guarding, seat belt sign, and systolic blood pressure <90 mm Hg) should prompt the need for rapid evaluation.27, 28 Although most laboratory tests lack specificity, BD, urinalysis, LFTs, and HGM are important tests whose findings should alert the clinician to the possibility of intra-abdominal injury in BAT.6

A positive FAST examination result points to a high chance of intra-abdominal injury. In patients who are hemo-dynamically unstable, a positive FAST may be taken as a confirmatory result for an intra-abdominal injury. A negative FAST in moderate- to high-risk
patients does not with high probability rule out intra-abdominal injury. While a negative FAST result in low-risk patients lowers the probability of intra-abdominal injury, it does not exclude it with high degree of certainty.\textsuperscript{6,29} It is therefore safe to conclude that FAST is best used as one of several explicit findings (combinations of clinical examination findings and laboratory data).\textsuperscript{9,6,29}

CT has known risks to the patient, such as anaphylactic reactions due to contrast and neoplasms from exposure to radiation. There is published literature on the relationship between prior CT and neoplasms. The high cost of CT has also been cited as one of its disadvantage and hence the need to develop a criterion for its use on select patients with BAT.\textsuperscript{12}

Finally, it is important to note that no algorithm exists that has been universally accepted as optimal in the investigation of abdominal injuries in BAT. Probably, each centre ought to develop its own protocol, based on the local pattern of trauma and the availability of the tests. However, it is prudent that the assessment protocol developed be regularly evaluated and reviewed.\textsuperscript{12}
JUSTIFICATION OF THE STUDY

Base deficit has been shown to correlate with severity of injury in abdominal trauma. Its use in prediction of mortality in trauma has been extensively studied and confirmed. Base deficit is also used to determine adequacy of resuscitation and the need for blood transfusion. However, studies to demonstrate its relevance in the diagnosis of significant intra-abdominal injury are few. There is no local study to that effect.

CT scan remains the best modality available in detecting intra-abdominal injury but its use in trauma is restricted to hemodynamically stable patients. Because of the cost implications, some authors have pointed out the need to have a criteria developed for guiding its use on select patients.

BD is a reliable, fast and cheap investigation that can be used to exclude patients who do not need to have a CT scan done. It can also be reliably used in complimenting FAST in the screening of abdominal trauma patients.

The aim of this study is to demonstrate the usefulness of base deficit in the evaluation of patients with blunt trauma and hence enable trauma surgeons use it as a tool among others in detecting significant intra-abdominal injury.

STUDY QUESTION

Does base deficit indicate significant intra-abdominal injury in BAT

NULL HYPOTHESIS

Base deficit does not indicate significant intra-abdominal injury in BAT

OBJECTIVES OF THE STUDY

Broad objective

To determine the usefulness of base deficit as an indicator of significant intra-abdominal injury
Specific Objectives

1. To determine the correlation between base deficit and presence of intra-abdominal injury in BAT.

2. To determine the correlation between BD and the need for therapeutic interventions in BAT. (presence of significant intra-abdominal injury)

3. To determine the correlation between BD and abdominal CT scan /FAST findings in BAT.
MATERIALS AND METHODS

Setting: The study was carried out in the A&E and the surgical Wards at KNH

Study population: Patients who were 12yrs old and above, admitted to A&E and the surgical wards and had suspected BAT were recruited into the study. Informed consent was sought from the recruited patients or their next of kin.

Duration of the Study: Six months (February 2015- May 2015)

Study Design: A Prospective observational Study

Sampling Method and Sample size Determination:

Consecutive sampling of eligible patients was done until the sample size was reached.

The sample size was calculated using the formula \( n = \frac{z^2pq}{d^2} \)

Where,

\( n = \) sample size

\( z = \) standard normal variant corresponding to the 95% confidence interval, and is 1.96

\( p = \) prevalence of blunt abdominal injury (9.8% M.N.Munguni et al)

\( q = 1-p \)

\( d = \) the required precision of estimate (0.05)

Thus,

\[ N = \frac{(1.96)^2 \times (9.8/100) \times (1 - 9.8/100)}{0.05^2} = 134 \text{ patients} \]

Inclusion Criteria

Patients who present with features of BAT (based on history and physical signs), were 12yrs and above and gave informed consent. For minors or those who had altered mental status consent was sought from the next of kin.
Exclusion Criteria

1. Patients who declined to give consent and those who were below 12yrs of age.

2. Patients who had been investigated and resuscitated elsewhere before arrival.

3. Patients with extra-abdominal injuries

Data Collection: Data was collected by the investigator and two research assistants. The research assistants were people who held at least an M B Ch.B degree and received training from the principle investigator on how to collect the data.

