

# **Penetrating Cardiothoracic Injuries at a District Level Hospital in Cape Town: A Retrospective Case Audit**

**STUDENT:** Dr. Sarwat Hameed-Ikram

**STUDENT NUMBER** HMDSAR001

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**Supervisor:** Dr Nkanyiso Hadebe

**Co-supervisor:** Professor Justiaan Swanevelder

**Department of Anaesthesia and Perioperative Medicine**

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**Candidate**

**Dr. Sarwat Hameed-Ikram**

**BSc, MBBS, DA (SA)**

Principal Medical Officer

Khayelitsha District Hospital

Department of Anaesthesia and Perioperative Medicine

Groote Schuur Hospital, University of Cape Town

**Supervisor**

**Dr. Nkanyiso Hadebe**

**MBChB, FCA**

Specialist

Department of Anaesthesia and Perioperative Medicine

Groote Schuur Hospital, University of Cape Town

**Co-Supervisor**

**Professor Justiaan Swanevelder**

**MBChB (Stell), DA, FCA, FRCA, MMED (Anes)**

**Professor and Head of Department (Anaesthesia)**

Department of Anaesthesia and Perioperative Medicine

Groote Schuur Hospital, University of Cape Town

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**DECLARATION**

I, Dr Sarwat Hameed-Ikram..., hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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Signature: 

Signed by candidate
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Date: 15-08-2016

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## List of Abbreviations

ABG	Arterial blood gas
ATLS	Acute trauma life support
ARDS	Adult respiratory distress syndrome
BE	Base excess
BD	Base deficit
CA	Coronary artery
CI	Confidence interval
CT	Computed tomography
CRF	Case report form
CVRS	Cardiovascular respiratory score
CXR	Chest X-ray
ECHO	Echocardiography
EMS	Emergency medical services
EC	Emergency Center
E-FAST	Extended Focused Assessment with Sonography for Trauma
EFMR	Emergency Family Medicine Registrar
FRT	Front room thoracotomy
GCS	Glasgow coma scale
GSW	Gunshot wound
HR	Heart rate
ICU	Intensive care unit
IVF	Intravenous Fluids
IMA	Internal mammary artery

IVC	Inferior vena cava
KDH	Khayelitsha district hospital
LA	Left atrium
LAD	Left anterior descending artery
LL	Lung laceration
LV	Left ventricle
MAP	Mean arterial pressure
MO	Medical Officer (House Officer)
MODS	Multiple organ dysfunction syndrome
N/A	Not applicable
PCI	Penetrating chest injury
POCUS	Point of Care Ultra Sound
PA	Pulmonary artery
PV	Pulmonary vein
RA	Right atrium
RTS	Revised trauma score.
RV	Right ventricle
SA	Subclavian artery
SV	Subclavian vein
SBP	Systolic blood pressure
SLHB	Straight left heart border
SMO	Senior Medical Officer
SVC	Superior vena cava
SW	Stab wound

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## **Abstract**

The Khayelitsha District Hospital (KDH) faces the difficult challenge of managing patients with high acuity penetrating cardiothoracic injuries, but without the full complement of resources to provide optimal care. At the time of this dissertation, we were unaware of the outcome of patients cared for at KDH, and of any potential modifiable risk factors that could improve their outcome. We therefore undertook a retrospective case audit to determine the outcome of patients presenting alive at our emergency unit with penetrating chest injuries (PCI).

## **Objective**

The objective of this study is to audit the KDH experience with penetrating chest injuries and to identify potential risk factors that predict outcomes in patients who sustain these injuries and require surgery at this district level hospital. The total study duration was 34 months.

## **Methods**

A retrospective review of all medical records of patients with PCI who were alive on presentation and had undergone surgery at KDH between 1<sup>st</sup> February 2012 and 31<sup>st</sup> December 2014 was undertaken. An audit was conducted on these files. During the audit, affected patient's clinical and physiological variables on admission, intra- and post-operative were collected and evaluated as potential predictors of outcome. This study also assessed a possible relationship between physiological parameters together with arterial blood gases (ABG) on presentation with immediate 48-hour mortality. The selected variables were: SBP (systolic blood pressure) <90 mmHg or >90 mmHg, palpable pulse, presence of a precordial stab wound, vascular injury, base deficit (BD) and lactate. A logistic regression analysis was performed to investigate the relationship between the

selected variables and the 48-hour mortality. The relationship between fluid, BD and lactate was compared using Pearson correlation.

Continuous data is presented as means  $\pm$  standard deviations. Estimates for predictor variables are presented with odd's ratios (OR) and 95% confidence intervals (95% CI). Permission of this study was gained from human research ethics committee of University of Cape town.

## **Results**

Over the 34-month study period, a total of 646 patients were admitted to KDH with penetrating cardiothoracic trauma. Fifty-six patients required surgery at KDH. These results show that KDH had a PCI incidence of 5.1%, and that this was predominantly amongst males in the 15 - 24 year age group. Fifty-five patients were male and only one female. Of the 56 operated patients, 37 (66%) presented in hemorrhagic shock with SBP < 90mmHg. The mean amount of resuscitation fluid, which included both crystalloid and colloid, administered in the Emergency Room (ER) was 2481 ml per patient. Ten (17.8%) patients had a front room thoracotomy (FRT), with a mortality rate of 6 (60%). The overall mortality rate amongst operated patients was 16 (31.3%). Thirty-three patients (58.9%) had an isolated cardiac chamber injury and 23 (41.1%) had a vascular injury. Mortality amongst patients with isolated cardiac chamber injury was 5 (31.2%) and mortality among patients with isolated vascular injury was 7 (43.7%). Two patients sustained a combined cardiac and vascular injury with a mortality of 12.5%.

The results of the logistic regression analysis revealed no statistically significant correlation between the selected predictors and 48-hour mortality (p-values: BP<90mmH p=0.27,

palpable pulse  $p=0.181$ , precordial stab  $p=1.17$ , vascular injury  $p=0.38$ , BE  $p=0.98$ , Lactate  $p=0.06$ ). Additionally, there was no statistically significant relationship between administered EC fluids and the acid base severity (Pearson correlation coefficient: BD  $r = 0.091$ , Lactate  $r = -0.13$ ).

## **Conclusion**

Physiological (blood pressure, pulse) and ABG parameters (lactate and base deficit) were not identified as significant risk factors for survival in the sample studied. The risk factor of isolated cardiac injury carried a better prognosis. Logistic regression analysis did not support the initial observation of higher mortality in patients with vascular injury. Additionally, there was no correlation between the severity of the acid base disturbance and the volume of fluid administered during resuscitation in ER. The outcomes of patients with PCIs presenting at KDH was within those published in the literature (range of published mortality: 17%-80%, survival 3-84%). The ideal predictor for PCI outcome in our cohort was indeterminate. Limitations of this study that include a small sample size and incomplete medical records, may have led to a type 2 error. A more comprehensive prospective study with meticulous record keeping is required to identify the factors that can influence the outcome of patients with PCI.

## **Chapter One: Introduction**

### **1.1 Background to KDH**

In South Africa trauma is the leading cause of mortality in male patients between the ages of 15 - 40 years [1]. The most common type of injury in this group is a precordial stab wound [1]. Only 6 - 10% of these patients survive until hospital admission, while most die at the scene [2,3,4]. Patients presenting alive at a hospital are in varying stages of hemorrhagic shock and pose multiple management challenges to the attending clinician. These multiple challenges are availability of blood products in a bleeding patient; lack of immediate surgical expertise, and delays in transferring the patient to tertiary level hospital for further management. A few of these challenges are elaborated on below.

The South African health care system is regionalized and works on referral systems between the clinics and hospitals. It is divided into different levels:

Primary Health care center

Level 1: District hospitals

Level 2: Regional hospitals

Level 3: Specialized tertiary centers [1,2].

The restructuring of primary health care system is part of an initiative to ease the mounting burden of disease on tertiary level hospitals. The new district level hospital model includes Surgery, Obstetrics, Medicine, Pediatrics, Anaesthesia and Psychiatry units, which are directed by family physicians and some specialists. Under the new organization, district level hospitals are faced with increased management challenges for patients with major

chest trauma, as these cases fall outside of the scope of practice of the district level primary service.

Khayelitsha district hospital is a district level facility situated in Khayelitsha, Western Cape, South Africa. Khayelitsha is a low socio-economic area with extremely high crime and homicide rates (451-458/100,000) amongst 15-24 year old males due to poor socioeconomic conditions and high unemployment rate [1]. KDH opened in February 2012, has a bed capacity of 300 and serves a population of over 1 000,000. On average, 3000 - 4000 patients are seen at the KDH emergency unit per month. Of these, approximately 800-1000 are trauma patients. The hospital has a busy Emergency, Obstetric, Medical, Surgical and Paediatric units. KDH has a high prevalence of infectious diseases such as Human Immunodeficiency Virus (HIV) and Mycobacterium Tuberculosis, as well as a large proportion of trauma cases, especially penetrating cardiothoracic trauma.

Hospital records indicate that on average 15 – 20 penetrating thoracic trauma patients present per week to KDH, of which 1 - 2 may be unstable and require emergency surgery. All new trauma cases present to the emergency room ER, which has a small trauma wing with two ventilated beds, and can accommodate a maximum of four critically injured trauma patients. There is no high-care or intensive care unit (ICU) facility on site.

Trauma patients are managed according to Advanced Trauma Life Support (ATLS) principles and transferred to a tertiary-level hospital with cardiothoracic surgical services once they are stabilized. Those who are unstable or unfit to be transferred are operated at KDH and then transferred by paramedics to tertiary level hospitals for further management.

High-risk patients consume a disproportionate amount of medical resources at district-level hospitals. These hospitals are faced with budgetary constraints, staff shortages, and lack of readily available blood products, medical supplies and equipment.

KDH does not have a cardiothoracic or trauma surgeon. There is a locum consultant surgeon and anaesthetist available after-hours on call. However, these consultants cover only 50% of the after-hour service. There is a shortage of specialist posts at district hospitals due to health budget restraints along with medical brain drain being a contributing factor. The balance is covered by consultant family physicians. The minimum travelling time for the senior personnel from home to hospital is approximately 30 minutes. Medical officers with varying degrees of experience cover after-hours onsite calls in all disciplines.

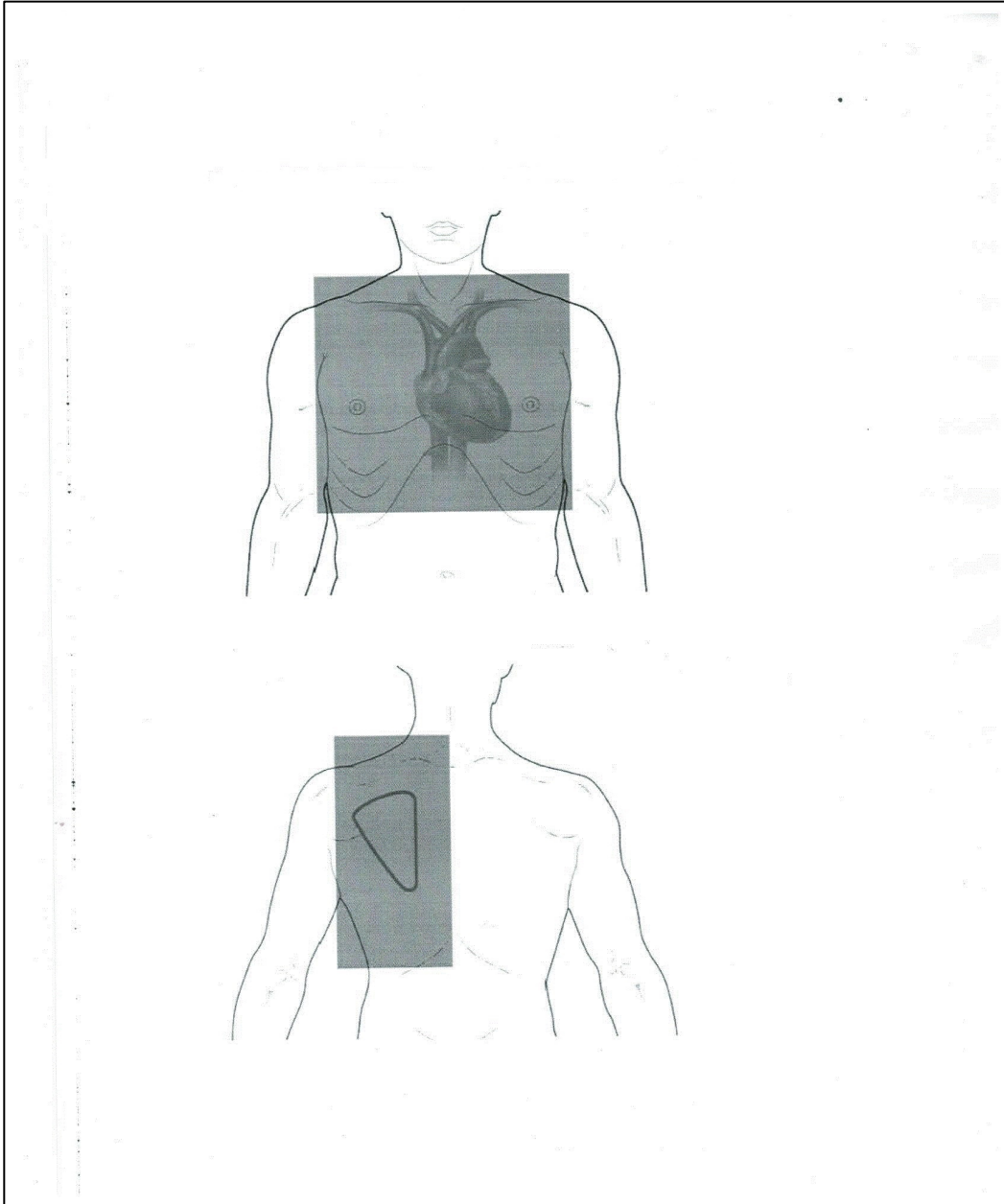
## **1.2 Penetrating cardiac injury**

### **1.2.1 Definition**

Penetrating cardiac injury is defined as injury to the pericardium and its contents, though any trauma to the chest may be associated with PCI [5,6]. Penetrating injury anywhere between two mid-clavicular lines anteriorly and the clavicles superiorly to their intersection with their costal margins inferiorly can involve the heart and the major vascular structures, but injuries to the heart with long penetrating objects have also been reported lateral to these margins [7].

Nicol described the “Cardiac Zone” for PCI (Fig 1). He stated that the area to be considered high-risk for cardiac stab wounds is the region extending from the right anterior axillary line across to the back of the left chest, up to the vertebral line with the superior margin being

the supra clavicular areas and the inferior margins being the costal margins, inclusive of epigastrium. [8]



**Figure 1. Cardiac Zone. The high-risk areas for penetrating cardiac injury Nicol et al, 2012 [8].**

## **1.2. 2 Incidence**

The national South African incidence of PCI is unknown. A study from Durban, South Africa reported a 6% incidence of PCI [9]. A study from the Cape Town, Groote Schuur level one trauma center reported an incidence of 3-12% of penetrating thoracic trauma [10]. Published series on penetrating cardiothoracic trauma from South Africa show that despite an increase in gunshot wounds (GSW) over the last 30 years, precordial stabs are still more prevalent [2,4].

## **1.2.3 Types of penetrating cardiac injury**

Common types of penetrating cardiac injuries are:

1. Stab wound to the heart
2. Gunshot wound to the heart
3. Injury to major vessels (aortic trunk, pulmonary vessels, internal mammary artery and intercostal arteries)

## **Chapter Two: Literature Review**

### **2.1 Introduction**

The main objective of this literature review is to determine the current best practice on the assessment and management of patients presenting with PCI, specifically on the following aspects of these injuries:

- Presentation, diagnosis, resuscitation (fluids and blood) and outcomes.

The second objective is to identify published independent risk factors for outcome that can further be explored in our audit.

### **2.2 Literature search strategy**

A PubMed literature search was undertaken, and the following terms and phrases were used:

- Penetrating chest injury
- Cardiothoracic trauma
- Management of PCI
- Resuscitation fluids
- Mortality of PCI
- Predictors of outcome
- Base deficit (BD)/Base excess (BE), pH, lactate in severe trauma
- Chest X-Ray (CXR)
- Extended Focused Assessment with Sonography for Trauma (E-FAST)

Results obtained from the PubMed search were reviewed for the relevant papers. The University of Cape Town and University of Stellenbosch Databases were used for relevant articles and publications. Only literature published from 1983 to 2015 has been included.

