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An autopsy study of splenic injuries seen in patients with blunt abdominal trauma at Parirenyatwa Group of Hospitals in Harare: Prevalence of missed splenic injuries

BY DR NOEL RALPH ZULU

SUPERVISOR: PROFESSOR G I MUGUTI

Dissertation submitted to the University of Zimbabwe in partial fulfilment of requirements for Master of Medicine degree in General Surgery (MMed. General Surgery)

Department of Surgery. College of Health Sciences. University of Zimbabwe 2012
I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material to which a substantial extent has been accepted for the award of any other degree or diploma of a university or other institute of higher learning, except where due acknowledgement is made.

………………………………………………

DR. NOEL RALPH ZULU
I dedicate this dissertation to my parents. They have been a pillar of strength and have shown me great love and support. I am here because of their matchless sacrifices and devotion toward my ambition of becoming a good surgeon.

May the Lord continue to bless them abundantly.
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# ABBREVIATIONS

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<tr>
<td>AAST</td>
<td>American Association for the Surgery in Trauma</td>
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<td>ATLS®</td>
<td>Advanced Trauma Life Support</td>
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<td>BSB</td>
<td>Blood Spleen Barrier</td>
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<td>CT</td>
<td>Computerised Tomography</td>
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<td>FAST</td>
<td>Focused Assessment with Sonography in Trauma</td>
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<td>GCS</td>
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<td>M/S</td>
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<td>NOM</td>
<td>Non-operative management</td>
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<td>OPSI</td>
<td>Overwhelming Post Splenectomy Infection</td>
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<td>SAE</td>
<td>Splenic Artery Embolism</td>
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<td>5HT</td>
<td>Serotonin</td>
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1. **ABSTRACT**

1.1 **BACKGROUND**

The spleen is one of the most commonly injured organs following blunt abdominal trauma\(^1\). Significant evolution has occurred in the management of splenic injuries, with a paradigm shift, from splenectomy to non-operative management.\(^2\) In low resource centres, absent management protocols and the lack of expertise and equipment, have resulted in a significant number of splenic injuries being missed.\(^3\)

1.2 **OBJECTIVES**

(i) To determine the frequency of missed splenic injuries related to blunt abdominal trauma at the Parirenyatwa Group of Hospitals at autopsy.

(ii) To evaluate the initial diagnostic modalities being utilised in screening for splenic injuries.

(iii) To identify other injuries associated with missed splenic injuries at autopsy.

1.3 **STUDY DESIGN**

Retrospective Descriptive autopsy study
1.4 MATERIALS AND METHODS

Records of autopsies done over the period January 2008-December 2011 were analysed in conjunction with those from casualty at the Parirenyatwa Group of Hospitals. All autopsies performed for blunt trauma were included in the study. Analysis was done using Stata version 10.0.

1.5 RESULTS

A total of 2171 autopsies were conducted for blunt trauma during the period January 2008 and December 2011. Of these, 136 cases were identified as having a missed splenic injury, giving a prevalence of 6% (p=0.001). Data for analysis was available in 87 cases. The remaining cases (n=49) were excluded from the study. Median age was 33 years (Q\(_1\)=27, Q\(_3\)=40). Male: female ratio was 4.2:1. Road traffic accidents accounted for 86% of all injuries. In 83% of cases, the initial attending clinician was the casualty officer. None of the initial attending clinicians had Advanced Trauma Life Support (ATLS®) training. Sixty per cent of cases presented with a GCS of 3-8. Head injuries were the most common association in 46% of cases. None of the cases had an ultrasound scan done. At autopsy, the median volume of haemoperitoneum was 1000ml; (Q\(_1\)=713 Q\(_3\)=1069). The commonest cause of death was hypovolemic shock in 60% of cases. Combined splenic and liver injuries accounted for 40% and isolated splenic injuries accounted for 33% of these cases.
1.6 CONCLUSION

The study confirms that a significant number of splenic injuries were missed by the attending clinician. A low Glasgow Coma Scale and the presence of serious injuries were the commonest associations. The lack of training in ATLS®, absence of protocols of managing trauma patients and inadequate diagnostic equipment and expertise were the other contributory factors associated with the missed splenic injuries. Early detection and appropriate management of these cases could significantly reduce the mortality of these polytrauma patients.
2. INTRODUCTION

The spleen is one of the most commonly injured organs in blunt abdominal trauma.\(^1\)

The spleen is particularly vulnerable to injury by virtue of its position and its fragile capsule. Decelerative forces cause avulsion injury at points of ligamentous or vascular insertion. Direct force either by anterior-posterior compression or direct postero-lateral blow, rupture the delicate capsule. Secondary penetrating injury from overlying fractured ribs also contributes to splenic injury.

Isolated splenic injury is rare. Splenic injury is usually associated with other severe injuries. These include chest injuries, head injuries as well as musculoskeletal injuries. These injuries have a masking effect that would result in a splenic injury being missed.

The ATLS has been recognised globally as the best modality in assessing polytrauma patients. This system provides a systematic approach of managing the patients. It begins with assessment of life threatening conditions first (primary survey), followed by serial sequential valuations to exclude other injuries (secondary survey) and finally a more comprehensive evaluation to identify any pre-existing conditions present.
During the initial assessment of the polytrauma patient, time is always of the essence. Hence, early identification of life threatening conditions and prompt initiation of definitive care are crucially important. A focussed abdominal sonography in trauma (FAST) is the earliest radiological modality utilised to exclude, presence of a cardiac tamponade as well as the presence of haemoperitoneum in a traumatised patient.\textsuperscript{5} Other radiological evaluations may be employed such as computer aided tomography scans (CT Scans) or X-rays, once the patient has been stabilised.