Patients who had suspected BAT were recruited after informed consent. Demographic information (age, sex) was collected for enrolled patients as well as medical histories and clinical data: initial GCS, blood pressure, pulse rate, temperature, presence or absence of peritonitis and presence or absence of extra-abdominal injuries. Clinical evaluation and decision on who had BAT was by the SHOs in the admitting firms. Arterial blood samples (0.5mls in heparinized 2.5ml syringes) was taken for all patients suspected to have BAT on admission to A&E. These samples were sent immediately for blood gas analysis using the blood gas analyzer (Siemens Rapid Lab 348) in the ICU laboratory at KNH. All patients suspected to have BAT underwent screening by FAST. Adominal CT Scan was obtained for patients who had unequivocal findings and remained clinically stable. Clinical, radiological and laboratory data as well as surgical results in operated patients were recorded in the data sheet.

Significant abdominal injury will be defined as any injury requiring surgical intervention.

Data Analysis:

All data was recorded in MS Excel data sheets that were protected from access by unauthorized persons. Hard copy back-up copies were securely locked. The dependent variable was BD. Data will subdivided according to sex, age, presence or absence of peritonitis, presence or absence of extra-abdominal injuries, and negative or positive findings on FAST, CT scan and laparotomy. Laboratory levels were given as mean values followed by the 95 percent confidence interval. Comparison of mean values of BD between significant abdominal injury and non- significant abdominal injury were performed. Sensitivity, specificity, NPV, PPV and likelihood ratio was calculated by correlating BD and the findings on FAST, CT scan and intra-operatively. All results were reported with 95%
confidence interval. Probabilities (P value) of less than 0.05 was considered statistically significant. Statistical analysis was performed using SPSS (version 17.0) software.

ETHICAL CONSIDERATIONS

Ethical approval was sought from Kenyatta National Hospital/University of Nairobi Ethics and Research Committee. Informed consent was obtained by the principle investigator and the research assistance from all the participants or their guardians before being enrolled into the study. Participants did not incur any extra costs and were free to withdraw from the study at any time. All information and data obtained during the study was kept confidential.

STUDY LIMITATIONS

1. The effect of alcohol and other drugs on BD
2. The effect of extra-abdominal injuries on BD

Results

A total of 134 patients with suspected BAT were recruited during the 4 months Study period. Two patients were excluded from the study because one died while awaiting explorative laparatomy while the other having been discharged from A&E did not answer calls when contacted. Out of the 132 analyzed, 108 patients (81.82%) were males giving a male to female ratio of 4.9:1. Eighty six patients were discharged from (A&E), seven patents were discharged from the wards in < 48 hrs after ruling out abdominal injury,33 patients were managed conservatively for AI while 13 patients underwent exploratory laparotomy. FAST was performed on all the recruited patients. Thirty eight patients (28.79%) had a positive FAST while 84(63.64%) had a negative FAST. Eight patients had a negative FAST despite having AI. CT scan was performed on 38 patients out of which 8 (21%) had no injuries while only 3 (7%) patients had significant injuries requiring surgical intervention. Only 1(2.6%) patient had a normal CT scan result despite having significant abdominal injury upon laparotomy. Forty six (34.85%) patients were confirmed to have AI by either FAST, CT scan, laparotomy or a combination of methods while the rest, 86(65.15%) did not have abdominal injury.
Table: 1 Patients outcome and its correlation with BD

<table>
<thead>
<tr>
<th>Outcome</th>
<th>BD of &lt;−6.85Meq/L</th>
<th>BD of &gt;6.85Meq/L</th>
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</thead>
<tbody>
<tr>
<td>Discharged from A&amp;E</td>
<td>3</td>
<td>83</td>
</tr>
<tr>
<td>Managed conservatively</td>
<td>25</td>
<td>8</td>
</tr>
<tr>
<td>Operated</td>
<td>12</td>
<td>1</td>
</tr>
</tbody>
</table>