The following Journals, Books and Website were searched for articles:

- Journal of Thoracic and Cardiovascular Surgery
- Journal of Cardiothoracic and Vascular Anaesthesia
- Journal of Trauma-injury Infection and Critical Care
- Journal of Trauma
- Journal of Surgical Research
- American Journal of Surgery
- British Journal of Surgery
- South African Journal of Surgery
- Journal of American Medical Association
- South African Medical Journal
- Journal of Emergency Medicine
- New England Journal of Medicine
- Book: Current Therapy of Trauma and Surgical Critical Care  
2<sup>nd</sup> Edition (Asensio and Trunkey)
- Website: ATLS Manual

### **2.3 PCI discussion**

PCIs are a lethal form of trauma and are associated with increased mortality worldwide. Penetrating cardiac injury has a pre-hospital mortality rate as high as 90-94% and an associated in-hospital mortality rate of 50% among initial survivors. Even studies that included only hospitalized patients in large urban trauma centers reported a mortality rate of 25%–65% [11,12].

PCIs are more prevalent in some parts of the world than others. For example Turkey, Brazil, South Africa and China have a much higher prevalence compared to European countries [13,14,15]. PCI has a reported global incidence rate of 0.1% of all the trauma admissions [13]. A study from the United States of America reported PCI incidence as 0.5% of all trauma admissions over a seven-year period while Asensio et al. (2001) reported a national (USA) incidence PCI of 0.016% [12,16].

South Africa has a high incidence of cardiothoracic trauma associated with a large number of PCIs due to high violence and crime rates. [2,3,15,17]. Despite a reported decline in PCI, these injuries are still commonly encountered in the Western Cape and pose a huge burden on a constrained South African health care system [2,3,9]. Numerous prospective and a few retrospective studies, a majority conducted outside of South Africa at specialized trauma centers, have evaluated different factors that influence patients outcomes.

### **2.3.1 Aetiology of PCI**

In South Africa, sharp objects such as knives, machetes, and axes cause most penetrating chest injuries [2]. Gangs, domestic violence, high crime rates, poor socio-economic conditions, drugs and alcohol abuse are also contributing factors for chest injury [18].

### **2.3.2 Clinical presentation**

The clinical presentation of PCI is variable, ranging from hemodynamic stability to acute cardiovascular collapse in a short period of time [16]. Approximately 15 - 20% of patients with PCI present with either normal vital signs or Class I shock (ATLS guidelines), and respond to fluid resuscitation [17]. Two thirds of these stabilized patients can deteriorate while awaiting investigations [18,19,20]. This clinical presentation is related to several factors, including but not limited to the following:

- Mechanism and extent of injury [4,16,17]
- Pre-hospital care [4,16]
- Time between injury and arrival to the hospital [13,16]
- Blood loss exceeding 40-50% of the intravascular blood volume (Class IV shock) (ATLS guidelines) [21]
- Presence or absence of pericardial tamponade [4,13,14,15,16]

### **2.3.3 Scoring systems**

Several validated scoring systems are available. These are based on clinical and physiological variables and are used to classify the clinical hemodynamic severity of

patients presenting with PCI, though they have not been universally adopted [8]. These scoring systems are meant to assist with the early patient triage and direct immediate resuscitative care. Scores by Harris, Chang, and Saadia are of particular interest to KDH due to their ease of use and their potential applicability to KDH's emergency service. The scoring systems rely on systolic blood pressure (SBP), but Chang distinguishes the cause for a low blood pressure (BP), which may be important in patient management. Harris's group 2 can be further scored according to a Chang type. PCI with low SBP from coronary artery interruption is rare and not covered in the scoring systems. Although numerous physiological indices and scoring systems have been employed, none can be applied uniformly to every scenario.

Harris et al (1999) from South Africa proposed the following classification for PCI: [20]

- Group 1: No vital signs
- Group 2: Agonal (SBP < 90mmHg)
- Group 3: Compensated shock (SBP >90mmHg)
- Group 4: Stable

Chang et al. (2004) also divided PCI patients into four clinical groups [19]:

- Type 1: Cardiac tamponade
- Type 2: Haemorrhagic shock
- Type 3: Combined, both signs present
- Occult: Neither sign present

DeGiannis proposed a clinical classification that incorporates the surgical management as well (fig 2).

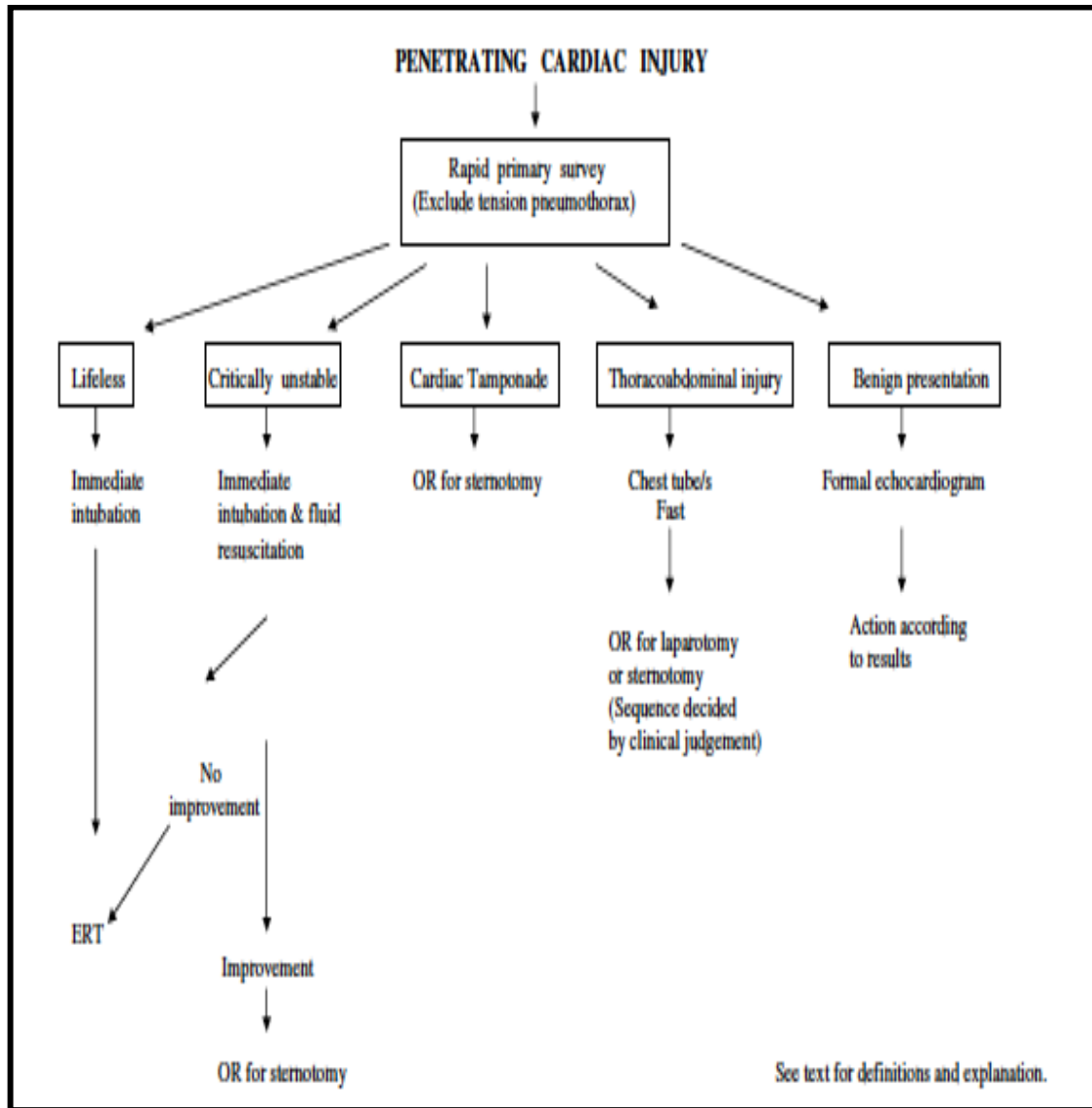


Figure 2: Algorithm for the management of PCIs (DeGiannis et al, 2006) [17]

### 2.3 .4 PCI diagnosis

The priority in the management of patients with PCIs is establishing the cause or potential cause of hemodynamic instability and addressing it without missing other important concurrent injuries. Therefore, the investigations are dictated by the patient's current clinical condition together with their sensitivity and specificity. Other considerations are bedside availability and prompt results to assist with decision making.

Different investigations have been described in the literature:

- 1) **Chest X-ray (CXR):** CXR is the most commonly performed imaging modality, which is mandatory as a part of ATLS primary survey in all patients who present to ER with cardiothoracic trauma. It is readily available, cost effective and quick to perform. A bedside CXR is an important supplement to the physical examination in trauma patients, especially in a limited resource environment. Bedside CXR provides vital information regarding injuries like rib fracture, pneumothorax, hemothorax, lung contusion, mediastinal hematoma (aortic disruption), cardiomegaly (effusion or hemopericardium), surgical emphysema and diaphragmatic injury. CXR has a sensitivity of 65% to detect acute injuries such as pneumothorax and hemothorax. Chest Computed Tomography (CT) has much higher sensitivity for detection of traumatic chest injuries, however in an unstable patient chest CT may not be a suitable option and is not available at every healthcare facility. Positive chest radiographs are of limited value in the initial assessment of patient with PCI [22]. CXR findings are present only in half of the patients with PCI. A normal CXR does not rule out cardiac injury and CXR findings may be non-specific. A CXR might be

misleading in a patient with cardiac tamponade and major haemorrhage [23]. Plain radiography cannot show myocardial contusion, acute valve or coronary artery injury. Despite being a valuable assessment tool in patients with cardiac trauma, it does not offer a complete picture of the full extent of cardiac injuries especially involving the heart and pericardium [24].

2) **Electrocardiography (ECG):** ECG is another investigation that is readily available in the EC. Eighty-Five% of penetrating chest trauma patients has a normal ECG, but a normal ECG does not exclude a cardiac injury. Incidence of abnormal ECG findings among patients with cardiac injury is reported to be around 30-60% [23]. ECG is more sensitive for injuries to coronary vessels or blunt cardiothoracic trauma and is difficult to perform, especially in an unstable patient. ECG changes in the presence of cardiac injury can manifest as sinus tachycardia, non-specific ST segment changes, myocardial infarction and a pericarditis like pattern [8]. It may be difficult to detect coronary artery injuries in the presence of a pericardial effusion as this may mask the classical ECG S-T segment changes observed with ischemia [13,23]. Usefulness of ECG to diagnose cardiac injury is more applicable in patients who might have occult cardiac injury and are stable.

3) **Ultrasonography (U/S):** U/S has currently become the most important tool for point-of-care evaluation of chest injury. It has a sensitivity of 83-100% for detecting cardiac injuries [8]. It can be performed simultaneously during resuscitation, providing vital information and allowing for rapid management without time delay. Bedside U/S is superior to CXR in identifying haemo-pneumothorax in addition to

detecting pericardial effusion [23,25,26,27]. Due to its accuracy, reproducibility, bedside feasibility, and non-invasiveness, this technology is being increasingly accepted in trauma care worldwide as part of E-FAST. E-FAST is also an accepted part of the ATLS algorithm [18,21]. Studies have demonstrated excellent positive and negative predictive values for this diagnostic tool. Rozycki et al in 1998 reported that U/S had a sensitivity and specificity of 100% and 99.7% for evaluation of PCI [27]. In the ER, E-FAST significantly decreases mortality in PCI patients [25]. E-FAST is dependent on availability of the equipment and a trained operator. Presence of hemothorax and pneumopericardium can limit screening sensitivity of U/S. Multiple studies have validated the valuable role of cardiac ultrasound in diagnosing cardiac injuries [20,23,26,28].

A South African study in 2012 by A. Nicol looked at the combined role of different clinical, radiological and electrocardiographic signs as a diagnostic tool to detect hemopericardium in stable patients with potential penetrating cardiac injury. They found certain clinical parameters extremely useful in the diagnosis of cardiac injury. They concluded

“A central venous pressure (CVP) of greater than 12 cm H<sub>2</sub>O, a new radiological sign on CXR called the “left straight heart border” and a new diagnostic sign on ECG called the “J wave”, are present when there is hemopericardium and will improve diagnostic decision making in PCI patients.” [8]

This diagnostic tool may be useful in management of PCI patients especially at facilities with limited resources, where cardiac U/S is not available or the operator is inexperienced.

### **2.3.5 Resuscitation**

The outcome of the patient is directly dependent on prompt assessment and effective resuscitation. Over the past two decades the approach to major trauma resuscitation has changed in quantity, composition and initial goals. Resuscitation of trauma patients presenting with haemorrhagic shock has shifted in favour of 'hypotensive resuscitation' rather than the aggressive preoperative fluid resuscitation targeting a normal mean arterial pressure (MAP) used in the past [29]. Major randomized, controlled trials have indicated that permissive hypotensive resuscitation is a safe strategy in trauma patients, is associated with lower mortality in truncal penetrating trauma, and is not harmful in blunt trauma, but requires quick surgical intervention [30,31]. The role of hypotensive resuscitation in trauma with suspected head injury and blunt trauma is controversial [31].

The approach to resuscitation in patients with PCI revolves around minimization of crystalloid resuscitation, prevention of hypothermia, metabolic acidosis, early use of blood products and an early definitive surgical control to minimize coagulopathy of trauma for favourable outcomes.

### **2.3.6 Volume resuscitation (fluid and blood)**

Fluid therapy is a vital component of resuscitation. The rationale of fluid resuscitation is to maintain tissue perfusion and oxygenation of vital organs. Fluid resuscitation should be administered in a goal-directed manner and should be targeted to the physiological needs

of individual patients, especially in a trauma setting. The goal and choice of fluids should target both hemodynamic and haemostatic resuscitation end points [30].

The British National Institute for Health and Care Excellence (NICE) guidelines recommend the following:

“No fluid should be administered in the pre-hospital resuscitation phase if a radial pulse is palpable. In the absence of this, 250 ml crystalloid is administered until these pulses return. Fluids should be delayed in penetrating torso trauma until the operative intervention.” [32]

Bickel et al. demonstrated that delayed fluid resuscitation in hypotensive patients with penetrating torso injuries was associated with less intraoperative hemorrhage, decreased length of hospital stay and fewer post-operative complications [30].

### **2.3.7 Crystalloids**

According to ATLS protocols, bleeding trauma patients should be resuscitated with an initial two-liter crystalloid (Ringer’s lactate/Hartmann’s solution) bolus [21]. Ringer’s lactate and normal saline 0.9% are the two most frequently used isotonic fluids for resuscitation of patients with PCI. Both are widely available and inexpensive. Ringer’s lactate is the preferred choice of fluid for trauma resuscitation. It is metabolized by the kidneys and the liver to form bicarbonate, which acts as a buffer against lactic acid and provides better acid base status. Normal saline infusion in large quantity is associated with worsening lactic acidosis through hyperchloremic metabolic acidosis [33,34]. Normal saline is slightly hypertonic and has equal amount of Na<sup>+</sup> and Cl<sup>-</sup>, making it both hypernatremic and

hyperchloremic relative to plasma. Excessive administration of crystalloid in a trauma patient can result in resuscitation injury i.e. tissue edema, impaired microcirculation, dilutional coagulopathy, multiple organ failure, high mortality and increased length of hospital/ICU stay [35]. Crystalloids, unlike colloids, have no specific adverse effects on renal function and no negative effects on coagulation [36].

### **2.3.8 Colloids**

Colloids are considered better volume expanders, as their larger molecules are retained in the intravascular space for longer than crystalloids. Current available colloid solutions are albumin, dextran, hydroxyethyl starches and gelatins [35,36]. Advantages offered by colloids are better hemodynamic effects, antioxidant effect, free radical scavenging, protection of glycocalyx (albumin), improved rheology, improved microcirculation, low risk of disease transmission, and longer intravascular half-life (gelofusine, dextran and hydroxyl ethyl starch 6%). They are also cheaper to manufacture than blood products [37]. Krausz's 1998 study showed that patients who were resuscitated with colloids had reduced fluid requirements and superior hemodynamic performance when compared to those who only received crystalloids [38].

Colloids were the preferred fluid of choice for trauma resuscitation until recently. Recent research (major trials, table 1) has revealed controversies regarding the use of colloids. Literature also suggests that they may have no superior advantage over crystalloids and that they are not without risk [35,36]. Hydroxyethyl starch has been associated with acute kidney injury, increased use of renal replacement therapy (RRT), coagulopathy, increased blood transfusions and mortality. James et al (2011) showed that in penetrating chest

trauma, colloids have an advantage over crystalloids [39]. Most of the studies look at intensive care patients with sepsis while very few look at the trauma patient.

Table one shows some of the major trials and results regarding colloids.