The problem of missed injuries has been noted for a long time. This has been alluded to: clinical and radiological misdiagnoses, the lack of equipment and the lack of experience. Commonly missed clinically significant injuries include: diaphragmatic, splenic, liver, duodenal, pancreatic, renal and colonic injuries.\textsuperscript{3,6}
2.1 AIMS AND OBJECTIVES

2.1.1 QUESTION
What proportion of splenic injuries are missed in blunt trauma at the Parirenyatwa Group of Hospitals?

2.1.2 HYPOSTHESIS
A significant proportion of splenic injuries are missed in patients with blunt trauma

2.1.3 OBJECTIVES
(i) To determine the frequency of splenic injuries related to blunt trauma at the Parirenyatwa Group of Hospitals at autopsy

(ii) To evaluate the initial diagnostic modalities being utilised in screening for splenic injuries.

(iii) To identify other injuries associated with missed splenic injuries at autopsy.
2.2 JUSTIFICATION

Trauma is globally accepted as the most common cause of morbidity in surgical patients. Blunt abdominal trauma confers a significant management challenge to surgeons.

Splenic injury is one of the commonest solid organ injuries incurred in blunt abdominal trauma.¹ There are no designated trauma units in the country as compared to more developed countries. Equipment and expertise is also inadequate.

Early detection and intervention is crucial in the management of blunt splenic injuries. This would result in reduction in the morbidity and mortality with respect to poly-traumatised patients.
3. REVIEW OF LITERATURE

3.1 HISTORICAL BACKGROUND

The spleen has been an organ of considerable mystery in the past millennia. Its importance has fluctuated among great men of Medicine, from just being a trivial or vestigial organ, to being an important component of the body’s immune system. Aristotle (384-322 BC), wrote, ‘for a better understanding of this note, there are four humors, blood, choler, phlegm and melancholy, each has its receptacle...but of a cold dry humour is melancholy engendered, and goes to the spleen...’

The concept of the spleen being an organ of laughter was carried throughout the Talmud era. Maimonides (1135-1204) highlighted the importance of the spleen in purifying blood. He also attributed impure blood to hinder laughter.

Louise Malpighi performed a study to evaluate the outcomes in splenectomised animals. In his study, he ligated the splenic artery in dogs and noted no serious effects after the procedure. His study reinforced the already accepted notion of the spleen being a vestigial organ.

Controversy exists over the timing of the first human splenectomy. Historians of medicine have brought forward many theories with regard
to the first splenectomy. Current literature identified the first successful splenectomy post trauma, as having been performed by Reigner in 1892.¹⁰

In 1918, Pearce reported how dogs developed pneumonia and peritonitis after splenectomy. His results were refuted by the existing body of surgeons at that time.¹⁰

In 1919, Morris and Bullock performed a study to evaluate the effects of a cultured bacterium in splenectomised animals. Their study demonstrated reduced survival in asplenic mice compared to mice with intact spleens.¹¹ Attempts at extrapolating their findings to the human population were met with fierce resistance. Ablative surgery for splenic trauma remained the mainstay of treatment.

The significance of preserving the spleen was eventually realised in 1952 following a ground breaking discovery of a fatal sepsis that was seen in children who had undergone splenectomy for congenital spherocytosis by King and Schumacker. This infection was coined “overwhelming post-splenectomy infection” (OPSI).¹²

In 1957, there was documented evidence of OPSI occurring in children who had undergone splenectomy for trauma.¹⁰ Since then, the
immunological role of the spleen has been the focus of on-going research.

3.2 SPLENIC ANATOMY

The spleen arises as a derivative of mesenchymal tissue from the dorsal mesentery of the foregut in the 5th week of development. It is located in the left hypochondriac region of the abdomen under the cover of the 9th to 11th ribs. It has a visceral surface in contact with the stomach, splenic flexure of the colon, pancreas at the hilum and the kidney and a diaphragmatic surface in contact with the diaphragm. The relatively avascular ligaments, (splenophrenic, splenorenal, splenocolic, and gastroplenic) secure the spleen in the left upper quadrant. The normal spleen weighs about 150g.

It derives its blood supply from the splenic artery, through at least five branches at the hilum. There is additional supply from the short gastric vessels derived from the left gastric artery. Venous drainage is through the splenic vein which joins with the superior mesenteric vein to form the portal vein.

Histologically, the splenic parenchyma is comprised of the red pulp, white pulp and marginal zone. The red pulp is comprised of sinusoids, which are filled with blood and splenic cords of reticular
fibers. The white pulp contains lymphoid follicles (Malphigian corpuscles) rich in B-lymphocytes and peri-arteriolar lymphoid sheaths that have plenty of T-lymphocytes.

### 3.3 SPLENIC FUNCTION

The blood-spleen barrier (BSB) plays an important role in splenic function. This forms a good barrier that allows for entrapment and effective processing of epitopes of organisms by the transformed antigen presenting cells. It is the antigen presenting cells that prime the naïve T cells into T helper cells facilitating the onset of cell mediated immunity and B-cell maturation into plasma cells. The immunological role of the spleen has been attributed to the production of tuftsin from leukokinen by enzymatic cleavage by the polymorphonuclear cells. This enhances production of opsonins which in turn facilitate phagocytosis by the natural killer cells.