Predictive values for abdominal injury versus non abdominal injury

Patients were categorized into two groups (abdominal injury versus no abdominal injury). After drawing the ROC curve, the cut-off value at which the greatest sum of sensitivity 82.98% (69.19% to 92.35%) and specificity 65.91% (55.03% to 75.68%) was obtained for base deficit was -4.15. The PPV was 56.52% (44.04% to 68.42%) and the NPV was 87.88% (77.51% to 94.62%). The LR(+) was 2.43 (1.77 to 3.35) while the LR(−) was 0.26 (0.13 to 0.49). At this cut-off point, AUC (95% CI) for BD was 0.863 (P=0.037).

Table 2: Predictive values for abdominal injury versus non abdominal injury

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>82.98%</td>
<td>69.19% to 92.35%</td>
</tr>
<tr>
<td>Specificity</td>
<td>65.91%</td>
<td>55.03% to 75.68%</td>
</tr>
<tr>
<td>Positive Likelihood Ratio</td>
<td>2.43</td>
<td>1.77 to 3.35</td>
</tr>
<tr>
<td>Negative Likelihood Ratio</td>
<td>0.26</td>
<td>0.13 to 0.49</td>
</tr>
<tr>
<td>Positive Predictive Value</td>
<td>56.52%</td>
<td>44.04% to 68.42%</td>
</tr>
<tr>
<td>Negative Predictive Value</td>
<td>87.88%</td>
<td>77.51% to 94.62%</td>
</tr>
</tbody>
</table>
Figure 1: ROC curve for BD versus abdominal injury

Predictive values for BD versus the need for operative management

Patients were categorized into two groups (those who underwent explorative laparotomy and those who did not). After drawing the ROC curve the cutoff value at which the greatest sum of sensitivity 73.33% (44.90% to 92.21%) and specificity 58.06% (39.08% to 75.45%) was obtained for base deficit was -4.15. The PPV was 45.83% (25.55% to 67.18%) and the NPV was 81.82% (59.72% to 94.81%). The LR(+) was 1.75 (1.05 to 2.93) while the LR(-) was 0.46 (0.19 to 1.12) At this cutoff point, AUC (95% CI) for BD was 0.863 (P=0.037).
Table 3: Predictive values of BD for the likely hood to undergo an operation

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sensitivity</strong></td>
<td>73.33%</td>
<td>44.90% to 92.21%</td>
</tr>
<tr>
<td><strong>Specificity</strong></td>
<td>58.06%</td>
<td>39.08% to 75.45%</td>
</tr>
<tr>
<td><strong>Positive Likelihood Ratio</strong></td>
<td>1.75</td>
<td>1.05 to 2.93</td>
</tr>
<tr>
<td><strong>Negative Likelihood Ratio</strong></td>
<td>0.46</td>
<td>0.19 to 1.12</td>
</tr>
<tr>
<td><strong>Disease prevalence</strong></td>
<td>32.61% (*)</td>
<td>19.53% to 48.02%</td>
</tr>
<tr>
<td><strong>Positive Predictive Value</strong></td>
<td>45.83% (*)</td>
<td>25.55% to 67.18%</td>
</tr>
<tr>
<td><strong>Negative Predictive Value</strong></td>
<td>81.82% (*)</td>
<td>59.72% to 94.81%</td>
</tr>
</tbody>
</table>
Figure 2: ROC for BD versus likelihood of undergoing exploratory laparotomy

ROC Curve

Diagonal segments are produced by ties.
Discussion

This study was conducted to determine the usefulness of base deficit in the diagnosis of significant abdominal injuries in adults who suffered suspected blunt abdominal trauma at Kenyatta National Hospital. The results of the study show that BAT is a predominantly male problem, affecting males 4.6 times more than the females. The mean (SD) age of the patients was 33.2±15.1. These findings are consistent with studies in many centres around the world which show that trauma largely affects males who are in the first 4 decades of their life.\textsuperscript{1} Musau \textit{et al} made a similar observation in a study conducted at this same institution.\textsuperscript{4}