<b>Trial</b>	<b>Population</b>	<b>Intervention</b>	<b>Control</b>	<b>Conclusion</b>
James 2011 (FIRST)	Trauma patients (PCI)	HES 130/0.4	Saline	HES provides better lactate clearance with decrease renal injury in PCI.
Myburgh 2012 (CHEST)	ICU patients	6% HES (130/0.4)	Saline	No mortality difference, increased AKI and RRT use with HES
Perner 2012 (6S)	ICU patients with severe sepsis	6% HES (130.0.42)	Ringer's acetate	Increased 90-day mortality with HES; increased use of RRT with HES.
Annane 2013 (CRISTAL)	ICU patients with hypovolemic shock	Colloids (gelatins, Dextrans, HES, 4% or 20% albumin)	Crystalloids (isotonic or hypertonic saline, Ringer's lactate)	No difference in 28-day mortality; 90-day mortality lower in colloid group
Caironi 2014 (ALBIOS)	ICU patients with severe sepsis or septic shock	20% albumin and crystalloid	Crystalloid solution	No difference in mortality or other outcomes

**Table number 1: Major Randomized Control Fluid Trials (Lira et al, 2014) [35].**

Fluid shifts associated with blood loss, crystalloid infusion, metabolic acidosis, hypothermia and transfusion of packed red blood cells contribute to dilutional coagulopathy in trauma. Development of early coagulopathy of trauma is an independent predictor of poor outcome [40]. The goal of trauma resuscitation is to achieve adequate tissue perfusion and oxygenation while correcting any coagulopathy. Early institution of blood component therapy with packed red cells, fresh frozen plasma and platelets in a ratio of 1:1:1 or 2:1:1

is recommended to achieve this goal [41]. It is often difficult to achieve this target due to limited access and supply of blood products in developing countries. Uncross-matched type-O packed red blood cells is used for initial resuscitation until cross-matched blood products are available. Patients who receive blood products as part of initial resuscitation are less likely to receive excessive fluids [33,34]. Blood transfusion is an essential part of patient care that not only saves lives but also improves patient outcomes. Hospitals that have immediate access to blood products and transfusion protocols in place for trauma patients not only have a decreased 30-day mortality, but also show reduction in transfusion of blood products [33,42,43].

Blood product transfusion also has associated risks and is a costly resource [41]. Plasma, platelets, and RBCs have associated risks of cross-match errors, allergic reactions, transfusion related acute lung injury, fluid overload, adult respiratory distress syndrome (ARDS), and disease transmission. However, in patients with severe traumatic injuries and hemorrhagic shock, the survival benefits of blood component therapy likely far exceed the risks associated with their use [44].

Trauma resuscitation has evolved towards more judicious fluid administration in the last decade. The selection, timing, and doses of resuscitation fluids should be evaluated carefully, as with other intravenous drugs. Fluids and blood products should be titrated to a specific physiological endpoint such as blood pressure, or even better, to base deficit and lactate [35].

### **2.3.9 Resuscitation markers**

Haemorrhagic shock leads to tissue hypoperfusion and inadequate oxygen delivery to the tissues. Inadequate tissue oxygenation leads to anaerobic metabolism and resultant tissue acidosis, increased base deficit and high lactate levels. Even in adequately resuscitated trauma patients with apparently normal physiological parameters, occult hypotension and hypoperfusion may be present. Heart rate, Glasgow Coma Scale (GCS), capillary refill time (CRT) and urinary output are considered non-specific clinical surrogates of tissue perfusion. These end-points are not considered adequate in identifying tissue hypoperfusion and oxygen debt, while serum markers like pH, lactate and base deficit are regarded as more accurate surrogates of tissue perfusion. Serum pH, lactate and base deficit have all been extensively studied as clinical markers of metabolic acidosis in shock [45]. These metabolic markers help to identify compensated shock before it progresses to overt shock. Improvements in point of care testing such as ABG have made these markers readily available. These metabolic markers have been validated in multiple studies as predictors of survival in PCI [46,47].

### **2.3.10 Base deficit**

Base deficit (BD) is an indicator of tissue hypoperfusion and anaerobic metabolism, and is considered a good surrogate marker of metabolic acidosis. Arterial pH is not as useful as it is influenced by the body's compensatory mechanisms [48]. Base deficit (i.e. a negative base excess) represents the amount of base in millimoles required to titrate one liter of whole arterial blood to a pH of 7.40, with the sample fully saturated with oxygen at 37 °C

and a PCO<sub>2</sub> of 40 mmHg. BD is correlated with injury severity and degree of hemorrhage that normalizes quickly with adequate resuscitation and hemorrhage control. If the base deficit remains elevated during volume resuscitation, it is an indication of ongoing tissue hypoxia. Several studies have correlated BD with survival, development of organ failure, and need for blood transfusion [46,47]. BD can be used as a tool to guide fluid therapy in trauma patients [49]. Davis et al found that high admission base deficit was associated with greater fluid requirement, ongoing blood loss, need for blood transfusion, coagulopathy, ARDS, length of ICU stay and multiple organ dysfunction syndrome (MODS) [50]. A study by Rutherford et al showed that base deficit in the first 24 hours was an independent predictor of mortality [51]. Bannon et al also found that base deficit and lactate levels correlated well with transfusion requirements and development of hemodynamic instability in patients with truncal trauma who required surgery [52].

### **2.3.11 Lactate**

Serum lactate is another valuable marker to assess adequacy of perfusion. Delayed lactate clearance is an indicator of inadequate cardiac output or resuscitation, resulting in higher mortality in a trauma patient. High lactate values on admission and at 24 hours after the injury are associated with poor outcomes [47]. A sustained increase or decreased lactate clearance predicts mortality, regardless of the associated BD level. However, a higher BD level does not correlate well with mortality if the lactate level is normal in a trauma patient [53]. Mikulaschek et al found that among trauma patients, lactate levels were higher in non-survivors than survivors, but found poor correlation for anion gap and base deficit [54]. Similarly Vincent et al found that time taken for lactate level to normalize was an important factor for predicting survival. All patients who had normal lactate level within 24 hours post

injury survived. Those patients who normalized their lactate levels between 24-48 hours had 25% mortality, and those who did not normalize their lactate levels by 48 hours had a mortality of 86% [55].

Both BD and lactate are reported commonly in literature, mostly as independent risk factors of mortality. Lactate is a marker of decreased tissue perfusion while a high BD can reflect volume status of the patient, or the presence of other acidifying metabolites independent of an increase in lactate. BD represents a summary of the total acid base disturbance and includes a contribution from lactate. Despite many endpoints available to clinicians, no single biomarker or a specific value can be utilized to guide resuscitation of all trauma patients.

### **2.3.12 Front Room Thoracotomy (FRT)**

Patients arriving at the hospitals in extremis with signs of life require a FRT as a lifesaving maneuver [16]. In international literature, FRT is a controversial procedure with high mortality, which is challenging and more complex when performed under the non-optimal conditions of the EC. FRT carries a higher mortality of 84% when compared to thoracotomy performed in an operating room 31% [4]. These numbers are however incomparable, as FRT is performed as the only option in order to save a patient's life, particularly when access to the operating theatre is unavailable, or the time delay in taking a patient to theatre will significantly increase chance of mortality.

After concerns that this procedure was performed randomly with poor outcomes, the American College of Surgeons (2001) reviewed published reports on FRT and made the following recommendations:

“FRT is best applied to patients who sustain PCI, and arrive at the trauma center after short scene and transport time, with witnessed or objectively measured signs of life.” [13]

In patients with eminent cardiac arrest and positive ultrasound findings, thoracotomy should be performed in the ER in addition to simultaneous volume resuscitation with packed cells or crystalloids [15]. FTR is the only option for survival in patients who arrive in extremis and taking the patient to theatre may not be a practical option. Without such emergency intervention, a patient who may be salvageable will not survive. As long as the patient meets the criteria for FRT, this procedure should be performed without further delay.

Indications of FRT	Contraindications of FRT	Aims of FRT
<ul style="list-style-type: none"> <li>• Penetrating cardiothoracic injury.</li> <li>• Traumatic arrest with previously witnessed cardiac activity</li> <li>• Rapid exsanguination from intercostal drains or into the airway</li> <li>• Hypotension unresponsive (BP&lt;70mm Hg)</li> </ul>	<ul style="list-style-type: none"> <li>• Blunt cardiothoracic injuries with no witnessed cardiac activity</li> </ul>	<ul style="list-style-type: none"> <li>• Relief of cardiac tamponade.</li> <li>• Control of haemorrhage</li> <li>• Access for internal cardiac massage</li> </ul>

**Table 2: Indications for FRT. Medscape, 2015 [56] .**

The most important aspect for resuscitation of haemorrhagic shock in an exsanguinating patient is source control either in EC, or quick transfer to theatre. These patients require ongoing resuscitation in theatre, with emergency packed red blood cells, fluids, and inotropes [35]. Successful repair of cardiac injuries depends not only on the skills of the surgical and anaesthetic team but also on the nature of the injury. An isolated stab wound to the heart carries a lower mortality of 8.5 -15%, as compared to a vascular injury [57].

Injuries of ascending aorta carry a mortality of 50% while injury to descending thoracic aorta is associated with mortality of 5 - 25%. Pulmonary artery and vein injuries are highly lethal with mortality in excess of 70%. Similarly injuries to thoracic vena cava are infrequent but also have an associated mortality of more than 60%. The reported mortality rate of innominate artery is around 25% [6].

### **2.3.13 Post-operative management**

Post-operatively, most of these patients are hypothermic, acidotic, and on inotropes, therefore requiring post-operative ventilation and continuous resuscitation. Immediate transport of severely injured patients to specialised ICU facilities improves outcomes [58,59].

### **2.3.14 Limitations of current studies on PCI**

Asensio et al (2001), and others, have identified the following limitations of published studies [16]:

- Most are retrospective studies, with only a few prospective studies. As reported by Nicol et al only fifteen prospective studies have been conducted on PCI to date [8].
- Most of these studies come from institutions that manage a limited number of patients with PCI at any one time.
- Small sample size in most studies.
- Multiple overlapping of serial studies from the same institutions.
- Omission of data due to the following reasons: omission of pre-hospital data, mortuary data, transport times, physiological variables on arrival, indications of FRT as predictors of outcomes that have not been statistically validated regarding their predictive values.
- Under-utilisation of protocols or scoring systems regarding management of these injuries.
- Wide variations are observed amongst the published series on PCI with regard to mortality (17%-80%) and survival rates (3%-84%). Some series reporting very high survival and mortality rates as compared to others [13]. These variations are largely attributed to whether or not pre-hospital mortality is included, also different selection criteria's for resuscitation, non-reporting of failed resuscitation attempts, and selection of patients with better physiological parameters and with less severe injuries by the clinicians.

#### **2.3.14 Factors affecting outcomes of PCI**

Several factors have been identified as predictors of outcome amongst multiple studies on penetrating cardiothoracic injuries. Physiologic condition of the patient in the field, the transport time to the hospital, physiologic parameters (BP, pulse, GCS) on arrival in EC,

mechanism and type of injury, thoracotomy indications, and intraoperative findings are identified as factors influencing the outcome of the patients with PCI [12].

### **2.3.15 Factors associated with poor outcomes of PCI:**

- Period from sustaining the injury until definitive care is received [16].
- Left ventricle (LV) injury [14].
- Multiple cardiac chamber injury [13].
- Major vessels injury: Injury to aorta, pulmonary vessels, coronary artery and inferior vena cava (IVC) or superior vena cava (SVC) is associated with rapid blood loss [15,16]. Patients exsanguinate and require re-exploration due to missed injuries, especially to the internal mammary artery (IMA) or intercostal arteries [20].
- Pre-hospital cardiac arrest [4,13].
- Profound shock on presentation or systolic BP < 90 mmHg is associated with increased mortality [12,16,28,60].
- ABG parameters – pH < 7.0 and BD of 20 mmol together with an increased lactate are the strongest predictors of poor outcome [61,62].

These end points are discussed in detail later under ‘end points of resuscitation’.

### **2.3.16 Factors associated with favorable outcomes of PCI:**

- Age of the patient, 14 - 25 years [2,13,14].
- Presence of cardiac tamponade [13,14].
- Immediate transfer to specialised trauma centre within one hour of injury [59].

- Early resuscitation with blood products when compared to colloids or crystalloids [43].
- Immediate surgical control of bleeding [40].
- Reversal or prevention of coagulopathy of trauma [40].
- Less severe injuries, for example, single chamber involvement; a LV injury is more severe than an injury to the right ventricle (RV) [15,16].

According to Mansour et al (2013): “It is difficult to evaluate the results of cardiac injuries because several factors affect the survival and mortality.” [63] The difficulty may not be analysis of the results, but to uniformly identify factors that will predict mortality globally in PCI patients.

Author Year of publication	No. Patients	Proportion GSW	Overall Survival	Major findings
Sugg et al. (1972)	459	73%	14%	High pre-hospital mortality (81%). Change in philosophy from peri- cardiocentesis and observation to emergency cardiorrhaphy.
Beal et al. (1972)	269	29%	75%	Changing practice overtime of pericardiocentesis and observation to immediate thoracotomy.  Large rise in GSWs.
Carrasquilla et al. (1972)	245	11%	Not reported	Six-fold increase in gunshot wounds over time.  74% survival for gunshot wounds for aggressive resuscitation and immediate thoracotomy.
Asfaw et al. (1977)	323	18%	84%	No role for conservative treatment. Recommend prompt resuscitation and immediate thoracotomy.
# Demetriades et al (1983) [11]. Retrospective Mortuary + EC data	532  2 years	4.3 %GSW  95.6% SW	17.9%	High pre-hospital mortality (80%). High index for suspicion required for diagnosis. Vascular injuries carry high mortality. Lower mortality for operated patients.
Henderson et al. (1994)	215	71%	15%	85% mortality in unselected series (unclear how many were already dead before arrival).  ER thoracotomy futile if no vital signs on arrival.
# Velmahos et al. (1994) [41].	373	17%	81%	Isolated single chamber stab wounds deemed a relatively innocent injury (8.5% mortality).

# Campbell et al. (1997)  Retrospective Mortuary + EC data [47]	1198  3 years	41%	3%	94% pre hospital mortality. 202 patients with tamponade due to isolated stab wounds may have potentially been saved with more prompt treatment.
Wall et al.  (1997)	711	42%	53%	8% had complex injuries, i.e. coronary, valve, fistula or septal defect. 53% mortality in this self-selected sub group.
Tyburski et al.  (2000) [46]	302	49%	41%	Worse prognosis for multiple chamber and great vessel injuries.  ER thoracotomy for GSWs uniformly fatal.
# Degiannis et al.  (2006) [14]  Retrospective  (EC data)	117  32 Months	18%	69%	Increase in GSW  Protocols in place result in favorable outcomes
# Clark et al (2011) [2]  (Retrospective) (Mortuary+ EC data)	1186  3 years	11%	24%	High pre-hospital mortality  GSW more lethal.  High survival in-patient reaching hospital alive
# Clarke et al.  2014 [3].  Retrospective (EC data)	134  6 years	PCI only  No GSW	83%	PCI require high index of suspicion  Early postoperative intervention

**Table 3: Largest Published Series of Penetrating Cardiac Injuries [13]**

**GSW= Gun shot wounds, PCI= penetrating chest injury (Stab wounds)**

**# = South African studies.**

## **CHAPTER 3: Aims and Objectives**

### **3.1 Purpose of the audit**

PCI, being high-risk trauma, is associated with increased mortality. The aim of the audit is to review the experience and management of PCI at KDH. Few studies have been conducted at district level hospitals where most of these injuries initially present. Studies on PCI from South Africa have been conducted mostly at the tertiary level or larger regional hospitals of Durban, Johannesburg, Pietermaritzburg and Cape Town.

This is the first audit to evaluate penetrating cardiac trauma at a district health facility in Cape Town. In this respect, it is the first audit to test the adequacy of the current district hospital service to manage high acuity injuries like PCIs. Therefore, this audit should also be seen as a dynamic component of managing not just the patients, but also the services that care for these patients. This audit was conducted early in the inception of the hospital and the care and outcome may be different from that of a well-established hospital.

Literature on PCI identifies and describes numerous factors that influence the outcome of these injuries. It generally concludes that early resuscitation, source control and immediate transfer to tertiary-level facilities improves the outcome of patients with PCIs. However, most of these studies have been conducted in developed countries that manage a limited number of these injuries on a regular basis. These studies do not therefore reflect the management challenges faced by district-level hospitals in developing countries, such as South Africa.

These injuries are not considered inside the scope of practice at district level hospitals. The main aim is to audit and identify the different risk factors that play a role in outcomes of PCIs at KDH and compare them with the ones described in literature.

### **3.2 Aims and objectives**

The main aim of the study was to audit penetrating chest injuries at KDH.

A specific objective of this research is to investigate whether a correlation exists between the following parameters and mortality in patients with PCI at KDH:

- Presentation on arrival i.e. shock determined by:
  - Palpable pulse
  - Blood Pressure < 90 mmHg)
- Presence of major vascular injury.
- BD /BE and lactate.
- Type and mean amount of fluid administered for resuscitation and its correlation with acid base severity.
- To audit the E-FAST data, as it is part of diagnostic work up in the management protocol for PCI at KDH.