Monocyte clusters reside in the spleen in an undifferentiated state i.e. not as macrophages or dendritic cells. These clusters have been seen to be in greater quantity than the circulating monocytes in the bloodstream. These monocyte clusters are mobilised with any ischemic injury and play a significant role in wound healing.
Apart from this, the BSB also facilitates for sequestration of senescent red blood cells and other particulate matter in the blood stream. The spleen acts as a reservoir for platelets. This has been demonstrated in conditions of stress which are associated with an increased flow of platelets from the spleen. Of the studied roles of platelets, is the importance of serotonin (5HT) which acts as a useful neuro-endocrine hormone. Platelets have been noted to have very high quantities of 5HT. The roles of platelets and serotonin were recently highlighted as novel contributors in the mechanisms of liver regeneration after partial hepatectomy. The spleen has also been noted to have an important part in erythropoiesis. This continues up till the 5th month of gestation and eventually ceases. The spleen has an integral role in tumour immunity.\(^{13}\)

Of prime importance in our geographical location (Sub Saharan Africa) is the importance of the spleen in malaria. Damaged (parasite infected) red blood cells are sequestrated via the reticulo-endothelial cells of the red pulp. In addition to this, the spleen has an integral role in generating immune T cell responses against the malarial parasite. A study by Chotivanich, etal, showed that parasite clearance was decreased after drug treatment in splenectomised individuals as compared to patients with an intact spleen.\(^{14}\) Despite its immunological and haematopoietic role, structural changes have been observed in patients who have suffered from recurrent
malarial attacks. One extreme form of malaria induced pathology, is the Tropical Splenomegaly Syndrome. There is disruption of T-cell regulation during recurrent malaria re-infection resulting in the over-production of IgM antibody, anti-Plasmodium antibodies and formation of large immune complexes, the end result being splenomegalgy.\textsuperscript{15} Such individuals are at risk of spontaneous rupture of the spleen as well as splenic rupture with minor abdominal trauma.\textsuperscript{16}

3.3 OVERWHELMING POST SPLENECTOMY INFECTION (OPSU)

Discovery of OPSI resulted in the appreciation of the immunological function of the spleen, in particular, opsonisation and phagocytosis of encapsulated organisms.

OPSU is noted to arise from infection by pneumococcus, meningococcal and haemophilus influenza strains. However E-coli has also been implicated in the pathogenesis of OPSI.

OPSU initially manifests with mild symptoms which include fever, nausea, vomiting, diarrhoea. With increasing severity, septic shock and coma ensue. It is mandatory that the polyvalent pneumococcal, meningococcal and haemophilus influenza vaccine be administered within two weeks of splenectomy. Administration of the polyvalent
vaccine was noted to have significant benefit in reducing the mortality of OPSI post splenectomy. However, greatest benefit was only noted in patients who were immunised prior to splenectomy. In this subset, greatest up regulation of immune function required administration of the vaccine to an intact spleen. Incidence of OPSI has been quoted as approximately 0.6% in paediatric patients and 0.3% in adult patients. Though incidence is low; mortality is as high as 50% even after administration of polyvalent pneumococcal vaccine.³

3.4 EPIDEMIOLOGY OF SPLENIC TRAUMA

The spleen is the most commonly injured organ following blunt abdominal trauma. In several studies, trauma has been noted to affect the young population in the 20-50 year age group and that males are affected more than the females.¹⁴-¹⁶

Motor vehicle accidents, falls, recreational accidents, sporting accidents and interpersonal violence are the commonest modalities of blunt abdominal injury in that order. Motor vehicle accidents cause high velocity injuries that result in polytrauma to the affected individual. Such patients present with multiple injuries and confer a serious management challenge to the attending practitioner.¹,¹⁷,¹⁸,¹⁹
Because of its unique location, splenic injuries are usually accompanied by other injuries and occur as isolated injuries in a small subset of patients. Reliance on clinical signs, such as Kerr’s sign, for diagnosis in trauma may not be beneficial. It was noted that clinical observation alone has a low sensitivity in diagnosing splenic injury. Evaluation of patients who may have a splenic injury may be impeded by the presence of distracting injuries or the central nervous system depressant effects of intoxicating substances. Hence, careful evaluation and a high index of suspicion are important, so as to avoid missing a silent splenic injury.

3.5 INITIAL MANAGEMENT

The Advanced Trauma Life Support (ATLS)® has been accepted globally as an effective method of assessment of the traumatised patient. This system describes a system that divides the assessment of a poly-traumatised patient into three phases. The initial phase deals with identifying and treating immediate life threatening injuries (primary survey). The second phase (secondary survey) deals with identifying all other injuries and initiating definitive treatment. The (third phase) tertiary phase is the final survey done as a mop up evaluation ensuring haemodynamic normality and identifying other co-existing morbidities.
3.5.1 Radiological investigations

A focused abdominal ultrasound in trauma (FAST) is the earliest diagnostic modality utilised in the primary management of a traumatised patient. It is used in the detection of haemoperitoneum with a sensitivity of 90-93% \(^5\). A FAST is a four quadrant view of the pericardium, splenic area, hepatic area (Morrison’s pouch) and pelvis. These areas being the common areas for life threatening haemorrhage. A study in Turkey showed usefulness of bedside scanning using a portable hand held ultrasound scan (V-Scan). They demonstrated similar outcomes in detecting haemoperitoneum and planning for more definitive investigations, in patients with blunt abdominal trauma. \(^20\)

FAST is slowly replacing the use of Diagnostic peritoneal lavage (DPL) in centres where resources are available. DPL is an invasive procedure which requires laboratory backup for not so overt haemorrhage. However DPL has a sensitivity of over 90% in detecting haemoperitoneum and still has a role in centres where an ultrasound scan is not readily available. \(^4\)

A positive FAST indicates the presence of hemoperitoneum. The presence of hemoperitoneum suggests likelihood of splenic injury. When a positive FAST result is obtained, if the patient is haemodynamically stable, a CT scan is warranted to identify the source of bleeding and
grade the injury.

FAST has a low sensitivity (60-80%) in detecting and grading splenic injuries, as a result there is a high probability of missing low grade splenic injuries.\(^2\hphantom{1}\)

Contrast enhanced ultrasound scans have been reported to have higher Sensitivity (80-85%) in detecting solid organ injuries, however their use is limited especially in the haemodynamically unstable patient.\(^2\hphantom{2}-\hphantom{1}2\hphantom{3}\)

Once splenic injury is suspected, the gold standard in diagnosing and grading splenic injury is a contrast enhanced computer aided tomography (CT Scan).\(^5\) However, this investigation is deferred in a haemodynamically unstable patient.