Regarding BD and its usefulness in the diagnosis of BAT, the results showed that BD less than or equal to -4.15 can determine with high accuracy intra-abdominal injury while a BD of -6.8 predicts quite accurately the need for surgical intervention among persons aged 12 years and above. In the current study, we observed that among the 46 patients who had AI, 39 patients had a BD of < 4.15 while out of the 13 patients who underwent explorative laparotomy 12 had a BD of less than -6.85. Of the 86 patients who were confirmed not to have abdominal injury, only 3 patients had a BD >6.85. These findings compare well with Drakhshanfaret \textit{et al} findings regarding BD and its accuracy in the diagnosis of BAT. They obtained a cut point for the amount of BD at -4.55. Their study also showed that out of 39 patients who had sustained blunt abdominal trauma, 34 patients had a BD < 4.15. A significant difference between their study and our study is that it was done on children under the age of 12 years.\textsuperscript{17}

In a similar study to ours though with a bigger sample size of 400 patients, Mofidi \textit{et al} established that a BD greater than -6 showed lack of intra-abdominal injury while a BD less than or equal to -6 strongly indicated presence of intra-abdominal injury and bleeding.\textsuperscript{22} Patients with a BD of -6 or lower achieved more laparotomy and blood transfusion compared with patients with a BD more than -6. He showed that 68\% of patients with a BD of less than -6 required transfusion.\textsuperscript{25} These findings are almost similar to our findings regarding presence of significant intra-abdominal injury in BAT. In another study a BD less than or equal to -6 was the single most significant indicator of AI (P less than or equal to .0001), and the odds ratio for AI increased with each category of increasing severity of BD.\textsuperscript{24}
The only study that is at a slight variance with our findings is by Deunk et al. They identified among other factors a base excess lower than -3 mEq/L in arterial blood gases as an independent predictor of significant intra-abdominal injury.\textsuperscript{12}

Our study established that the sensitivity and specificity of BD as a diagnostic tool for significant BAT was 82.98\% (69.1\% to 92.35\%) and 65.91\% (55.0\% to 75.68\%) respectively. These figures vary slightly from figures established by other studies. In fact there are no studies that showed similar results of sensitivity and specificity. Drakhshanfar et al showed sensitivity of 91\% and specificity of 86\% while Mofid et al established a sensitivity and a specificity of 88.2\% and 95.2\% respectively.\textsuperscript{17, 25} Despite the differences, all the studies showed that BD is both sensitive and specific in determining presence of significant intra-abdominal injury in BAT. Similarly different studies showed variable results of PPV and NPV. The PPV and NPV established by our study were 56.52\% and 88.7\% respectively. According to Drakhshanfaret al. the PPV and the NPV was 71.05\% and 97.7\% respectively. Mofidetal found a PPV and a NPV of 79\% and 97.5\% respectively.\textsuperscript{17, 25}

CT scans were done on 38 patients out of which 8 (21\%) had injuries while only 3 (7\%) patients had significant injuries requiring surgical intervention. These results are consistent with findings by Deaunk et al. They demonstrated that just about 20\% of patients suspected to have BAT will have injuries on CT scan while less than 3\% will have serious injuries requiring therapeutic intervention.\textsuperscript{14} In most studies a BD of -6 mEq/L or less has been shown to be predictive of significant intra-abdominal injury in BAT and hence the need for a CT scan.\textsuperscript{6} In our study all patients except 1 who had significant findings requiring exploratory laparotomy had a BD of less than -6.85 Meq/L.