## **Chapter 4: Research Methodology**

### **4.1 Introduction**

**This is a retrospective, single center audit that was performed at KDH, a district level hospital, in Cape Town, South Africa over a period of 34 months (February 2012 to December 2014).**

### **4.2 Approval from the Human Research Ethics Committee of UCT**

The study protocol approval:

- The human research ethics committee (HREC) of the Faculty of Health Science University of Cape Town (HREC REF: 349/2015).
- Dr. Anwar Kharwa, Dr. Rosie Burton and Dr. Kitesh Moodly approved ethics approval at KDH.
- Dr. Anwar Kharwa (CEO, KDH) and Mrs Elmarie Van Tonder granted permission to access medical record at KDH.
- Dr. Bernadette Eick (COO-Groote Schuur Hospital) granted permission to access medical records at Groote Schuur Hospital.
- Dr. Nicola Barsdorf, Head of Ethics Health Research, Dr. D Erasmus (CEO, Tygerberg Hospital) granted permission to access medical records at Tygerberg Hospital.

### **4.3 Setting and study population**

KDH is a district level facility situated in the suburb of Khayelitsha, in Cape Town. From February 2012 to December 2014, 57 patients with penetrating chest injuries, secondary to stab wound presented to the EC and underwent surgery at KDH. We specifically looked at the outcomes of the patients who were considered unstable for transfer to specialist

centers. The patients who underwent surgery were then followed up in ICU at specialist centers to determine their outcomes and if they developed any complications.

#### **4.4 Exclusion criteria**

Patients with blunt cardiothoracic trauma, GSWs, and missing medical records were excluded from the study.

#### **4.5 Inclusion criteria**

All the patients who sustained penetrating chest injury secondary to stab wound and were operated on at KDH.

#### **4.6 Data collection**

The case report form (CRF) below was designed to collect the information from the medical records of patients that required surgery at KDH. The following parameters from EC, theatre and ICU were collected:

#### **4.7 Data collection form**

##### **4.7.1 Emergency Unit Parameters:**

- Surname and initials
- Folder number
- Age
- Sex
- Date and time of arrival
- Physiological parameters on admission
  - Systolic BP >90mm Hg or <90mm Hg
  - Pulse; palpable/non-palpable

- GCS
- Respiratory rate
- Spontaneous ventilation/intubation

#### **4.7.2 Emergency Unit ABG Parameters**

- Time
- pH
- Lactate
- SBE
- PaCo<sub>2</sub>/PaO<sub>2</sub>
- HCO<sub>3</sub>
- Haemoglobin (Hb)

#### **4.7.3 Resuscitation Fluid Type and Volume Administered**

- Crystalloids
- Colloids
- Blood products
  - Packed cells
  - Fresh frozen plasma (FFP)
  - Platelets

#### **4.7.4 Type of injury**

- SW
- GSW
- Others
- Diagnosis: Cardiac ultrasound (E-FAST) and its findings
- Other Investigations

#### **4.7.5 Theatre parameters**

- Date and time of arrival in theatre

- Type and time of surgery
- Type and time of anaesthetic
- Duration of surgery
- Fluids administered: type (amount)
  - Crystalloids
  - Colloids
  - Blood products
- Time and location of transfer

#### **4.8.6 Intra-operative ABG parameters**

- Time
- pH
- Lactate
- SBE
- PaCO<sub>2</sub>/PaO<sub>2</sub>
- HCO<sub>3</sub>
- Hb

#### **4.7.7 Tertiary level facility (ICU) parameters**

- Hospital
- Date and time of arrival
- Ventilated
  - Yes/No
- Duration
- Extubation
- Days in ICU/outcome

#### **4.7.8 ICU Fluids**

- Crystalloids
- Colloids
- Blood products:

- Packed cells
- FFPs
- Platelets
- Pre and post-transfusion Hb

#### **4.7.9 ICU ABG Parameters**

- Time
- pH
- Lactate
- SBE
- PaCo<sub>2</sub>/PaO<sub>2</sub>
- HCO<sub>3</sub>
- Hb

#### **4.7.10 Further surgical intervention**

- Yes/No

#### **4.7.11 Outcome**

- Survivor/non-survivor.

### **4.8 Consent**

The Ethics Committee waived consent as it was a retrospective case audit and no intervention was instituted on the patients.

## 4.9 Data analysis

Objectives of data analysis were the following:

1. To explore the relationship between 48 hour mortality and predictors (shock, palpable pulse, BD, lactate, mechanism of injury i.e. precordial stab and vascular injury).
2. Explore the relationship between fluids (administered in ER) and shock, lactate and BD.
3. To audit the E-FAST data, as it is part of diagnostic work up in the management protocol for PCI at KDH.

In this study the data was collected using a basic Excel spreadsheet designed by the candidate. The software program R, Version 3.13 was used for data analysis with the help of a statistician.

We chose shock, palpable pulse, precordial stab and vascular injury, BD and lactate as predictors of 48-hour mortality, either as a combined model or independently.

- Shock, pulse, precordial stab and vascular injury as binary response of YES/NO.
- The relationship between predictors and mortality within 48 hours was estimated by odds ratio together with a 95% confidence intervals (CI) and p-values by fitting two sets of logistic regression models to the data.
- Simple regression models including one predictor at a time.
- A multiple regression model including all predictors.
- Categorical data was reported as frequencies and percentages.
- Frequency histograms, scatter plots, Pearson coefficients, charts, tables and descriptive statistics were used to evaluate the data.

## Chapter 5: Results

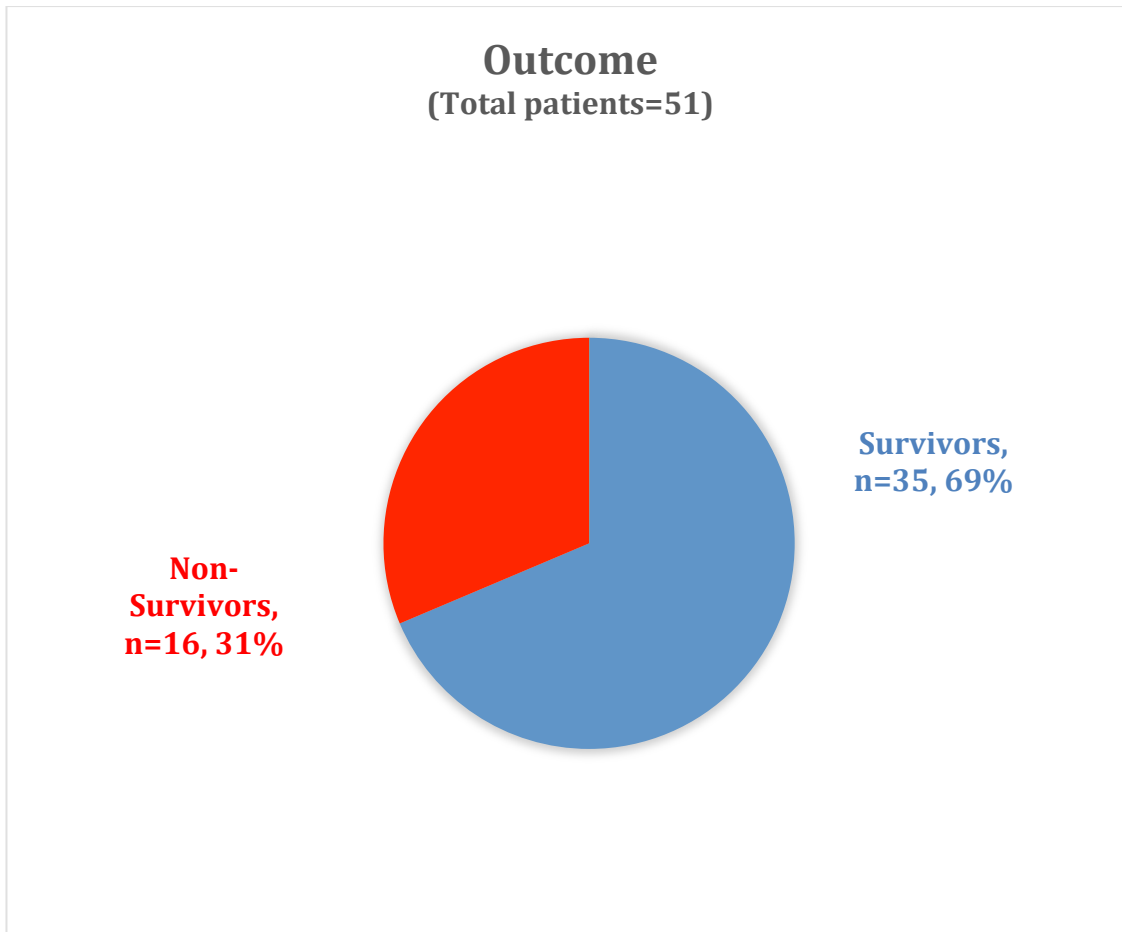
### 5.1 Introduction

During the 34-month period, 646 patients with penetrating chest trauma were admitted and managed at KDH. Fifty-seven out of 646 patients with PCI required surgery at KDH.

- One patient had no notes in the folder and was excluded from the audit resulting in 56 folders to be audited.
- Five patients were transferred from KDH via Emergency Medical Services (EMS) but had missing data at tertiary level (8.9%). Therefore, survival of these patients is unknown and they were excluded from the further 48-hour survival analysis. The sample size was reduced to 51 patients.

From the patients who sustained a PCI and underwent an operation, the following results were obtained (fig 3):

- 35 survivors (68.6%)
- 16 non-survivors (31.4%).
- Overall mortality was 16/51 (31.3) %.



**Figure 3: Graphical Representation of Study Outcome.**

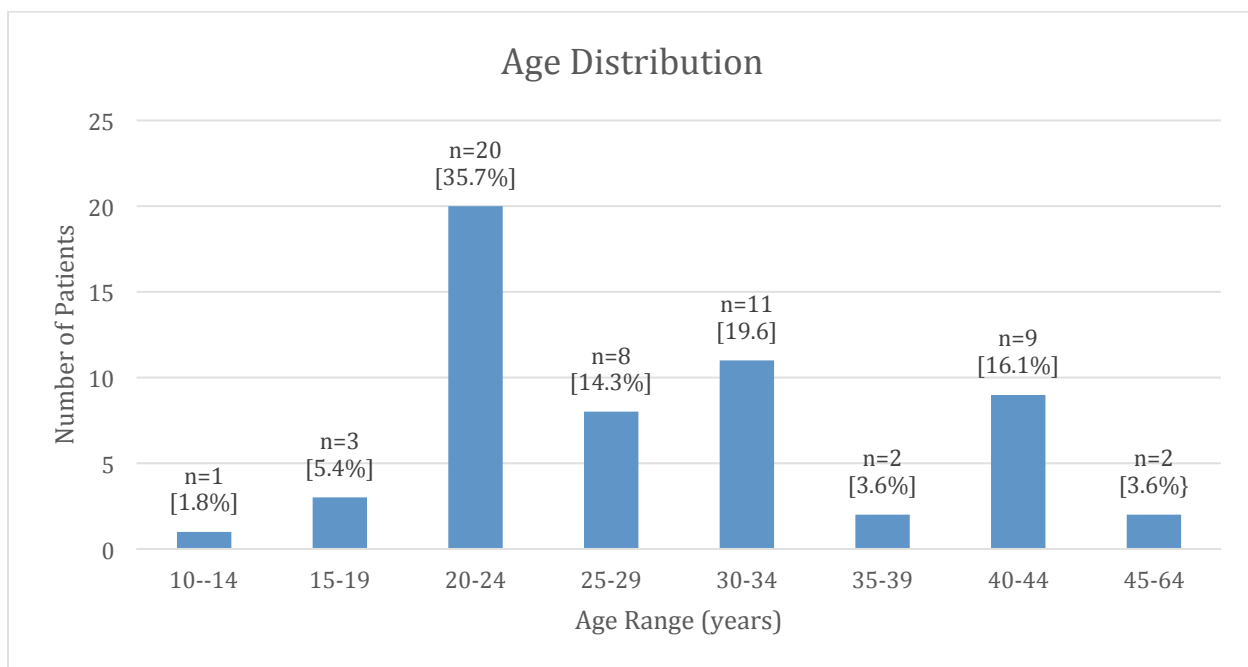
Demographics data (EC variables)	Total patients N=56	Survivors (N=35)	Non-survivors (N=16)	P-value ( $< 0.05$ )
Age (Mean $\pm$ SD)	29.2 $\pm$ 9.1	28.9 $\pm$ 9.31	29.9 $\pm$ 8.42	
Male	55	34	16	
Female	1	1	0	
SBP (Mean $\pm$ SD)	84.86 $\pm$ 21.12	82.26 $\pm$ 29.48	52.81 $\pm$ 39.38	
Number of patients with SBP $< 90$ mmHg	37	23	14	0.279
Number of patients with SBP $> 90$ mmHg	19	12	2	
Pulse (palpable) (Mean $\pm$ SD)	96.52 $\pm$ 7.76	92.31 $\pm$ 26.38	107.89 $\pm$ 27.98	0.181
Number of patients with FRT	10	4	6	
Number of patients with Pericardial Tamponade	13	10	3	
Number of patients with vascular injury	23	14	9	0.385

**Table 4: Audit of EC Data**

Table 4 shows the summary of demographic data and EC parameters of the all-56 patients on admission with their means and standard deviations.

## 5.2 Demographic data

Figure one illustrates the age distribution of the operated patients at KDH. Most patients were young males between 14 and 35 years of age. There were 55 males and one female. The mean age was  $29.2 \pm 9.1$  years. The age group with the largest representation of 20 patients (35.7%) was between ages of 20 to 24 years. There were 4 (7.2%) victims between 10 and 20 years of age, the youngest victim being 14 years old. There were 8 patients (14.3%) in the 25 to 29 year age group and 11 patients (19.6%) between the ages of 30 to 34 years. The age groups representing 40 to 44 years and 45 to 64 years comprised 8 patients (15.7%) and 2 patients (3.9%) respectively. As seen in figure 4 most of the patients that were operated at KDH were young males.



**Figure 4: Age Range of the Patients (n=56)**

### 5.3 Mechanism of injury

All patients presenting to ER sustained a single or multiple SW on the precordium, back and neck area. Some patients also sustained abdominal SWs.

### 5.4 Presentation: Hemodynamic Variables

#### 5.4.1 Blood pressure

Shock and hypotension is defined as a SBP<90 mmHg [16]. Out of all 56 patients, 37 (66.1%) presented with a SBP<90 mmHg and 19 patients (33.9%) had SBP>90mmHg. Four (10.8%) of 37 hypotensive patients arrived in extremis (un-recordable BP and unconscious). Overall mean blood pressure was 84.8 mmHg.

Mortality among patients with SBP <90mmHg was 14/37 (37.8%) while mortality among patients with SBP>90 mmHg was 2/14 (14.2%). Hypotension did not however predict poor outcome in our audit, as 23 (65.7%) of our 35-hypotensive patients survived (p=0.279, regression analysis). This is summarized in figure 5.

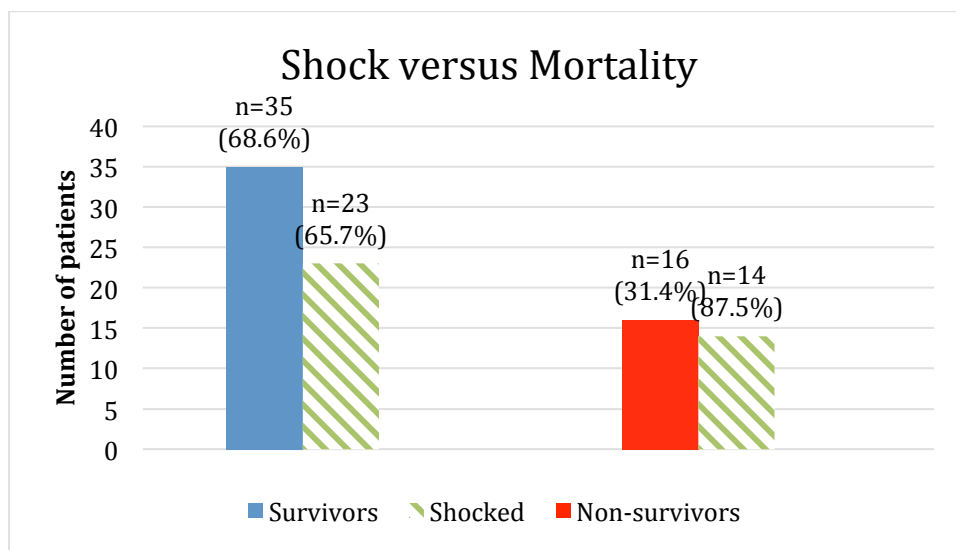
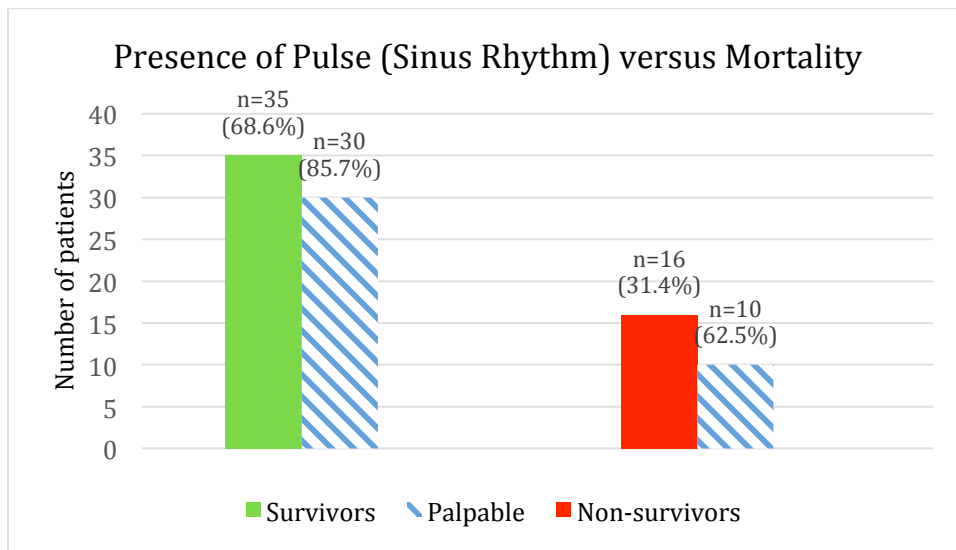


Figure 5: Incidence of Shock amongst the Non-survivors and Survivors.