Several grading systems have been described for splenic injuries. The most widely accepted system is the American Association for Surgery in Trauma injury scale (AAST).(Table 1)
Table 1: American association for the surgery in trauma splenic injury grading 1994

3.6 SURGICAL OPTIONS FOR TREATMENT

Significant evolution has occurred over the past 120 years in the management of trauma to the spleen. Management has evolved from splenectomy to non-operative management (NOM). This has been attributed to appreciation of the functional role of the spleen as well as success rates of non-operative management in the paediatric population post trauma (>85%). However, lower rates have been documented in adults subjected to non-operative management. This has been a subject of on-going controversy and research.
The choice of management depends on the presentation of the patient, facilities present, surgical expertise on hand and a strong patient follow up system.

3.6.1 Management of the unstable patient with splenic injury

The patient that presents with haemodynamic instability is resuscitated according to ATLS guidelines.\(^4\) If haemodynamic stability cannot be achieved, an immediate laparotomy is warranted. At laparotomy, the presence of multiple injuries involving other systems would demand that an immediate splenectomy be done to stop bleeding and facilitate adequate stabilisation of the patient.

3.6.2 Management of the stable patient with splenic injury

Management of the stable patient can be operative or non-operative. Because of the high mortality of OPSI, attempts at preservation of the spleen should be made if possible. There are a variety of splenic salvage techniques described all of which depend on the grade of injury. These include topical haemostatic agents, suturing techniques, mesh wrapping and partial splenectomy.\(^2\)\(^4\) The frequency however of these procedures has declined as a result of the advent of splenic artery angiography and embolisation. Splenic salvage techniques have been noted to take a longer operating time compared to splenectomy. Performance of these procedures has been noted to depend on the level of experience of the
surgeon. A study by Ankinkoulie, in Nigeria, showed that the determinants for splenectomy in the low resource centres included the hierarchy of the surgeon as well as of the assistant. The less experienced surgeon would do a splenectomy rather than a splenorrhaphy.\textsuperscript{25}

It has been shown that effective management of the patient with blunt abdominal trauma is best instituted in centres dedicated to trauma care. Higher rates of splenectomies have been noted in centres not dedicated to trauma as well as the lower level trauma units. Inadequate resources, which include trauma surgeons, theatres, technical equipment as well as, the loss to follow up and refusal of medical advice, have plagued the low resource areas such that most patients with blunt trauma are managed at the discretion of the attending practitioner\textsuperscript{26}

### 3.7 POST OPERATIVE MANAGEMENT

All patients that have undergone splenectomy should receive polyvalent pneumococcal vaccine within two weeks of surgery. The role of prophylactic antibiotics is controversial.\textsuperscript{2,24}

### 3.8 NON OPERATIVE MANAGEMENT

The role of non-operative management in documented splenic injury, in adults, remains a subject of debate in many centres worldwide. High volume trauma centres have published data that supports non-operative management.
This involves careful observation of the patient as an in-patient through watchful waiting, serial physical examinations and serial haematological investigations. During this period, the patient would receive blood transfusions to correct the existing blood loss.

The role of serial CT scanning after the initial diagnostic CT Scan has been debated in particular reference to the haemodynamically stable patient. A study by Kuo and co-workers has shown that these are unnecessary.\textsuperscript{27}

Higher success rates of NOM have been achieved as a result of the advent of splenic artery embolization (SAE) as an adjunct to NOM. Presence of a contrast blush, pseudo aneurysms, a large haemoperitoneum and posttraumatic arteriovenous fistulas on CT scan, are indications for splenic artery angiography and embolization. Common complications of SAE include worsening haemorrhage (vessel injury), abscess formation, contrast nephropathy, coil migration and splenic infarction.\textsuperscript{28,29}

Pointers of failure of NOM would be-:

(i) Failed splenic artery embolization
(ii) Increasing transfusion requirement >5 units

(iii) A persistent drop in the haematocrit > 4 units

(iv) Increasing abdominal girth

(v) Peritonitis

At this juncture, a laparotomy is warranted and almost inevitably, a splenectomy is performed\(^{28,29}\)

Many studies have been undertaken to determine the appropriate choice of patient to whom NOM would be of greatest benefit as well as identify markers that predict failure of NOM. Initially the splenic injury grade was considered a significant prognostic indicator for failure or success of non-operative management. However, success has been demonstrated with higher injury grades (III-IV) subjected to splenic artery embolization. However, it has been shown that CT Injury grade alone is a poor predictor of success of non-operative Management (Odds ratio-0.3).\(^{27}\)

Age above 55 years has been identified as an independent predictor of failure of non-operative management (NOM).\(^ {30-32}\) The Multicenter study of the Eastern Association for the Surgery of Trauma (EAST) identified a large haemoperitoneum, high injury severity score and age above 55 years as predictors of failure of NOM.\(^ {31,33}\) It was noted that associated
head injury was associated with inappropriate classification of patients to the category of non-operative management, with resultant failure of NOM.

A study by Goan and co-workers, showed that haemoperitoneum is not a predictor of failure and that successful outcomes of NOM could be achieved in the presence of large haemoperitoneum. A study by Goan and co-workers, showed that haemoperitoneum is not a predictor of failure and that successful outcomes of NOM could be achieved in the presence of large haemoperitoneum.  

McIntyre, showed that age above 55 years and a high Injury Severity Score predicted failure of NOM. It was also noted that better outcomes for NOM were achieved in higher level trauma units as compared to the lower level units. The study recommended in-hospitalisation for 5-7 days for patients at risk for failure of NOM.

It has been noted that despite the challenges of lack of equipment and expertise, non-operative management can still be practised in Africa. In a study performed locally by Muguti and Zengeza, 22% of patients underwent splenectomy and 56% were managed non operatively. The splenic injuries were diagnosed on ultrasound.