**Conclusion.**

The findings of our study show that BD is an early available tool that can be used to predict presence of AI as well as significant AI (injuries requiring exploratory laparotomy). At a cut-off of -4.15, the likelihood of abdominal injury is so high that an objective evaluation using imaging is warranted. On the other hand a normal BD, though an important indicator of absence of injury does not rule out presence of injury, however our findings show that a patient with significant intra-abdominal injuries requiring surgical intervention is unlikely to have a BD > -6.85 Meq/L.
**Recommendations.**

Studies regarding the usefulness of BD as an indicator of significant intra-abdominal findings are still few and there more studies need to be conducted. Combined predictive value of BD, FAST and clinical findings is another raw area that requires research.
## STUDY TIME FRAME

<table>
<thead>
<tr>
<th>ACTIVITY</th>
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<tr>
<td>Proposal development</td>
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</tr>
<tr>
<td>Proposal presentation</td>
<td>November 2014</td>
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<tr>
<td>Ethical approval</td>
<td>November 2014</td>
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<tr>
<td>Data collection</td>
<td>December 2014 – May 2015</td>
</tr>
<tr>
<td>Data analysis and presentation of dissertation</td>
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## BUDGET

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</tbody>
</table>
References


4 Musau P, Jani P G, Owillah F A. Pattern and outcome of abdominal injuries at Kenyatta National Hospital, Nairobi.*East African Medical Journal.* 2006; 83(1):37-43


APPENDIX I: DATA COLLECTION WORKSHEET

DATE ______________________________________________ _________

STUDY NUMBER __________________________________________

PATIENT NUMBER ________________________________________ ________

AGE _____________________________________________________

RESIDENCE ______________________________________________

CONTACT NO. ______________________________________________

1. Glasco coma scale at presentation
   1. 13-15 □
   2. 9-12 □
   3. < 8 □

2. Vital signs at presentation
   i) blood pressure —
      a) hypotensive □
      b) normotensive □
      c) hypertensive □
ii) Pulse rate  
   a) <100 beats/min  
   b) >100 beats/min  

iii) Temperature  
    a) Normothermic  
    b) Hypothermic  

3. Abdominal examination findings at presentation  
   1. Peritonitis present  
   2. Peritonitis absent  
   3. Unequivocal findings  

4. Presence of extra-abdominal injuries  
   1. Head injury  
   2. Chest injuries  
   3. Musculoskeletal injuries  

5. Findings on FAST  
   A] Positive  
   B] Negative  

6. CT scan findings  
   A] Haemoperitoneum  
   B] Pneumoperitoneum  
   C] Visceral organs injury  
   D] Retroperitoneal haematoma
7. Base deficit on blood gas analysis

   1. lower than -6 mmol/l [ ]
   2. 0 -6 mmol/l [ ]
   3. >0 mmol/l [ ]

8. Findings at laparotomy

   1. haemoperitoneum [ ]
   2. solid organ injury [ ]
   3. hollow viscera injury [ ]
   4. retroperitoneal haematoma [ ]

9. Interview results after 5 days

   1. patient okay [ ]
   2. patient not okay [ ]
      a) admitted in another hospital [ ]
      b) admitted at KNH [ ]
      c) Still at home but deteriorating [ ]
      d) Operated [ ]
      e) Not operated. [ ]
APPENDIX II: INFORMED CONSENT

STUDY TOPIC: the use of base deficit as an indicator of significant intra-abdominal injuries in blunt abdominal trauma at KNH

This informed consent form is for patients who have sustained blunt abdominal injury and are undergoing treatment at KNH. I am inviting you to participate in this research on a voluntary basis.

Principal Investigator: Dr. Daniel Nyongesa Mukwana

Institution: University of Nairobi, School of Medicine, Department of Surgery.

This Informed Consent Form has three parts:

1) Information Sheet (to share information about the research with you).
2) Certificate of Consent (for signatures if you agree to take part).
3) Statement by the researcher/person taking consent.

You will be given a copy of the full informed consent form.
PART I Information Sheet

Introduction

My name is Dr. Daniel Nyongesa Mukwana, a post graduate student in General Surgery at the University of Nairobi. I am carrying out a research to determine the use of Base deficit in the diagnosis of significant intra-abdominal injury in patients with blunt abdominal trauma at KNH.
**Purpose of the research**

BAT is a leading cause of morbidity and mortality in Kenya today. Diagnosis of significant intra-abdominal injury can be quite challenging. This is because the physical signs are sometimes masked by the neurological status of the patient, drugs and alcohol. The current modalities for the investigation of significant intra-abdominal injury include FAST, DPL and CT scan. All this modalities have their own limitations hence the need to study other ways to complement them. Base deficit has been shown to correlate very well with severity of injury. The purpose of this research is to determine whether base deficit in blunt abdominal trauma can be used to predict significant intra-abdominal injury.