### 5.4.2 Pulse

Forty-five (80.1%) patients had a palpable pulse on arrival and 11 (19.6%) patients had no palpable pulse. Overall mean pulse was 96 beats/minute.

As shown in figure 6 below, out of 35 survivors, 30 (85.7%) patients had a palpable pulse and 5 (14.7%) patients had no palpable pulse. Among 16 non-survivors, 10 (62.5%) patients had a palpable pulse and 6 (37.5%) had no palpable pulse. Mean pulse rate among survivors was 82 beats/minute and 107 beats/minute among non-survivors.



**Figure 6: Presence of a Palpable Pulse and Mortality**

## **5.5 ABG Results**

Only 38 (67.8%) out of 56 patients had ABG available in the medical records. Of these 38 patients, 89.5% of both survivors and non-survivors had metabolic acidosis on ABG with abnormal pH on arrival. Only 4 (10.5%) out of 38 patients had normal pH on ABG. Lowest recorded value of pH was 6.8 while highest value was 7.45. After removal of 5 patients with unknown survival the sample size was reduced to 33 patients.

### **5.5.1 Lactate**

Mean lactate level recorded on admission was 7.7mmol/L, which is significantly raised compared to normal and indicates on going tissue hypo perfusion. The highest recorded value of lactate was 15 mmol /L and lowest was 0.7 mmol/L, which represents a normal value.

The regression analysis showed that for every mmol/L increase in lactate, the odds ratio (OR) changed by a factor of 1.273 (95% CI 0.99 to 1.63,  $p = 0.06$ ). There is a small increase in likelihood of the patient dying with increase in each unit of lactate. Thus, there is minimal correlation between patient mortality and increase in lactate as  $p < 0.05$ .

### **5.5.2 BD**

The mean BD (i.e., negative base excess) on admission was 11.4mmol/L. The highest recorded value of BD was 7.2 and the lowest was 24mmol/L. According to the regression analysis, for every mmol/L increase in BD, OR changes by a factor of 0.988 (95% CI 0.882 to 1.107,  $p = 0.837$ ). There is no correlation between patient mortality and increase in the BD.

## E-FAST RESULTS

<b>E-FAST (U/S)</b>	<b>Patient (n=56)</b>	<b>Percentage %</b>	<b>CI lower limit</b>	<b>CI upper limit</b>
E-FAST Performed in EC	39/56	69.4%.	55.9	81.22
Effusion present on U/S	29/39	74.36%	57.87	86.96
Operative results available	54/56	94.7%	85.38	98.9
Surgery: hemopericardium Present	36/54	66.6%	52.3	78.91
Sensitivity	27/31	87.1 %	70.17	96.3
Specificity	9/10	90.0%	55.5	99.75
Positive predictive Value	27/28	96.43%	81.65	99.91
Negative predictive value	9/13	69.23%	55.5	90.91

**Table: 5 Results of E-FAST**

## 5.6 Echocardiography results

Table 5 displays the results of cardiac U/S. Out of 56 operated patient, 39 (69.4%) had a cardiac U/S performed on admission to EC. Pericardial effusion was present in 29 (74.3%) patients. Haemopericardium was detected in 36 (66.6%) patients on operation. Cardiac U/S had a sensitivity of 87.1% and specificity of 90% with positive and negative predictive values of 96.43% and 69.23% respectively. There was one false positive examination. There was no documentation of haemopericardium in the operative notes of 3 patients by the operating surgeon. This might have resulted in lower negative predictive value than expected.

## Data Analysis

### 5.7 Data analysis of predictors

Variable (predictor)	Category	Frequency	Percentage	Valid Percentage
<b>Shock</b>	No	19	33.3	33.9
	Yes	37	64.9	66.1
	Total	56	100.0	100.0
<b>Palpable pulse</b>	No	11	19.1	19.6
	Yes	45	80.7	80.4
	Total	56	100.0	100.0
<b>Precordial stab</b>	No	21	37.1	37.5
	Yes	35	62.2	62.5
	Total	56	100.0	100.0
<b>Vascular injury</b>	No	33	57.9	58.9
	Yes	23	40.4	41.1
	Total	56	100.0	100.0
<b>Died in theatre</b>	No	46	82.5	82.5

	Yes	10	17.5	17.5
<b>Died &lt;48 hours</b>	No	38	68.4	74.5
	Yes	13	22.8	25.5
	Outcome unknown	5	8.8	8.8
	Total	56	100.0	100.0

**Table 6: Frequencies and Percentages of Categorical Variables**

The above table displays the frequencies and percentages of the selected predictors of outcome (EC variables) and the 48-hour mortality. The table includes data of the full patient (56) sample group, except for 48-hour mortality category where the 5 patients with unknown survival outcome were excluded and sample size is 51 patients.

**Shock:** 37 (66.1%) out of 56 operated patients at KDH presented in hypovolemic shock with SBP<90 mmHg and 19 (33.9%) patients presented with SBP> 90mmHg.

**Pulse:** 46 patients (80%) had a palpable pulse on arrival while 10 (17.9%) patients had no palpable pulse.

**Precordial Stab:** 35 (62.3%) sustained stab wounds to the precordium, while 21 (37.5%) patients had stab wounds outside the precordium.

**Vascular injury:** 23 (41%) patients had sustained vascular injuries.

**48-Hour Mortality:** 13 (22.8%) patients out of 56 non-survivors died within 48-hours of sustaining the PCI. Ten (17.9%) of these patients demised in theatre at KDH.

Variables	Valid n	Mean	SD	Minimum	1st Quartile	Median	3rd Quartile	Maximum
<b>BD</b>	33	11.4	7.0	24.0	15.5	11.2	6.5	7.2
<b>Lactate</b>	33	7.7	3.6	0.7	5.3	7.4	9.7	15.0
<b>Crystalloid</b>	51	2200	930.9	1000.0	2000.0	2000.0	2000.0	5000.0
<b>Colloids</b>	51	281.8	394.0	0.0	0.0	0.0	500.0	1500.0
<b>Cryst + coll</b>	51	2481.	881.7	1000.0	2000.0	2500.0	3000.0	5000.0

**Table 7: Data Analysis of BD, Lactate and Fluids**

The above table illustrates the data regarding ABG variables (lactate, SBE) and fluids administered to the PCI patients in the EC.

Only 38 patient folders had documented ABG results available. The 5 patients with unknown survival were also excluded from the data sample resulting in 33 patient folders being evaluated for ABG analysis.

### **BD**

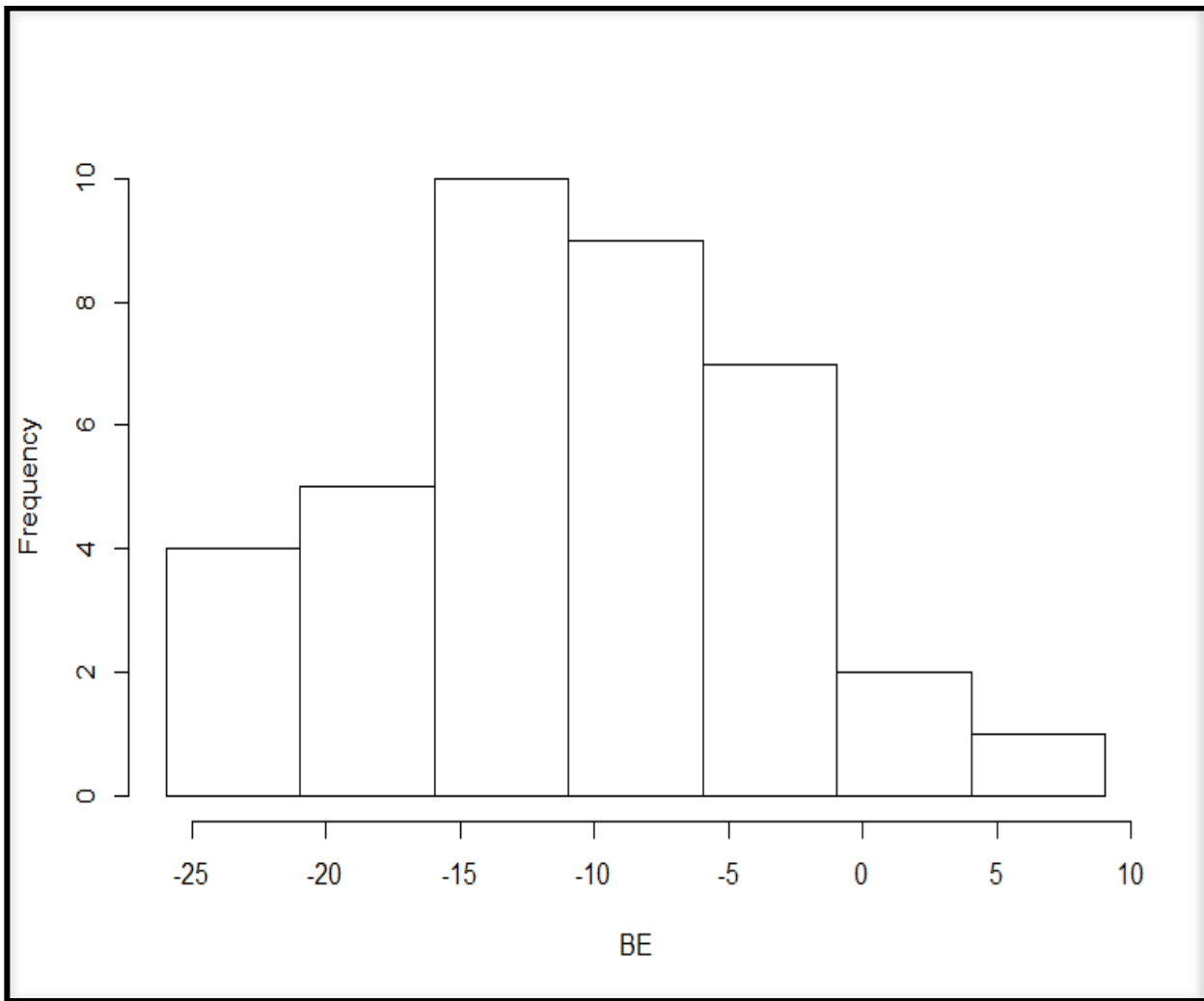
As illustrated, the mean BD on admission was 11.4 mmol/L with a median value 11.2 mmol/L and a standard deviation of 7 mm/L. The highest recorded value of BD was 7.2 and the lowest was 24 mmol/L.

**Lactate**

Average admission lactate level recorded was 7.7mmol/L. The median lactate value was 7.4mmol/L. The highest recorded value of lactate was 15 mmol/L and lowest was 0.7mmol/L, which represents a normal value.

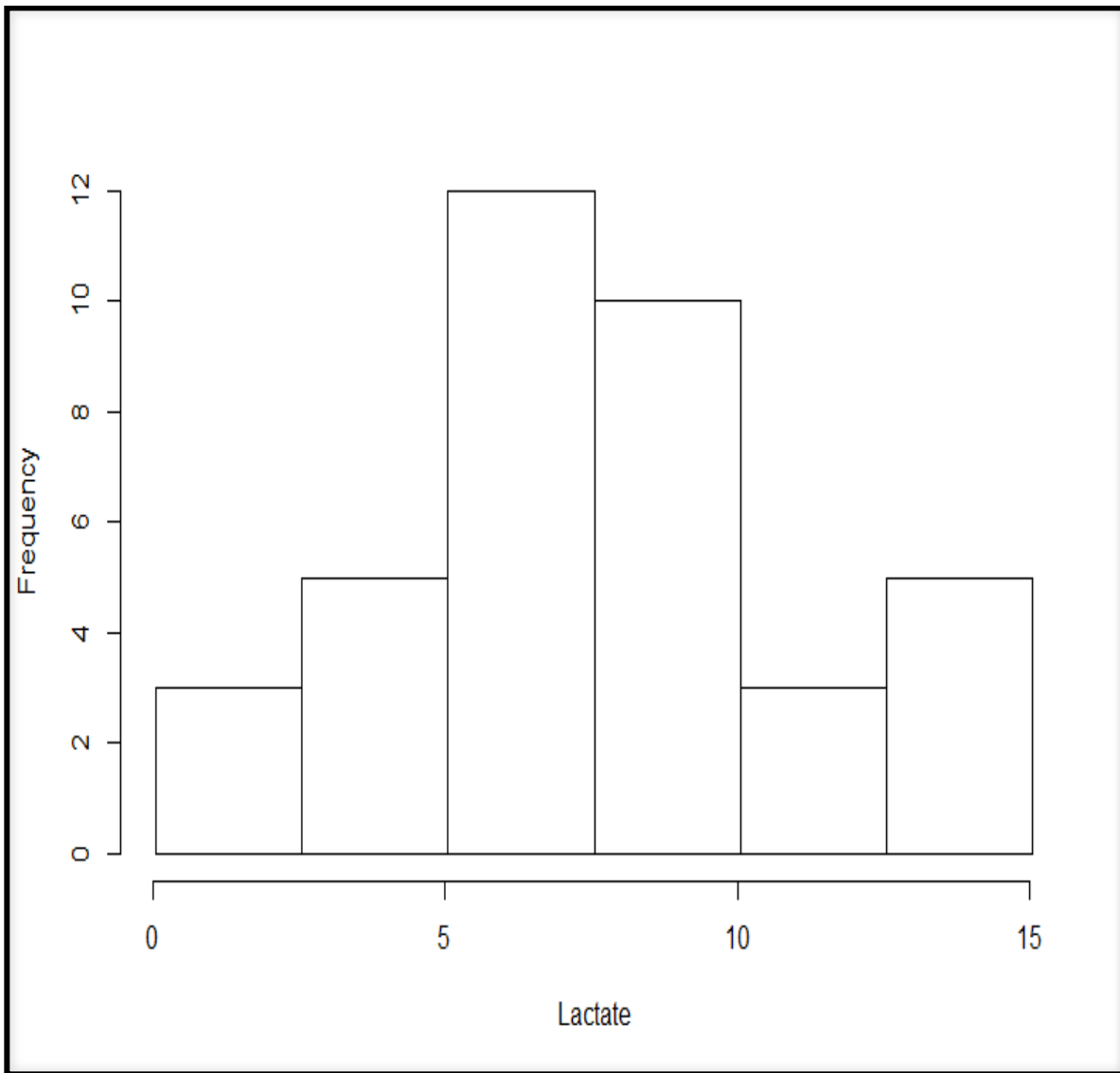
**Fluids**

Mean amount of crystalloids and colloid was 2481 ml with a median value of 2500 ml. A minimum amount of 1000 ml and a maximum amount of 5000 ml fluids was administered to patients in EC.