Another area of interest has been period of rest until resumption of normal activity. Dulchavsky showed improved tensile strength of the splenic wound after 6 weeks in animal models. Could this period of restraint from physical activity be applied to the paediatric population? In a local study, all patients were advised to rest for 4 weeks with no
reported complications.\textsuperscript{36}

Delayed splenic rupture has been cited in literature. It is accepted that the incidence of true delayed rupture is very low (<1\%) and that higher rates correlate to delay in diagnosis.\textsuperscript{2}

3.9 MISSED INJURIES

Injuries not identified during the primary, secondary and tertiary surveys would be considered as being missed injuries. Literature defines missed injuries as injuries not detected after a period of 24 hours after presentation.\textsuperscript{6,38} Clinically significant missed injuries result in serious complications and death. These comprise between 20-40\% of all missed injuries. Incidence of missed injuries is variable from 0.6\% to 65\%. The large variation arising as a result of the application of different methodologies of retrospective studies as well as the definition of missed injuries. The clinically significant missed injuries include diaphragmatic, colonic, splenic, liver and musculoskeletal injury.\textsuperscript{6,38-41} In a review by Montmany and co-workers the incidence of clinically significant missed injuries was 10-20\%.\textsuperscript{6} Clinical judgmental errors, radiological misdiagnoses, admission to wrong wards were contributory to missed injuries \textsuperscript{6,38-41}

A relationship exists between missed injuries and presence of any of the following:-

A high injury severity score
Positive toxicology

Haemodynamically unstable intubated patients.

It has been also noted that the level of the admitting centre and the expertise in a trauma centre have a bearing on the occurrence of significant missed injuries. Clearly, the use of good clinical judgement and protocols of management and adequate radiological back-up have been noted to result in a lower rate of missed injuries. In resource limited environments, the lack of expertise and equipment pose a significant challenge in managing poly-traumatised patients. In a study done in Uganda, incomplete assessment, inexperienced staff, delays in arrival, radiological failures were all contributory to missed injuries. Intra-abdominal injuries accounted for over 40% of missed injuries. A similar study has not been conducted in Zimbabwe.
4. **METHODOLOGY:**

4.1 **MATERIALS AND METHODS**

Records of all autopsies performed at the Parirenyatwa Group of Hospitals for blunt trauma were reviewed and the following study variables were extracted,

(i) Age  
(ii) Sex  
(iii) Mechanism of trauma  
(iv) Level of expertise of first attending clinician  
(v) Investigations ordered  
(vi) Initial diagnosis  
(vii) Time spent in casualty  
(viii) Initial management instituted  
(ix) Autopsy cause of death

4.2 **INCLUSION CRITERIA**

All adult patients with blunt trauma identified as having splenic injury at autopsy.

4.3 **EXCLUSION CRITERIA**

The study excluded all patients who died before arrival at casualty and all penetrating abdominal injuries.
4.4 SAMPLE SIZE

Study sample comprised all records of splenic injuries identified at autopsy which were reported at the Parirenyatwa Group of Hospitals between January 2008-December 2011.

4.5 DATA MANAGEMENT AND ANALYSIS

Statistical analysis was done using Stata version 10.0.

4.5.1 DATA ENTRY

Data was extracted from the data entry forms and entered into Microsoft excel 2010. Data was then imported into STATA 10.0 for cleaning and coding.

4.5.2 DATA CLEANING AND CODING

Data cleaning and coding was done in Stata. The data for categorical variables was coded and a coding manual as shown in Appendix 1.

4.5.3 DATA ANALYSIS

The results in this study are presented using descriptive statistics. Frequencies and percentages were used according to quantitative and qualitative variables. Means and standard deviations were used for continuous variables. Where distribution did not follow a
normal pattern, medians and interquartile ranges were used instead. Graphical representation was shown in pie charts and histograms.

Proportions of splenic injuries missed in blunt abdominal trauma and the corresponding 95% confidence interval were calculated. A p-value of < 0.05 was considered statistically significant.

4.7 ETHICAL CONSIDERATIONS

Permission to conduct this study was obtained from the Joint Parirenyatwa and College of Health Sciences Research Ethics Committee. To ensure confidentiality, names and identity particulars of patients were removed. Unique identity numbers were assigned to each patient record. This enabled data cleaning and error checking to be verified with the actual patient files where there were queries and missing information.
5. RESULTS

A total of 2171 autopsies were conducted for blunt trauma during the period January 2008 to December 2011. Of these, 136 cases were identified as having splenic injury. This gives a prevalence of 6% (p=0.001). The degree of splenic injury was not documented according to the AAST system but was labelled as either “splenic laceration” or “ruptured spleen”. Data for analysis was available in 87 cases. The remaining cases (n=49) were excluded from the study.

5.1 AGE-SEX DISTRIBUTION

Age was documented in 77 cases. Median age was 33 years (Q1=27 Q3=40). Eighty four per cent of the cases were in the 21-55 year age group, 7% were below 20 years of age, 4% were in the 55-65 year age group and 5% were above 65 years. There were 71 males and 16 females in the study (M: F: 4.2:1) (Fig.1)
Figure 1: Age: Sex Distribution

5.2 MODE OF INJURY

The commonest causes of injury were: road traffic accidents (86%), followed by falls (5%), assault (5%), industrial accidents (3%) and animal attacks (1%) (Fig.2). No data was available for analysis of road traffic accidents with respect to whether the victim was a passenger, pedestrian or cyclist. No information was available with regard to wearing of seat belts or the mechanism of injury.

Figure 2: Mode of Injury

5.2.1 MODES OF INJURY IN THE DIFFERENT AGE GROUPS

The 21-55 year age group appeared to be more prone to injury in each of the described modalities of trauma. Eighty six per cent of the road traffic accidents (58/67), all assaults (4/4) and 75% per
cent (3/4) of all falls were noted in this category. (Figure 3)

![Figure 3: Modes of Injury in the different age groups](image)

**5.3 ATTENDING CLINICIAN**

In 83% of all cases, the first attending clinician was the casualty officer. In the remaining 17% the respondent was the intern. None of the initial attending clinicians held any training in ATLS®. (Fig 4)

![Figure 4: Attending Clinician](image)
No information was available with regard to the period of service of the attending clinician. No consultants or registrars were involved in the initial evaluation.