I am going to give you information and invite you to be a participant in this research. There may be some words that you do not understand or that you may need clarification. Please ask me to stop as we go through the information and I will explain or clarify.

**Type of Research Intervention**

This research will involve physical examination of your body, your arterial blood gas analysis, examination of your imaging results and post-operative medical records with your doctor’s permission [or their representative] to find intra-operative injury. If you are discharged shortly after admission or from A$E, you will receive a phone call 7days later to find out how you are doing.

**Voluntary participation/right to refuse or withdraw**

It is your choice whether to participate or not. Whether you choose to participate or not, all the services you receive at this hospital will continue and nothing will change. If you choose not to participate in this research project, you will be offered the treatment that is routinely offered in this hospital for your condition. You have a right to refuse or withdraw your participation in this study at any point.

**Confidentiality**

The information obtained will be treated with confidentiality and only be available to the principal investigator and the study team. Your name will not be used. Any information about you will have a number on it instead of your name. We will not be sharing the identity of those participating in this research.
**Sharing the results**

The knowledge that we get from this study will be shared with the policy makers in the Ministry of Health, KNH and doctors through publications and conferences. Confidential information will not be shared.

**Risks**

There is no direct risk resulting from your participation in the study.

**Cost and compensation**

There will be no extra cost incurred for participating in this study nor is there compensation offered. However your time will be required to participate in the interview.

This proposal has been reviewed and approved by UoN/KNH Ethics Committee, which is a Committee whose task is to make sure that research participants are protected from harm.
PART II Certificate of Consent

I have read the above information, or it has been read to me. I have had the opportunity to ask questions about it and any questions that I have asked have been answered to my satisfaction. I consent voluntarily to participate as a participant in this research.

Print Name of Participant ____________________________________________________

Signature of Participant ____________________________________________________

Date ________________________________________________________________

If Illiterate:

I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

Thumb print of participant

Print Name of witness _________________________________

Signature of witness _________________________________

Date ______________________________________________
Who to contact

If you wish to ask any questions later, you may contact:

1. Principal Researcher:
   Dr. Daniel Nyongesa Mukwana
   Department of Surgery, School of Medicine, University of Nairobi
   P.O. Box 19676 KNH, Nairobi 00202.
   Mobile no. 0722 274 903

2. University of Nairobi Supervisors:
   i. Dr. Daniel K. Ojuka,
      MBCh.B, M.MED (Gen Surg.),
      Consultant Surgeon/Lecturer,
      Department of Surgery, School of Medicine, University of Nairobi,
      P.O. Box 19676 KNH, Nairobi 00202.
      Mobile no. 0722322246
   ii. Prof. Peter N. Mungai,
       MBCh.B, FRCS
       Professor of General Surgery/Urology,
       Department of Surgery, School of Medicine, University of Nairobi,
       P.O. Box 19676 KNH, Nairobi 00202.
       Mobile no. 0722 708 808
If you have any ethical concerns, you may contact:

Secretary,

KNH/UoN-ERC,

P.O. Box 20723 KNH, Nairobi 00202

Tel +254-020-2726300-9 Ext 44355

Email: KNHplan@Ken.Healthnet.org
FORM PART III Statement by the researcher

I have accurately read out the information sheet to the participant, and to the best of my ability made sure that the participant understands that the following will be done:

- Refusal to participate or withdrawal from the study will not in any way compromise the care of treatment.
- All information given will be treated with confidentiality.
- The results of this study might be published to facilitate treatment and diagnosis of prostate cancer.

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

A copy of this Informed Consent Form has been provided to the participant.