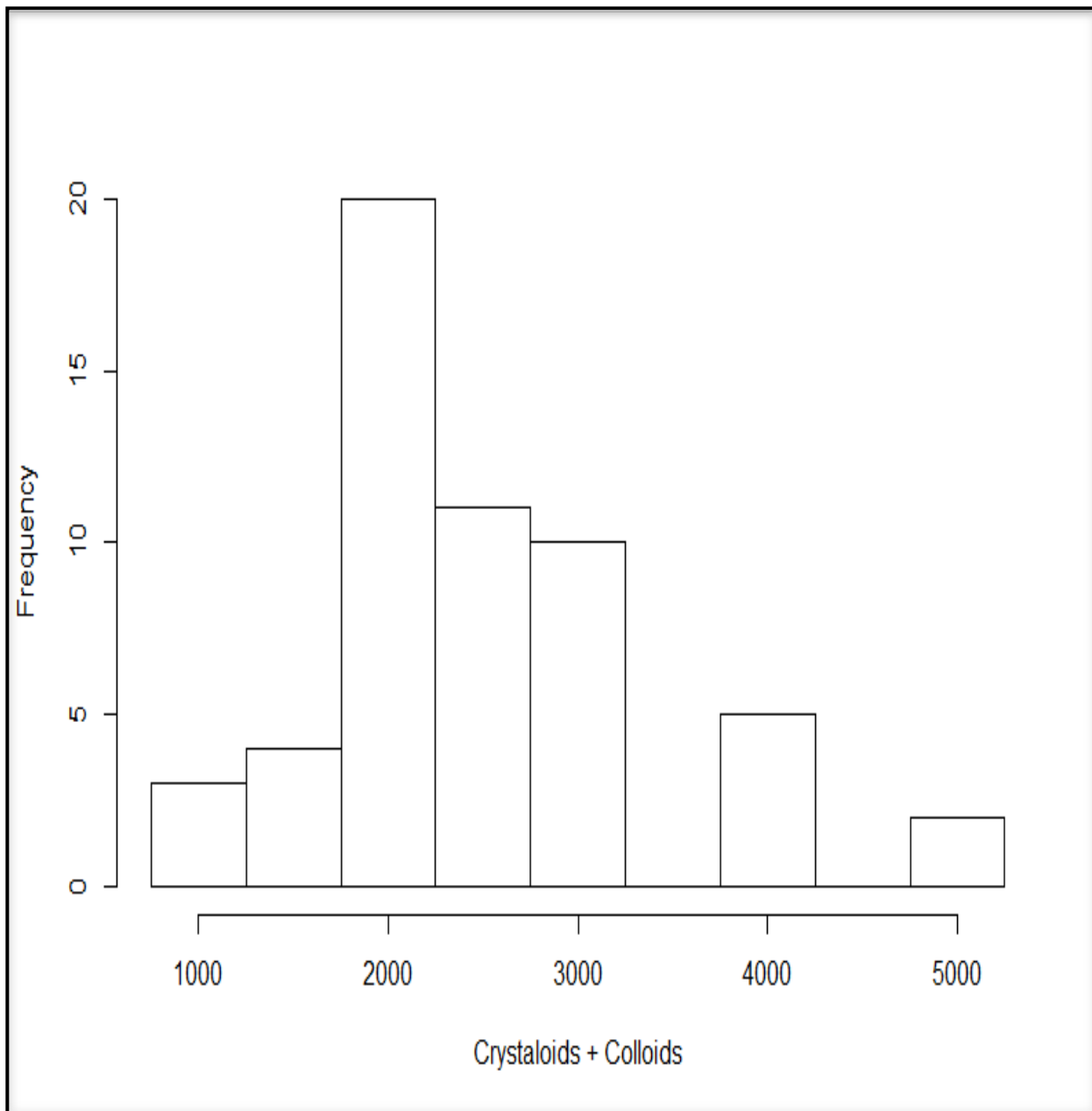
**Figure 7: Histogram Representing the BD/BE values (mmol/L) vs Frequency (number of patients)**

Figure 7 represents the BD/BE levels recorded from the patients on admission. The mean BD on admission was 11.4 mmol/L with a median value of 11.2 mmol/L. The highest recorded value of BD was 11.4 and the lowest was 24 mmol/L.



**Figure 8: Histogram Representing the Lactate Values (mmol/L) vs Frequency (number of patients)**

Figure 8 represents the lactate values obtained from patients on admissions. Most of the patients had lactate levels recorded between 5-10mmol/L. The highest recorded lactate value was 15mmol/L and the lowest was 0.7mmol/L. The median lactate value was 7.4mmol/L.



**Figure 9: Fluid Histogram Showing Distribution of Fluid Administered Amongst the Study Sample**

Figure 9 represents the amount of fluid administered on admission in EC. Most of the patients received 2000-3000ml fluids on admission in EC, with the median value of 2500ml. The highest amount of fluid was 5000ml and the lowest amount was 1000ml.

## **5.8 Fluids**

The audit looked at the type and amount of fluid administered to PCI patients in the EC and its relationship with shock, lactate and BD.

This audit found that at KDH:

- Patients were resuscitated with both crystalloids and colloids on admission.
- Overall mean amount of crystalloid administered was 2200 ml.
- Overall mean amount of colloids administered was 281 ml.
- Overall mean amount of fluids was 2481 ml in this study, the mean amount of fluid used for pre-operative resuscitation was in excess of 20% of recommended ATLS guidelines (i.e. 2000 ml of fluids). Fifty-Eight% of the patients received over 2000 ml of crystalloids for resuscitation. The minimum amount of fluids was 1000 ml and maximum amount administered was 5000 ml.

## **5.9 Blood**

Survivors received an average of 1.8 units of packed cells while non-survivors received an average of 2.87 units of packed cells. Only emergency red packed cells are available at KDH and no fresh frozen plasma and platelets.

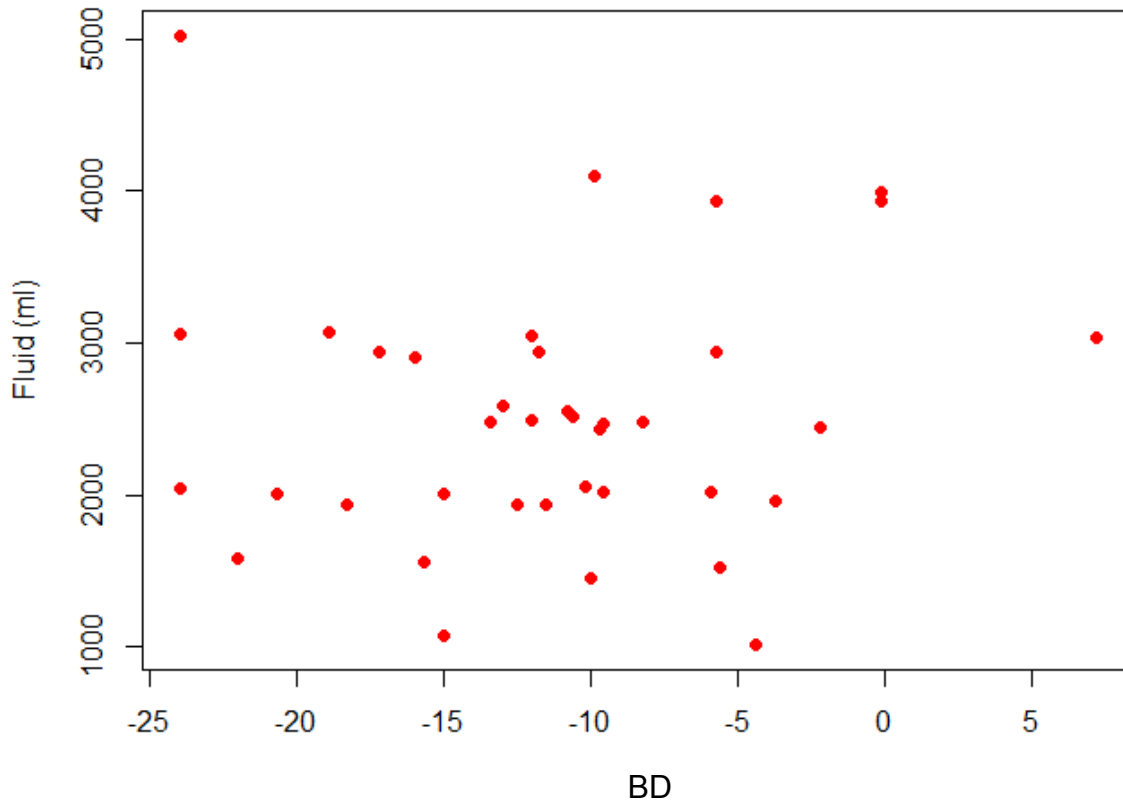
## Relationships between Shock, BD, Lactate and Fluids administered

	Shock	n	Fluids (Mean)	SD	Min	1 <sup>st</sup> quartile	Median	3 <sup>rd</sup> quartile	Max
1	No	19	2605.263	936.5858	1000	2000	2500	3000	5000
2	Yes	37	2416.667	857.7379	1000	2000	2000	3000	5000

**Table 8: Shock and Fluid Summary**

As illustrated in the table 8, the mean amount of fluids administered to 37 patients who presented in shock on admission was 2416 ml with a median value of 2000ml and a standard deviation of 857ml. Patients who were not in shock received a mean amount of 2605 ml with a median value of 2500 ml. Both groups received almost equal amounts of fluids for resuscitation. The highest recorded value of fluids administered was 5000 ml and the lowest was 1000 ml.

## Relationship between administered fluids and BD

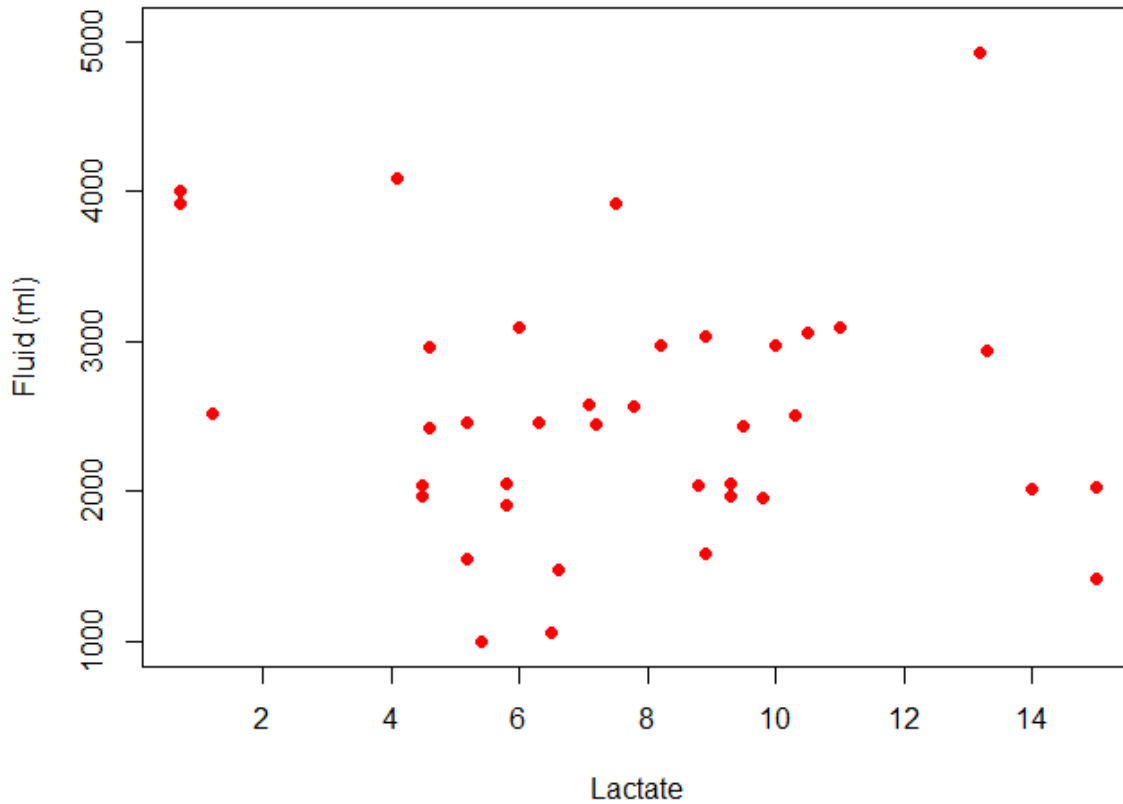


**Figure 10: Scatter Plot of BD and Fluids**

The scatter plot of BD versus Fluids does not show any clear relationship between the two variables (linear or otherwise).

There is no clear pattern. The Pearson correlation coefficient is 0.091 (95% CI: -0.235, 0.400)

## Relationships between administered fluids and lactate



**Figure 11: Scatter Plot of Lactate and Fluids**

The scatter plot of Lactate versus Fluid does not show any clear relationship between the two variables (linear or otherwise).

Again there is also no clear pattern. The Pearson correlation coefficient is -0.103 (95% CI: -0.409, 0.223).

When fitting a regression model to the data, there is no significant relationships between fluid and BD/shock/lactate.

### 48-hour Mortality (N=13)

Variable	Category		# Dead	# Total	Estimate	95% CI	
						Lower limit	Upper limit
All	1		13	51	25	14.03	38.95
Shock	No		2	14	14.28	1.66	40.46
	Yes		11	37	29.72	14.2	45.19
Palpable pulse	No		4	10	40	12.16	73.76
	Yes		9	41	21.95	8.82	34.87
Shock & Palpable pulse	Non-palpable pulse & Shock		4	10	40	12.16	73.76
	Palpable pulse & not shocked		2	15	13.33	1.66	40.46
	Palpable pulse& Shocked		7	26	26.92	8.97	43.65
Precordial stab	No		4	17	23.53	6.81	49.9
	Yes		9	34	26.47	12.88	44.36
Vascular injury	No		6	31	19.23	7.45	37.47
	Yes		6	20	30	11.89	54.28
	N/A		1			2.5	100
BD	<12	Mean 18.7	3	12	25	5.49	57.19
	12 to 6	Mean 10.5	3	11	27.27	6.02	60.97
	> 6	Mean 2.6	1	10	10.00	0.25	44.00
	No ABG available		6	18	31.58	12.58	56.55
Lactate	<5	Mean3.1	1	8	12.5	0.32	N/A
	5 to 10	Mean 7.4	3	18	16.67	3.58	41.42
	>10	Mean13.1	3	7	42.86	9.90	81.59
	No ABG available		6	19	31.58	12.58	56.55

## **Table 9: 48-Hour Mortality and EC Clinical Predictors.**

**N/A= No documentation/No data available**

### **5.10 EC predictors and 48-Hour mortality**

The table above illustrates the observed clinical EC variables (categorized YES/NO) and estimated (percentage) probability of death at 48 hours, with 95% Confidence intervals. Thirteen patients died within 48 hours while 3 patients died after 48- hours.

Shock and palpable pulse were combined into one variable of three categories. Categories were also created for SBE and lactate. Mean values for corresponding categories of BE and Lactate are provided.

The most significant predictors of 48-hour mortality in decreasing prevalence were:

- Lactate (>10mmol): 42.8% patients died (95%: CI 9.90% to 81.59% for estimated probability of death.)
- No palpable pulse: 40% patients died (95% CI: 12.16 to 73.76)
- Vascular injury (YES): 30% patients died (95%CI: 11.89 to 54.28)
- Shock (YES): 27.78% patients died (95%CI: 14.2% to 45.19%)
- BD (6 to 12mmol): 27.27% patients died (95%CI: 6.02% to 60.97%)

## Regression Analysis

### Simple logistic regression analysis

Variables		OR	95% CI lower limit	95% CI upper limit	P-value
BD	1 mmol /mL increase	0.988	0.882	1.107	0.837
Lactate	1 mmol /mL increase	1.273	0.99	1.638	0.06
Shock	Yes	2.5	0.476	13.119	0.279
Palpable pulse	Yes	0.364	0.083	1.601	0.181
Shock and pulse	Palpable pulse and no shock	0.231	0.033	1.628	0.141
Shock and pulse	Palpable and shocked	0.45	0.095	2.141	0.316
Precordial stab	Yes	1.17	0.302	4.536	0.82
Vascular injury	Yes	1.786	0.483	6.599	0.385

**Table 10: Simple Logistic Regression Analysis of Variables**

## 5.11 Interpretation simple logistic regression analysis

One predictor is included in the regression model at a time.

- **Shock:** Progressing from haemodynamic stability to the shocked state, the OR for death increases by a factor of 2.5. (95% CI 0.476 to 13.119,  $p=0.279$ ). There is a small increase in likelihood of patient dying when patient is shocked, but the p-value of 0.279 that is not statistically significant.
- **Pulse:** With a palpable pulse there is a very small reduction in likelihood of patient dying (95% CI 0.83 to 1.60,  $p=0.181$ ), again the result is not statistically significant.
- **BD:** For every mmol/L increase in BD, OR changes by a factor of 0.988 (95% CI 0.882 to 1.107,  $p = 0.837$ ). There is no correlation between patient mortality and increase in BD.
- **Lactate:** For every mmol/L increase in lactate, the OR changes by a factor of 1.273 (95% CI 0.99 to 1.63,  $p = 0.06$ ). There is a small increase in likelihood of patient dying with increase in each unit of lactate. Thus there is minimal correlation between patient mortality and increase in lactate as  $p < 0.05$ .
- **Vascular Injury:** Presence of vascular injury increases the likelihood of patient dying by a factor of 1.78 (95% CI 0.483 to 6.599,  $p=0.38$ ). P-value of  $>0.05$  shows no correlation between patient mortality and vascular injury.

There are wide CIs for ORs for all the categories.

## Multiple logistic regression analysis

### 5.12 Interpretation

Multiple predictors are included in the model at a time. Variables are included as main effects; an OR describes the impact of a change in a variable, holding all other variables constant. The sample size here is reduced to 33 subjects.

The combined model was unable to distinguish the impact that lactate and BD have together on the response. Therefore, in one model BD was included, and in another, Lactate was included (together with shock & palpable, precordial stab, vascular injury).