5.4 INITIAL OBSERVATIONS

5.4.1 GLASGOW COMA SCALE (GCS)

Information on GCS was available in 35 cases. Sixty per cent (21/35) of cases presented to casualty with a GCS of 3-8, 14% (5/35) were noted to have a GCS of 9-12 and 26% (9/35) with a GCS of 13-15. The median GCS was 6 (Q₁=4 Q₃=13). (Fig.5)

![Glasgow Coma Scale](image)

**Figure 5: Glasgow Coma Scale**
5.4.2 SYSTOLIC BLOOD PRESSURE

Information on blood pressure measurements was available in 33 cases. Thirty six per cent (12/33) presented with a systolic blood pressure above 120mmHg and 27% (11/33) presented with a systolic blood pressure below 90mmHg. Median systolic blood pressure was 100mmHg. (Q₁=85, Q₃=127) (Fig6)

![Systolic Blood Pressure Chart]

Figure 6: Systolic Blood Pressure

5.4.3 PULSE

Information on pulse rate was available in 24 cases. Thirty eight per cent of cases (9/24) presented with a tachycardia, 33% (8/24) with a normal pulse rate and 29 % (7/24) presented with a bradycardia (Pulse<60/min). The median pulse rate was 77/min (Q₁=57, Q₃=111) (Fig.7)
5.4.4 TEMPERATURE

Information on temperature was available in 24 cases. Eighty three per cent of cases (20/24) presented with a temperature between 35°C and 37.5°C. Mean temperature of the sample was 35.9°C (S.D. ± 1.1) (Fig.8)
5.5 PRESENTING INJURIES

The patients in this study had mixed injuries. These included: head, chest, abdominal and musculoskeletal injuries (M/S). In all injuries recorded, there was an underlying splenic injury identified at autopsy. The main injury identified, determined the specialty that would admit the patient from casualty. Head injuries were the main injury in 46% of cases. Chest injuries were the main injury in 20% of cases. In 21% of cases, musculoskeletal injuries were the main injuries. Abdominal injuries were the main injuries in the remaining 13% of cases. (Fig 9)

![Bar chart showing frequency of main injury categories]

**Figure 9: Main injury identified by clinician**

Of the cases identified as having chest injuries as the main injury, isolated chest injuries as identified by the clinician comprised 70% of cases.
Combined chest/abdominal injuries and chest/spinal injuries each accounted for 6% (1/17) of cases. (Fig.11)

![Pie chart showing chest injuries and associations](image)

**Figure 10: Chest injuries and associations**

Of the cases identified as having head injuries as the main injury, isolated head injuries as identified by the clinician comprised 62% of cases (25/40). Figure 11 shows the other associated injuries. In this sub group no associated abdominal injuries were identified by the clinician.
Figure 11: Head injuries and associations

Of the cases identified as having musculoskeletal injuries as the main injury, isolated musculoskeletal injuries as identified by the clinician comprised 76% of cases (25/40). Musculoskeletal and chest injuries accounted for 18% (3/40) of cases. Combined musculoskeletal and abdominal injuries comprised 6% (1/18) of this group. (Fig 12)
Of the cases identified as having abdominal injuries as the main injury, isolated abdominal injuries as identified by the clinician comprised 67% of cases (8/12). The other associated injuries are as shown in Figure 13.
5.6 TIME IN CASUALTY

Information on time spent in casualty was available in 83 cases. Forty per cent of patients spent between 1 to 3 hours in casualty. The maximum time spent in casualty was 22 hours. The median time in casualty was 2 hours (Q$_1$=1, Q$_3$=3.9) (Figure14).

![Figure 14: Time spent in casualty](image)

5.6.1 CAUSE OF DELAY

Seventy one per cent of patients (59/83) spent more than 1 hour in casualty. Sixty three per cent of these (37/59) had been sent for X-rays. In the remainder of cases (n=22), the delay was due to the casualty officer failing to contact the admitting specialty doctor. (Figure 15)
Figure 15: Cause of delay

5.7 INVESTIGATIONS

None of the cases evaluated had an ultrasound scan ordered in casualty.

Chest X-rays were done in 44% of patients. Forty six per cent of the patients had a skull X-ray done. Fourteen per cent of cases had a cervical spine X-ray requested. Musculoskeletal X-rays were requested in 9% of the cases. In only 1% of the patients were pelvic X-rays requested.

(Fig16) Blood was collected for grouping and cross match in 5% of cases. A full blood count was requested in 9% of cases. The results of the full blood count were not available for analysis.
5.8 INITIAL MANAGEMENT INSTITUTED

Intravenous fluids were administered in 44% of patients. Oxygen was prescribed in 33% of patients. Only 10% of patients were intubated. Chest drains were inserted in 13% (6/48) of cases with identified chest injury. Five per cent of cases had a urethral catheter inserted. None of the patients had a nasogastric tube inserted. Twenty four per cent of cases received opioid analgesia. Antibiotics were given in 22% of cases. Administration of tetanus toxoid was documented in 21% of cases.
5.9 HEMOPERITONEUM

Information on quantity of haemoperitoneum was available in 32 cases.