Name of researcher/person taking consent

___________________________________________

Signature of researcher/person taking consent

Sign: ________________________________________

Date: ________________________________
ASSENT FORM FOR MINORS (PATIENTS BELOW 18 YEARS)

I…………………………..freely agree to participate in the research being conducted by Dr. Daniel Nyongesa Mukwana on finding out the utility of BD as an indicator of significant BAT. I have received adequate information on how the research will be conducted and given the option to accept or decline being a participant in this research and that declining to participate will in no way affect the quality of management I will be accorded here at KNH. I have allowed my parent/guardian to sign on my behalf. I understand that I can opt out of the research at any time. The outcome of this research may help doctors use BD in determining the extend of intra-abdominal injury in BAT.
APPENDIX III: FOMU YA MAKUBALIANO YA KUJIUNGA NA UTAFITI SEHEMU YA KWANZA

SWALA LA UTAFITI: Matumizi ya BD kwenye uchunguzi wa majeruhi makubwa ndani ya tumbo katika hospitali kuu ya Kenyatta

Hii fomu ni kwa ajili ya wagonjwa ambao wameumia t umbo na wanaendelea na matibabu katika KNH. Mimi nakukaribisha wewe kushiriki kati ka utafiti huu kwa hiari yako.

Mtafiti mkuu: Dkt. Daniel Nyongesa Mukwana

Kituo: Kitengo cha Upasuaji, Shule ya Afya, Chuo Kikuu cha Nairobi.

Fomu hii ya makubaliano ina sehemu tatu:

1) Habari itakayo kusaidia kukata kauli
2) Fomu ya makubaliano (utakapoweka sahihi)
3) Ujumbe kutoka kwa mtafiti

Utapewa nakala ya fomu hii.

SEHEMU YA KWANZA: Ukurasa wa habari

Kitambulizi


Nia ya utafiti huu

Utafiti umeonyesha kwamba BD inaweza kutumika katika uchunguzi wa majeruhi mabaya tumboni. Sababu ya utafiti huu ni kujaribu kuthibitisha kwamba BD inaweza kutumika katika uchunguzi huo.

Nitakupa habari na kukualika kuwa mshiriki katika utafiti huu. Kunaweza kuwa baadhi ya maneno ambayo huelewi. Ikiwa kuna chochote huelewi, tafadhali nisimamishe ndio nikuelze kwa kina.

**Aina yaUtafiti**

Utafiti huu utahusu kufanyia mwili wako uchunguzi, kutoa damu yako ili ifanyiwe uchunguzi, kusoma nakili za faili ya matibabu yako na picha utakazo pigwa kwa ajili ya uchunguzi. Hii itakuwa ni kwa idhini ya daktari wak o au mwakilishi wake. Ikiwa utaruhusiwa kwenda nyumbani bila kulazwa au kupasuliwa utapigiwa simu baada ya siku 7 ili utweleze unavyo endelea.

**Haki ya kukataa utafiti**

Kushiriki kwako kwa utafiti huu ni kwa hiari yako. Una uhuru wa kukataa kushiriki, na kukataa kwako haku-tatumiwa kukunyima matibabu . Uko na haki ya kujitoa katika utafiti wakati wowote unapo amua.

**Tandhima ya siri**

Ujumbe kuhusu majibu yako yata hifadhiwa .Ujumbe kuhusu ushiriki wako katika utafiti huu utawezekana kupatikana na wewe na wanao andaa utafiti na wala si mti yeyote mwingine. Jina lako halitatumika bali ujumbe wowote kukuhusu utapewa nambari badala ya jina yako.

**Hatari unayoweza kupata**

Hakuna hatari yeyote ambayo yaweza kutokea kwa sababu ya kuhusishwa  kwa utafiti huu. Muda wako ndio utakao tumiwa wakati wa mahojiano.
SEHEMU YA PILI: Fomu ya makubaliano


Jina la Mshiriki___________________________________

Sahihi ya mshiriki __________________________________

Tarehe_____________________________________________

Kwa wasioweza kusoma na kuandika:


Alama ya kidole cha mshiriki

Jina la shahidi______________________________

Sahihi la shahidi______________________________

Tarehe_____________________________________________
Anwani za Wahusika

Ikiwa uko na maswali ungewapenda kuuliza baadaye, unaweza kuwasiliana na:

1. Mtafiti Mkuu:

   **Dkt. Daniel Nyongesa Mukwana,**
   
   Kitengo cha Upasuaji, Shule ya Afya, Chuo Kikuu cha Nairobi,
   
   SLP 19676 KNH, Nairobi 00202.
   