#### Including BD

	OR estimate	95% CI lower limit	95% CI upper limit	P-value
<b>**Model intercept</b>	0.127	0.003	5.232	0.276
<b>BD</b>	0.995	0.884	1.121	0.937
<b>Shock _ palpable - palpable &amp; not shocked</b>	0.433	0.014	13.331	0.632
<b>Shock _ palpable - palpable &amp; shocked</b>	0.937	0.059	14.836	0.963
<b>Precordial stab - yes</b>	1.305	0.184	9.24	0.79
<b>Vascular injury - yes</b>	4.78	0.716	31.893	0.106

Table 11: Multiple Regression Analysis of BD with Predictors

A likelihood ratio test suggested that an interaction between Precordial stab and Vascular injury was unnecessary (0.5442), or rather that there is a lack of evidence to reject that there is no interaction.

Overall model significance (comparing the above model to one with no predictors):

p-value = 0.5609

### Including Lactate

	<b>OR estimate</b>	<b>95% CI lower limit</b>	<b>95% CI upper limit</b>	<b>P-value</b>
<b>**Model intercept</b>	0.015	0.000	1.626	0.079
<b>Lactate</b>	1.250	0.935	1.671	0.132
<b>Shock _palpable - palpable &amp; not shocked</b>	0.667	0.018	24.901	0.826
<b>Shock _palpable - palpable &amp; shocked</b>	0.983	0.053	18.074	0.991
<b>Precordial stab - Yes</b>	1.580	0.185	13.484	0.676
<b>Vascular injury - Yes</b>	4.760	0.644	35.173	0.126

**Table 12: Multiple Regression Analysis of Lactate with Variables**

A likelihood ratio test suggested that an interaction between Precordial stab and Vascular injury was unnecessary (0.3942), or rather that there is a lack of evidence to reject that there is no interaction.

Overall model significance (comparing the above model to one with no predictors):

p-value = 0.2637.

### 5.13 Front Room Thoracotomy

Out of the 56 patients, 10 (17.8%) were peri-arrest on arrival and underwent FRT. Six (60%) out of 10 patients demised and 4 (40%) survived. Two (20%) patients demised in ER and 4 died in theatre (40%) later.

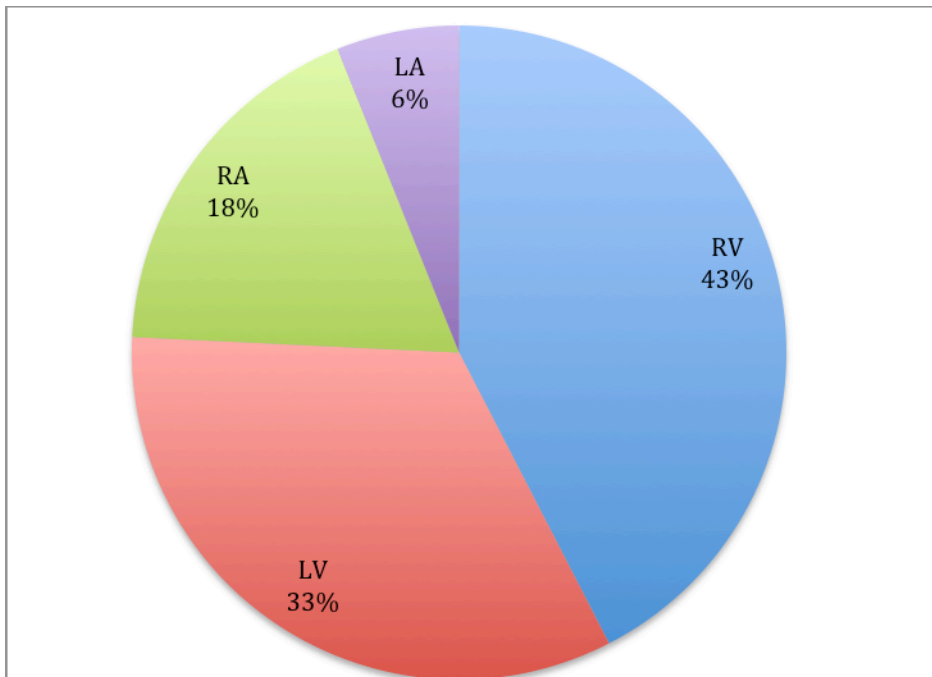
All patients who underwent FRT had pericardial tamponade. Three patients presented with clinical features of pericardial tamponade while tamponade in 7 patients was detected on cardiac ultrasound.

<b>FRT (n)</b>	10 (17.8%)
Survivors	4 (40%)
Non survivors	6 (60%)
-Died in ER	2 (33.3%)
-Died in Theatre	4 (66.6%)

**Table 13: FRT Findings**

### 5.14 Operative findings

Thirty-three (58.9%) of 56 patients sustained single cardiac chamber injury and one patient (1.7%) had multi-chamber injury. Twenty (35.7%) patients had sustained extra cardiac injuries involving major vessels, lungs, gut or liver. The RV was the most frequently injured chamber (n=14; 42.5%) followed by the LV (n=11; 33.3%). Six (18.2%) patients sustained injury to the RA and 2 patients (6.06%) had LA injury. Ten patients (30.3%) with cardiac injury also had concomitant vascular injuries.



**Figure 12: Percentage and Type of Cardiac Chambers Involved**

<b>Injuries</b>	<b>Total (n=51)</b>	<b>Survivors (n=35)</b>	<b>Non-survivors (n=16)</b>
<b>Right atrium</b>	6	3 (8.6%)	3 (18.8%)
<b>Left atrium</b>	2	1 (2.9%)	1 (6.25%)
<b>RV</b>	14	11 (31.5%)	3 (18.8%)
<b>LV</b>	11	11 (31.5%)	0
<b>CA</b>	2	2 (5.7%)	0
<b>Aorta</b>	2	1 (2.8%)	1 (6.25%)
<b>PA</b>	1	1 (2.8%)	0
<b>Vena Cava</b>	3	2 (2.8%)	1 (6.25%)
<b>PV</b>	1	0	1 (6.25%)
<b>LL</b>	20	14 (40%)	6 (37.5%)
<b>Liver</b>	2	2 (5.7%)	0
<b>Colon</b>	1	0	1 (6.25%)
<b>SA</b>	1	0	1 (6.25%)
<b>SV</b>	1	0	1 (6.25%)

**Table 14: Summary of Surgical Findings**

### 5.15 Mortality

Overall, the mortality rate was 31.3% (16 of 51 patients). Two (12.5%) patients died in the EC, 10 patients (62.5%) demised in theatre, and four patients (25.%) died later in ICU. One patient died within 48-hours of ICU admission and three patients died after 48-hours. Mortality within 48 hours was 13 (81%) due to exsanguination secondary to vascular and cardiac injuries. The mortality after 48 hours was 18.7% with three patients dying due to multi-organ failure and sepsis in ICU.

<b>Mortality</b>	<b>N</b>	<b>Percentage (%)</b>	<b>Cause</b>
<b>Overall</b>	16/51	31.3%	
<b>&lt;48-hours</b> ER=2 Theatre=10 ICU=1	13	81%	<ul style="list-style-type: none"> <li>• Exsanguination,</li> <li>• Vascular and cardiac injury.</li> <li>• Brain death due to prolong hypotension.</li> </ul>
<b>&gt;48-hours</b> ICU	3	19%	<ul style="list-style-type: none"> <li>• Sepsis and Multi-organ failure.</li> </ul>

**Table 15: 48-hour Mortality**

### 5.15.1 Mortality and vascular Injuries

Overall twenty-three patients (41.1%) sustained vascular injury either isolated or combined with other injuries. Out of 16 non- survivors, 7 (43.7%) had sustained an isolated vascular injury. Five (31.2%) patients died of injury to one of the cardiac chambers. One patient had a dual cardiac chamber injury. Two patients who sustained both cardiac and vascular injury also died.

One patient with multiple stab wounds to the chest demised as a result of bilateral lung lacerations and no cardiac injury. Lung lacerations were present in 37% (5) of non-survivors.

<b>Mortality (N=16)</b>	<b>N</b>	<b>%</b>
Vascular	7	43.7%
Cardiac	5	31.2%
Vascular +Cardiac	2	12.5%
Unknown (FRT with no documentation of injury site in notes)	2	12.5%

**Table: 16 Injuries and Mortality**

### 5.16 Length of ICU stay

The length of ICU stay amongst survivors ranged from 0-14 days, with a mean of 2.4 days, and a mean of 5.5 days amongst non-survivors.

### **5.17 Complications in the postoperative period**

Four survivors (7.5%) required re-do surgery within 24 hours post-transfer. Three patients underwent re-do sternotomy, one to repair a missed lung laceration and two patients for missed internal mammary artery injuries. One patient required CPB to repair a severed left anterior descending artery (LAD) that was repaired at KDH with a feeding tube as a conduit. This patient survived.

Two non-survivors required multiple laparotomies and one required upper limb amputation secondary to tying off subclavian vessels intra operatively at KDH to achieve hemostasis. This incidence of re-operation at tertiary level facilities is largely due to lack of specialized surgical expertise at the district level. Indication for re-operation was surgical bleeding and no patients were re-operated due to hemorrhage from coagulopathy of trauma.

## **Chapter 6: Discussion**

### **6.1.Introduction**

This retrospective audit was performed to evaluate penetrating chest injury in patients operated upon at KDH, a district hospital in Cape Town, South Africa. In addition, the correlation was examined between mortality within 48 hours and lactates, SBE, shock, vascular injury and the effect of resuscitation fluid administered.

The objectives were to identify potential risk factors for mortality and to guide EC clinicians to risk stratify PCI patients and deploy medical resources appropriately. Similar work has been performed in the setting of blunt abdominal vascular trauma [64].

Numerous physiological indices and scoring systems have been employed, however none can be applied specifically and uniformly to every scenario. In order to improve and assess perioperative care, it is essential to monitor postoperative outcomes. The emphasis in South Africa is on striking a balance between optimal and economical health care.

PCI are complex injuries posing a serious management challenge in any clinical setting, particularly at hospitals with limited experience of the condition. Over the past 40 years, there is consensus that PCI carries a high mortality and several factors influence outcomes [16].

South Africa has a high incidence of cardiothoracic trauma associated with a large number of PCIs. [2,3,15,17]. Despite a reported decline in PCI [13], these injuries are still commonly

encountered in the Western Cape and pose a huge burden on a constrained South African health care system.

## **6.2. Incidence**

The reported incidence of PCI ranges from 0.1% to 0.5% of acute trauma [14]. In our study, amongst 56 operative cases at KDH, 33 patients sustained isolated injury to one of the cardiac chambers. This incidence of penetrating cardiac injury of 5.1% of all the penetrating cardiothoracic trauma patients is 10-fold higher than is reported in the literature. KDH sees on average 800 - 1000 trauma patients per month. Of those, an average of 80 - 90 are penetrating chest injuries, giving an incidence of approximately 10%.

Patients who demise before reaching KDH are transferred to a larger state mortuary in another part of the city. There is no data interface between the two facilities. The audit results showed that the victims of PCI are predominantly young males, congruent with other studies [15,17]. Similar to previous research, this audit investigates only SWs at KDH, as GSWs have a different pathophysiology [65]. The results confirm that SWs are still highly prevalent in the Khayelitsha area, as indicated by Bradshaw et al [1].

## **6.3. Mortality**

Overall, the mortality rate was 31.3% (16/51 patients). Two (12.5%) patients died in the EC, 10 patients (62.5%) demised in theatre, whilst four patients (25.%) died later in ICU. One of the four patients died within 48-hours of ICU admission. Mortality within 48 hours was 13 (81%) due to exsanguination secondary to vascular injuries. The mortality after 48 hours was 18.7% with three patients dying of multi-organ failure and sepsis.

Mortality of 31.3 % in this audit is lower than the reported mortality for PCI in literature, and is probably influenced by the fact that no mortuary data was included in the study. One South African study reported similar mortality rates of 33% [2], and another publication reported a mortality rate of 15.6% [3]. In comparison, a Brazilian study reported a low mortality rate of 10.3% [28]. Research that has included the pre-hospital data (field and mortuary data) clearly confirms that PCIs are indeed a lethal form of trauma that carries a high mortality rate. However, patients with isolated cardiac injury who survive until admission to the EC have higher survival rates [2, 13,17].

Vascular injuries carry higher mortality due to more rapid exsanguination, and can also pose a more complex challenge to repair for the surgeon at a district level hospital who may not have extensive surgical expertise or experience.

Clinical presentation and mortality is also influenced by the following factors [15,1617]:

- Mechanism and extent of the injury.
- Time interval between sustaining the injury and surgical control of bleeding.
- Presence of cardiac tamponade.
- Number of associated injuries.

The management of PCI is a challenging task and requires a diligent team approach. Early resuscitation and surgical intervention by an experienced practitioner, and good post-operative critical care can result in good outcomes. At KDH, patients who are hypotensive but stable are resuscitated and transferred to tertiary level facilities. Some patients decompensate while awaiting transfer to the tertiary level facilities. Patients who are

shocked and unstable with ongoing blood loss (intercostal chest drainage of blood >1500 ml and refractory hypotension despite ongoing resuscitation) are taken to a KDH theatre for immediate surgical exploration via thoracotomy or sternotomy.

#### **6.4. Predictors of mortality (48-Hours)**

##### **6.4.1. BP/Pulse**

Although 37 (66%) patients in this audit did present in shock (SBP<90mmhg), the regression analysis results showed that hypotension (< 90 mmHg) was not a predictor of mortality in our patient population (p=0.279) as 23 (65.7%) of 35-hypotensive patients survived.

Mortality rate was 6/16 (37.5%) among patients who arrived with non palpable pulse as compared to patients who had a palpable pulse but it was also not a predictor of death in our cohort with p= 0.181.

Arreola et al identified MAP < 50 mmHg to be associated with poor outcomes, but not as a predictor of mortality. SBP < 90 mmHg was not a predictor of poor outcome in their study [66]. A study by Rodrigues et al also found SBP<50 mmHg upon arrival at the hospital a predictor of outcome [60]. Asensio et al identified absence or presence of initial cardiac rhythm (sinus, ventricular fibrillation asystole) on arrival in EC or when the pericardium was opened as a strong predictor of outcome [12,16].

### **6.4.2.GCS**

Although the GCS of the patient is recorded on admission at KDH, it was not included as part of the study because a majority of the victims had confounding factors such as alcohol intoxication that affected the GCS. Asensio et al stated that GCS is dependent on hemodynamic stability and is not a reliable independent predictor of outcome [4]. However, some studies have identified GCS as a strong predictor of outcome [53,55]. Nine patients arrived unconscious (GCS<8) at KDH.

### **6.4.3.Lactate and BD as predictors**

#### **Lactate**

The highest recorded value of lactate on admission was 15 mmol/L and lowest was 0.7mmol/L, which represents a normal value. A one unit increase in lactate resulted in a 27% increase in mortality, and with a 4 unit increase, the mortality doubled, although not statistically significantly (p=0.06).

Initial levels of lactate and BD on admission have been correlated strongly with survival and injury severity, as Husain et al showed in a study of surgical ICU trauma patients [46]. Serum lactate can also be used to monitor the response to fluid resuscitation in a trauma patient [62].

Lactate clearance at 24 and 48 hours has also been validated to predict mortality in trauma patients, especially in penetrating chest trauma in adults and children. A South

African study also showed that improved lactate clearance within 48 hours post injury in penetrating trauma patients was associated with better survival as compared to the blunt trauma [61,62].

One study showed that higher lactate levels were more predictive of survival than BD and anion gap. There was a poor correlation between these variables in the prediction of survival, because of the small sample size. This ICU study examined the data from 52 trauma patients to determine whether BE or anion gap could predict lactate, but it found no correlation between lactate versus BE or anion gap versus BE [53].

In this audit, p-value of lactate was 0.06. The sample size was reduced to 38 patients because of the missing data. If the complete data set on ABG was available, the results regarding lactate, as a predictor of mortality, might have been statistically significant. If however, when evaluating immediate and intraoperative mortality, lactate may be significant independent predictor of mortality.

### **Base Deficit**

The highest recorded value of BD on admission was 7.2 mmol/L and the lowest was 24 mmol/L. The results of the regression analysis showed that with 1 mmol increase in BD, the likelihood of patient dying increased by a factor of 0.988 (p=0.83).

BD is also considered a useful surrogate for resuscitation as long as it is a result of hyperlactatemia in a trauma patient. This relationship becomes incongruous if a change in base deficit is due to saline overload or renal dysfunction and ketoacidosis. Absolute value

of BD as a surrogate for resuscitation in trauma care is not considered reliable by many clinicians [62]. A study by Mikulaschek et al showed that 33-58% resuscitation decisions would have been wrong if BD had been used as sole criteria rather than serum lactate [54]. As in the case of lactate clearance on admission, BD and time taken for normalization of these levels correlate well with transfusion requirements, coagulopathy, and risk of death and multi-organ failure. 70% of trauma patients with BD >6 mmol/L have been found to have higher transfusion requirements than patients with BD <6mmol/L [50,53,62].