The median volume of hemoperitoneum was 1000mls 

(Q1=713,Q3=1069). In 50% (16/32) of cases the volume of 
hemoperitoneum was 500-1000mls. The volume of hemoperitoneum was 
greater than 1000mls in 28% (9/32) of cases. The maximum volume 
documented was 3500mls. (Fig.18)
Information on the cause of death was documented in autopsy records in 87 cases. In 60% (52/87) of cases the autopsy defined cause of death was attributed to hypovolemic shock. Chest wall injuries accounted for 22% (19/87) and head injuries accounted for 11%(10/87) of cases. Cervical spine injuries, pulmonary injuries and pulmonary embolism each equally accounted for 2%(2/87) of cases. In the remaining 2%(2/87) the cause of death was attributed to multiple injuries (Fig 19).
Sixty per cent (52/87) of cases were documented with hypovolemic shock as the cause of death. Isolated splenic rupture accounted for 33% (17/52) of these cases, combined liver and splenic injuries accounted for 40% (21/52) of cases. Massive hemothorax accounted for 19% (10/52) of cases. Liver and kidney injuries were responsible for 8% (4/52) of cases (Fig 20).
Figure 20: Causes of hypovolemic shock

5.10.2 ANALYSIS OF HEAD INJURIES ASSOCIATED WITH SPLENIC TRAUMA

Ten cases were certified to have had traumatic brain injury as the cause of death. Subdural haematomas accounted for 40% (4/10) of traumatic brain injury cases. In 40%, (4/10) the injury was documented as diffuse brain injury. Twenty per cent (2/10) of patients had trans-tentorial herniation of the cerebrum (Fig 21)
5.10.3 ANALYSIS OF CHEST INJURIES ASSOCIATED WITH SPLENIC TRAUMA

Nineteen cases were certified to have severe chest injuries as the cause of death. Hemopneumothorax accounted for 58% (11/19) of cases. Pulmonary contusion accounted for 11% (2/19), tension pneumothorax 21% (4/19) and cardiac tamponade 11% (2/19) of cases. (Fig 22)
Figure 22: Chest injuries
6. DISCUSSION

The prevalence of missed splenic injuries is 6% from this study. This is comparable with other studies that have shown the prevalence to vary between 10-20\%.\(^6\) This variability has been attributed to the differences in study design and method.\(^6\)

In this study, missed splenic injuries are defined as splenic injuries not documented ante-mortem but identified at autopsy. By consensus, missed injuries are defined as injuries identified more than 12-24 hours after admission.\(^6,38\) Based on this definition, the calculated prevalence in this study of splenic injuries is lower than expected. This is due to the fact that this study excluded patients, with splenic injury, who survived their trauma insult.

There was an overall male predominance, with a male: female ratio of 4.2: 1. Patients’ ages ranged from 13 years to 72 years. The median age was 33.\((Q1=27, Q3=40)\). Most injuries affected patients in the 21-55 year age group, which is the working population. This finding correlates with other studies done in different populations that also noted most deaths affecting persons under 50 years of age and affecting more males than
females.\textsuperscript{17-19}

It has been noted that motor vehicle accidents, globally, account for more than 75\% of all trauma related deaths.\textsuperscript{17,18} The current study showed that motor vehicle accidents accounted for 86\% of all blunt trauma related deaths. Falls, assaults, industrial accidents and animal attacks contributed to the remainder of causes of blunt abdominal trauma.

Sixty per cent (21/35) of patients presented with a low GCS (\(<8\)).This figure correlates well with other studies that demonstrated that in the majority of trauma related deaths most patients presented with a low GCS (\(<8\)).\textsuperscript{6} A low GCS has been observed as one of the predisposing factors for missed injuries.\textsuperscript{18} These patients are not coherent and are not able to give feedback with respect to injuries suffered. In addition they are unable to protect their airway from naso-gastric secretions. It becomes mandatory that such patients are intubated.\textsuperscript{4} In this study, only 10\% (8/87) of patients were intubated.

Blood pressure measurements were only documented in a small subset of patients in this study (33/87). Reasons for this could not be ascertained in this retrospective study. However, in the cases evaluated, the median
systolic blood pressure was 100mmHg. (Q1=85mmHg, Q3=127) This is a generally low range of blood pressures. The pulse rates analysed showed a predominant picture of a tachycardia. Only 44% of patients received intravenous fluids and only 5% of patients were catheterised, hence resuscitation and monitoring of these patients was inadequate. This is evidenced by the low number of patients who received intravenous fluids as well as the significant proportion (75%) of patients certified with hypovolemic shock as the cause of death.

A number of studies have shown that most patients that died post trauma in hospital, were young (<50 years), had presented with a low GCS, had come in respiratory distress and were hypotensive (Systolic Blood Pressure less than 90mmHg). 6,17-19,39. These observations are in agreement with the findings in the current study.

The golden hour has been defined as the critical time in the immediate post trauma period at which effective management instituted would yield greater success in trauma resuscitation. 4 During this time, prompt identification of life threatening conditions is made and necessary interventions are effected.

All cases analysed in this study died in casualty within 24 hours of their
injury. Forty per cent of patients spent 1-3 hours in casualty. Seventy one per cent of patients (59/83) spent more than 1 hour in casualty. The longest time spent was 22 hours. This was a patient who had had a head injury, together with chest trauma, and had a low GCS and was intubated and ventilated but there was no free Intensive care unit bed for admission.

The main reasons for delay in casualty were attributed to delays in the X-ray (63%) department as well as delay in response by the admitting specialty junior doctor in 37% of cases. Forty six per cent of cases had skull X-rays, 44% had chest X-rays and only 1% had pelvic X-rays. A significant number of patients were sent for skull X-rays. Skull X-rays have been noted to add very little value in head trauma 42, hence, routine ordering of skull X-rays has since been discouraged. Important X-rays needed during the initial surveys of a traumatised patient are, chest X-ray, C-spine X-ray and a pelvic X-ray. 4 At our hospital mobile X-rays are not readily available. A non-contrast CT Scan is considered as the gold standard for evaluating head injury radiologically.