   Simu: 0721216904

2. Wahadhiri wahusika:

   i. **Dkt. Daniel K. Ojuka,**
      MBCh.B, M.MED (Gen Surg.),
      
      Consultant Surgeon/Mhadhiri,
      
      Idaraya Upasuaji, Shule ya Afya, Chuo Kikuu cha Nairobi,
      
      SLP 19676 KNH, Nairobi 00202.
      
      Simu: 0722322246

   ii. **Prof. Peter N. Mungai,**
        MBCh.B, FRCS,
        
        Profesa wa Upasuaji/Urology,
        
        Idara ya Upasuaji, Shule ya Afya, Chuo Kikuu cha Nairobi,
        
        SLP 19676 KNH, Nairobi 00202.
        
        Simu: 0722708808
3 Wahusika wa maslahi yako katika Utafiti:

Karani,

KNH/UoN-ERC

SLP 20723 KNH, Nairobi 00202

Simu: +254-020-2726300-9 Ext 44355

Baruapepe: KNHplan@Ken.Healthnet.org
SEHEMU YA TATU: Ujumbe kutoka kwa mtafiti

Nime msomea mshiriki ujumbe kiwango ninavyoweza na kuhakikisha kuwa mshiriki ame fahamu ya fuatayo:

- Kutoshiriki au kujitoa kwenye utafiti huu hautadhur u kupata kwake kwa matibabu.
- Ujumbe kuhusu majibu yake yata hifadhiwa kwa siri.
- Matokeo ya utafiti huu unaweza chapishwa kusaidia katik a uchunguzi wamajeruhi mabaya ya tumbo.

Nina thibitisha kuwa mshiriki alipewa nafasi ya kuuliza maswali na yote yakajibiwa vilivyoo. Nina hakikisha kuwa mshiriki alitoa ruhusa bila ya kulazimishwa.

Mshiriki amepewa nakala ya hii fomu ya makubaliano.

Jina la mtafiti

______________________________________________________________

Sahihi ya Mtafiti

______________________________________________________________

Tarehe_______________________________________________________
Idhini ya wale walio na miaka chini ya 18

KNH/UON-ERC APPROVAL LETTER

UNIVERSITY OF NAIROBI
COLLEGE OF HEALTH SCIENCES
P O BOX 19767 Code 06202
Tel: 234-950 376303 Ext 44255

KHEYATTA NATIONAL HOSPITAL
P O BOX 26723 Code 06202
Tel: 726300-8
Fax: 720272

Ref: KNH-ERC/1/69

Dr. Daniel Nyongesa Mukwana
Dept of Surgery
School of Medicine
University of Nairobi

Dear Dr. Nyongesa

Research Proposal: Base deficit as an indicator of significant blunt abdominal trauma at Kenyatta National Hospital  
(P696/11/2014)

This is to inform you that the KNH/UoN-Ethics & Research Committee (KNH/UoN-ERC) has reviewed and approved your above proposal. The approval periods are 12th February 2015 to 11th February 2016.

This approval is subject to compliance with the following requirements:

a) Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b) All changes (amendments, deviations, violations etc) are submitted for review and approval by KNH/UoN ERC before implementation.
c) Death and life threatening problems and severe adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH/UoN ERC within 72 hours of notification.
d) Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH/UoN ERC within 72 hours.
e) Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. 
(Associate a comprehensive progress report to support the renewal).
f) Clearance for export of biological specimens must be obtained from KNH/UoN-Ethics & Research Committee for each batch of shipment.
g) Submission of an executive summary report within 60 days upon completion of the study 
This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/or plagiarism.

For more details consult the KNH/UoN ERC website www.erc.uonbi.ac.ke

Protect to discover

12th February, 2015
Yours sincerely,

[Signature]

PROF. M. L. CHINDIA
SECRETARY, KNH/UoN-ERC

c.c.  The Principal, College of Health Sciences, UoN
     The Deputy Director CS, KNH
     The Chairperson, KNH/UoN-ERC
     The Assistant Director, Health Information, KNH
     The Dean, School of Medicine, UoN
     The Chairman, Dept of Surgery, UoN
     Supervisors: Dr. Mark Nelite Awori, Dr. Ojuku Kinyuru Daniel

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