Undue delay arose from patients being sent for unnecessary investigations, in some cases, whilst, at the same time patients not being adequately monitored and resuscitated.
In this study, none of the initial attending clinicians had formal training in ATLS. All patients were treated at the discretion of the casualty officer or intern who did not have the necessary expertise to make prompt and life saving decisions to save the patient. The current set up in our casualty department where the casualty officer does the initial assessment and management of the patient then calls the admitting surgical team can lead to significant delays in appropriate treatment of critically ill patients. Because of the need to call different specialties to attend to emergency cases in casualty, fragmentation of care and undue delay are experienced by each casualty. In 37% of cases the doctor on call for a specialty was not available. Unfortunately the reason for non-availability could not be evaluated in this study. This highlights the lack of adequate supervision by senior personnel able to manage trauma cases efficiently. Studies have emphasised the benefit of ATLS guidelines in the initial evaluation of patients as well as having a trauma team available at the time a casualty arrives at the hospital.\textsuperscript{4} Our hospital does not have a formal trauma unit.

A Ugandan study showed that level of admitting centre and expertise are key contributors to the prevalence of missed injuries. A low level of expertise and lack of equipment resulted in the prevalence of missed
abdominal injuries being as high as 40%. Literature has confirmed that a FAST is the quickest and most reliable tool in detecting ongoing haemorrhage as well as life threatening cardiac tamponade. Its sensitivity is greater than 90%. Our casualty department does not have any mobile ultrasound scan facilities readily available when required, hence no FAST was done for any patient in this study. No diagnostic peritoneal lavage was performed on any patient during the study period. It has been shown that clinical evaluation has very low sensitivity in identifying splenic injury and will result in missing life threatening injuries. Hence, it must be accompanied by radiological investigations. Most of the patients attended to, in this study, were evaluated clinically without the recommended radiological investigations. Hence the outcomes agree with the aforementioned study.

It has been shown that a high injury severity score, low GCS, and intoxication result in significant intra-abdominal injuries being missed. In the present study, no abdominal injuries were detected clinically in all patients with head injuries. Presence of other injuries (e.g. chest, musculo-skeletal injuries) resulted in a low pick up rate of associated abdominal injuries. Abdominal injuries were suspected in 6% of patients with musculo-skeletal injuries and in 6% of patients with chest
trauma.

Splenic injuries hardly occur as isolated injuries but usually have association with other organ injuries, this is because of the unique anatomical location of the spleen. In this study, splenic injuries were associated with head injury in 46% of cases, musculoskeletal injuries in 20% and with chest injuries in 21% of cases. In these cases, the diagnosis of a possible splenic injury was not made.

At autopsy, splenic injuries were found as isolated intra-abdominal injuries in 33% of cases. These injuries were seen in conjunction with liver injuries in a further 40% of patients diagnosed with hypovolemic shock.

The median volume of hemoperitoneum was 1000ml (Q₁=713 Q₃=1069). In 50% (16/32) of cases the volume of hemoperitoneum was 500-1000mls. This suggests the cause of death was attributable to other causes. However, the cause of death in this study was attributable to hypovolemic shock in 60% (52/87) of cases.

This discrepancy is due to the absence of adequate documentation of the volume of haemoperitoneum from autopsy records. Studies have noted
that the main causes of death in trauma are the result of head injury in
greater than 50% and exsanguination in 5-10%.\textsuperscript{17-19}

The present study has shown that a significant number of splenic injuries
were missed as a result of human error and technical challenges. Early
detection and appropriate management of these cases could significantly
reduce the mortality of these polytrauma patients.
7. CONCLUSION

A significant number of splenic injuries were missed by the attending clinician in this study. A low Glasgow Coma Scale and the presence of other serious injuries were the commonest associations. The lack of training in ATLS®, absence of protocols of managing trauma patients, lack of diagnostic equipment and expertise were the other contributory factors associated with the missed splenic injuries.

8. LIMITATIONS OF THE STUDY

This retrospective study was affected by missing information with respect to initial observations (i.e. Blood Pressure measurements, Pulse, Temperature). In addition, autopsy records were not specific with regard to the volume of hemoperitoneum.

9. RECOMMENDATIONS

(i) Design of a template record chart for use in casualty would facilitate better record keeping as well as setting up protocol in assessment of the traumatised patient.

(ii) There is need for establishment of a trauma unit with designated trauma surgeons. Segmented care increases the risk of missing significant injuries. Investment may need to be made in the training
of trauma surgeons in this country. Our current surgical unit lacks a casualty based portable scan to perform FAST.

(iii) There is a need to set up protocols of managing trauma cases. This may include ATLS training for all residents, abbreviated ATLS courses for nursing staff. In addition, practice drills in managing different scenarios of trauma would be beneficial.
**APPENDIX 1: DATA ABSTRACTION SHEET**

<table>
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<th>Date</th>
<th>:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of patient</td>
<td>:</td>
</tr>
</tbody>
</table>

**Age (years)** :  
- <20 [0]  
- 21-40 [1]  
- 41-55 [2]  
- 55-65 [3]  
- >65 [4]  

**Sex** :  
- Male [0]  
- Female [1]  

**Nature of trauma** :  
- Road traffic [0]  
- Interpersonal/Violence [1]  
- Falls [2]  
- Sport [3]  
- Other [4]  

**Designation of initial clinician** :  
- Casualty officer [0]  
- Intern [1]  
- Registrar [2]  
- Consultant [3]  

**Investigations done** :  
- Chest x-ray [0]  
- Cervical Spine X-ray [1]  
- Pelvic X-ray [2]  
- Ultrasound scan [3]
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**Initial Observations**

**Blood Pressure/(mmHg)**

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**Pulse/(b/min)**

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**Temperature/(°C)**

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<td>35-37.5</td>
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<tr>
<td>&gt;37.5</td>
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</table>
Level of consciousness (Glasgow Coma Scale)/15

3-8 [0]
9-12 [1]
13-15 [2]

Associated injuries

Chest [0]
Head/Neck [1]
Musculoskeletal [2]
Abdomen [3]

Initial management .................................................................

Degree of Splenic Injury

Grade I [0]
Grade II [1]
Grade III [2]
Grade IV [3]
Grade V [4]

Volume of haemoperitoneum/ml

0-500 [0]
500-1000 [1]
>1000 [2]
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<td>Multiple Injuries</td>
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