Eachempati et al also found that high BD in first 24 hours, BP on admission, and estimated blood loss were predictors of mortality by univariate analysis, whilst BD was the only predictor by multivariate analysis [67]. Both serum lactate and BD are important end points of resuscitation that should be targeted early to guide and optimize the resuscitation of PCI patients.

## **6.5. Fluids**

The main aim in hypovolemic patient care is rapid and effective restoration of blood volume, improvement of oxygen delivery to the tissues and limiting the coagulopathy of trauma, while minimising the excessive use of crystalloids and colloids until the definite repair of the injury is achieved. Fluid resuscitation of trauma patients has always posed a dilemma for clinicians. Type of fluid, appropriate rate of fluid, and resuscitation remains controversial [30]. Aggressive fluid resuscitation (>40 ml/kg) not only dilutes the clotting factors but increases bleeding and mortality. Aggressive fluid therapy should be avoided until hemostasis has been secured [34].

Over the past decade, clinical practice has evolved in favor of “judicious fluid resuscitation” i.e. use of small fluid boluses (100-250 ml isotonic crystalloids) titrated to maintain SBP between 80 - 90 mmHg in trauma patients (until source control) and targeting lactate and BE as endpoints of resuscitation. Although fluid resuscitation is one of the corner stones of PCIs, very few studies on PCI mention the fluids or blood products administered to these patients.

The debate about which type and quantity thereof is still ongoing. Resuscitation fluid choices are not only influenced by local clinical practices but also by availability of resources. Limited resources and unavailability of blood products further aggravates the resuscitation challenge. Standard practice indicates that fluid should be tailored according to the patient’s physiological condition and injury severity. Not every trauma patient may require 2 liters fluid bolus. Jin-Mou et al (2004) mentioned the use of 1000 ml of preoperative resuscitative fluid for PCI patients [19]. Mean amount of fluids administered in our audit was 2481 ml, which is in 20% excess of recommended ATLS guidelines. At KDH crystalloid resuscitation is favored over colloid resuscitation for PCI patients. In cases of ongoing bleeding and unavailability of blood products ER clinicians have no choice but to use the colloids (6% Voluven® Fresenius Kabi) with crystalloids as well.

This audit was unable to show any correlation between BD, lactate and survival, due to the small sample size and missing data. Also, the audit was unable to establish the effect of fluid administered on shock, BD and lactate most probably due to the fact that we attempted to follow hypotensive resuscitation strategy in our ER. BD and lactate should be

targeted early in resuscitation and a patient with very high lactate and low base excess should be approached with different resuscitation strategy regarding early source control and resuscitation with blood products.

## **6.6. E-FAST (cardiac U/S)**

Cardiac U/S has currently become the most important tool for point-of-care evaluation of cardiothoracic trauma. It can be performed simultaneously in an unstable cardiac trauma patient during resuscitation and provides vital information regarding suspected tamponade and pericardial effusion. In the ER, E-FAST significantly decreases mortality in PCI patients [25]. It has a sensitivity of 83-100% to detect the cardiac injuries [8].

Rozycki et al in 1998 reported that U/S had a sensitivity and specificity of 100% and 99.7% for evaluation of PCI. Other studies also have demonstrated excellent positive and negative predictive values for this diagnostic tool [27]. Presence of hemothorax and pneumopericardium can limit screening sensitivity of U/S and can result in false negative result as demonstrated by Ball et al [68].

The results showed that cardiac U/S had a sensitivity of 87.1% and specificity of 90% with positive and negative predictive values of 96.43% and 69.23% respectively. Lower negative predictive value might have been influenced by non-documentation of hemopericardium in three patients by the surgeon.

In this audit, E-FAST examination was sensitive and specific in the determination of traumatic pericardial effusion effectively guiding emergent surgical decision-making

regarding FRT in seven patients who were peri arrest with no clinical signs of cardiac tamponade.

### **6.7. Pericardial Tamponade**

Studies that show high survival rates are supportive of pericardial tamponade as a determinant of survival in patients with PCI [14,15]. However, Asensio et al, in two large prospective studies (69 and 105 patients respectively), were unable to show these results. Asensio believes that “The truth lies in the middle.” [12,16] Pericardial tamponade limits the bleeding and prevents death by exsanguination, but the time frame of this protective effect is unknown (no data exists). Once this time frame is passed pericardial tamponade has deleterious effect on cardiac function resulting in bad outcome [4,16].

This audit found that presence of pericardial tamponade was associated with increased survival rate. In our study, 13 patients (23.2%) presented with clinical and U/S features of tamponade and 10 of them survived (76.9%). The author believes that pericardial tamponade may confer a protective effect against exsanguination to an unknown time period and patients presenting alive in tamponade should have immediate surgical intervention to salvage them. The author also believes that this time period is also proportional to the injury site, severity and the time frame over which the tamponade develops.

## 6.8. Front Room Thoracotomy

FRT or resuscitative thoracotomy is performed for PCI patients who present in cardiac tamponade and who are peri-arrest with signs of life on arrival. FRT carries a higher mortality (84% vs. 31%) when compared to thoracotomy performed in theatre, with an overall mortality that ranges from 4% - 33%. [4,69]. Despite being performed globally and in different trauma settings, it is still a controversial topic regarding its indications. Hunt et al (2006) stated

“The decision to proceed with FRT depends greatly on many local circumstances, including availability of and preparedness of correct surgical equipment and trained personnel, department policies and protocols, and the experience of the unit in carrying out such procedure.” [70]

They also stated that the availability of specialist personnel, and accessibility and proximity to appropriate operating facilities are important components to be considered [70].

FRT is performed at our center for PCI patients with the following indications:

- Peri-arrest with signs of life on arrival.
- In hospital cardiac arrest.
- Clinical signs of tamponade with echocardiographic evidence in a patient with signs of life.
- 

Some clinicians believe that hypotension (SBP<60 to 70 mmHg) that does not respond to fluid resuscitation in a PCI is also an indication to perform FRT [13]. However, not all the patients present with the clinical features of pericardial tamponade due to severe

hypovolemic shock. E-FAST is crucial to detect pericardial tamponade in these scenarios. E-FAST is a part of KDH PCI management protocol.

In this audit 10 (17.8%) patients underwent FRT. Two (20%) patients demised in the ER and eight (80%) survived to theatre. Four (40%) patients demised in theatre whilst four survived to ICU and were later discharged. The survival rate for FRT was 40% and mortality rate of 60%. These results confirm that FRT is associated with a high mortality.

The author agrees with Hunt et al that the outcomes of FRT are influenced by a number of factors mentioned above. With no trauma surgeon on call at night and a minimum travelling time to the hospital of between 30 to 45 minutes, our ER personnel have to proceed with FRT as a life-saving maneuver in patients who are peri-arrest and access to the operating theatre is unavailable, or the time delay in taking a patient to theatre will significantly increase chance of mortality.

At KDH, an Emergency Medicine registrar or a senior surgical house officer on call generally performs the FRT. In a South African health care setting with high prevalence of blood borne diseases like HIV and hepatitis, FRT also exposes health care providers to increased risk of these diseases.

FRT, despite being associated with high mortality and exposure risks, might be the only option to salvage the selected group of PCI patients who may not survive without it.

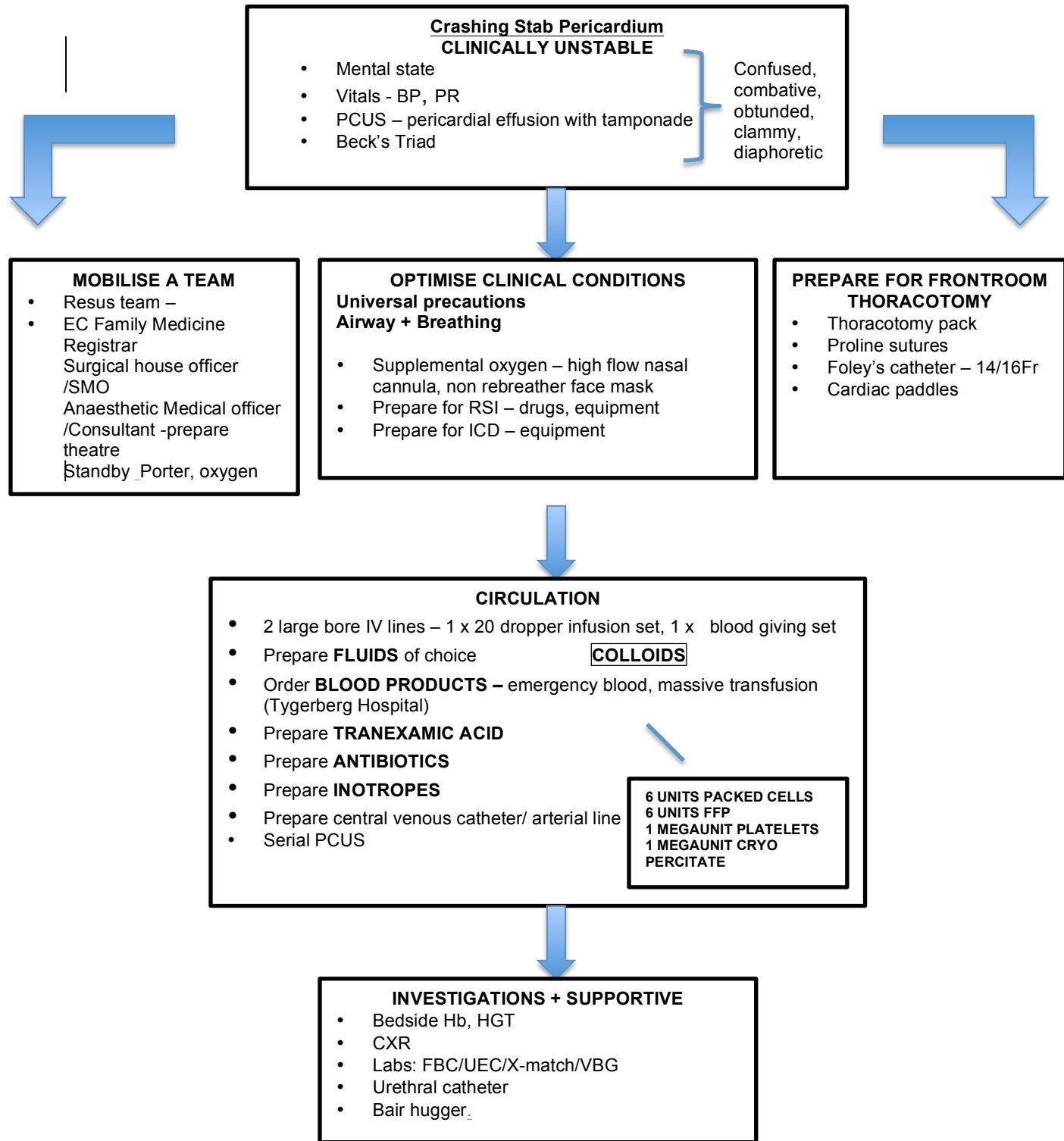
## **6.9. Intraoperative findings**

The incidence of isolated cardiac chamber injury was relatively high (58.9%), as compared to the 41.1% of vascular injuries. However, vascular injuries were associated with a higher mortality of 43%. As discussed by Velmahos et al, an isolated cardiac injury indeed is a relatively innocent injury in a hospital accustomed to manage them and carries a lower mortality rate [57].

### **Protocols**

At KDH, trauma patients are resuscitated according to ATLS guidelines and KDH has a protocol (as described below) for the management of penetrating cardiothoracic trauma patient. At district level hospitals, junior medical staff is often faced with difficult decisions. Often the management decisions of PCI patients are made when most of these patients present in the late evenings. In these cases, management protocols help junior staff to diagnose the injury and start appropriate resuscitation while waiting for a senior to assist or arrive. [3].

To follow a set resuscitation protocol for every patient presenting with PCI is often not possible, especially in the face of ongoing bleeding and rapidly deteriorating patient. The efficacy of management protocols should be audited regularly and protocols revised to match the latest trauma and resuscitation guidelines.



**Figure 13: Management protocol of PCI KDH (EC). Adapted from emergency medicine guidance for western cape, 2013 [71].**

## **6.10. Challenges**

Considerable challenges regarding data collection in ER at KDH were encountered during this audit, as data is not collected electronically. Patient details are entered manually in the ER records. The following challenges were faced during this audit:

- Multiple patient record books were missing in ER and were not organised.
- Data was missing from the patient notes e.g. blood gases.
- Clinical notes were incomplete and the doctors and nursing staff completed some notes retrospectively.
- There was discrepancy between doctor and nursing notes, regarding arrival times and other important information. Some folders contained notes from other patients.
- Important physiological parameters like GCS were not recorded in patient folders and the author was unable to utilise them as part of scoring system for patient risk stratification.

Although the author faced similar struggles regarding data collection in theatre and ICU, it was less challenging. Theatre books were more organised and with correct entries. However, some patients were operated at KDH, but the author could not find their record in ER books.

## **6.11. Blood Products**

Currently early institution of packed cells and component therapy is the main approach to prevent and correct coagulopathy in trauma patients with hemorrhagic shock (ATLS Guidelines). At KDH there is a significant delay of at least 3 - 4 hours in obtaining blood products from a tertiary level facility as there is no onsite blood bank. The ER and theatres

have a total of six units of packed cells each, shared with a busy obstetric unit. In a bleeding and exsanguinated trauma patient, this precious resource is exhausted quickly.

### **6.12. Postoperative transfer**

Transfer of these patients can take anywhere between 1 to 3 hours at KDH. A postoperative PCI patient on inotropes and awaiting further blood products to correct the coagulopathy of trauma is challenging for the staff. On occasions, there is no ICU bed available at the tertiary trauma centre for many hours, resulting in a blockage of the theatre at KDH hospital while other emergencies wait. At times, the tertiary level institutions also have ICU bed shortages forcing patients to remain ventilated longer at KDH and blocking the theatre.

## **Chapter 7: Conclusions and Recommendations**

### **7.1. Introduction**

This chapter summarises the major observations of the study. The limitations are also discussed. Conclusions are drawn and recommendations are made on the analysis of the data gathered by our study.

### **7.2 Conclusions**

It is well known that PCIs are a lethal form of trauma, and expeditious and timely resuscitation improves outcomes of these patients. KDH has a high incidence of penetrating cardiothoracic injuries. It is important for anesthesiologists to be at fore front in formulating and implementing resuscitation protocols not only in theatre but also in the EC. One of the objectives of this audit was to identify risk factors that may influence mortality in the cohort, and that could guide EC clinicians to prioritize and optimise the resuscitation of PCI patients. Additionally, EC clinicians would be able to better identify unsalvageable patients early, and better utilize the health resources (blood products) at KDH. While this audit examined factors such as BP on arrival, palpable pulse, injury location, pericardial tamponade, BD and lactate for their possible link with increased likelihood of mortality in the cohort, it was not possible to establish any significant association between them.

Although these results were not statistically significant (possibly due to missed data and a small sample size), the author believes that physiological and clinical parameters described in the audit and literature have a role for predicting outcomes and perioperative complications and assist medical personal in clinical decisions making. These factors have

been validated in literature as predictors of outcome. Numerous studies comparing the endpoints of resuscitation as predictors of survival have failed to show clear benefit of one over the other. Early involvement of anesthesiologists during resuscitation and prompt surgical intervention is vital to achieve favorable outcomes in any clinical setting. According to Mansour et al [63], it is difficult to evaluate the results of cardiac injuries because several factors affect the survival and mortality:

- There is no gold standard when it comes to outcome prediction in patients with PCI.
- Some factors have proven to be more superior to others as predictors of outcome.
- Outcomes in patients with PCI will always be influenced by the setting/system in which they occur.
- Further prospective studies with higher number of patients and pre-hospital data are required at KDH.
- Mechanism of injury and period from sustaining the injury until definitive medical care might be the most important factors that influence the outcomes rather than physiologic parameters.
- Patients presenting alive with worse ABG parameters e.g. pH, BE and lactate, should be resuscitated not only with blood products promptly but also with early surgical intervention.

### **7.3.Limitations**

- Retrospective study
- Pre-hospital variables were not included in the study.
- Missing data. Only 38 (66%) patients had the ABG available. This resulted in a further reduction of the study sample and impacted negatively on the evaluation of BE and lactate as predictors.

### **7.4. Recommendations**

- KDH needs an organised electronic data capturing system for the PCI patients. The Trauma team needs to maintain a PCI registry. A dedicated clerk or medical personnel would be ideal. The checklist designed for data collection of this audit can be modified and used to collect the data for PCI patients in the future.
- Nursing staff working in EC should have an awareness of the importance of good record keeping, as it is vital and can help in future studies. This should be emphasised or communicated regularly to the doctors and nurses working in ER, as many are non-permanent staff or working as locums at KDH.
- Regular auditing of the patients folder should be carried out in order to ensure good record keeping. Regular morbidity and mortality meetings should be conducted to improve emergency care and resuscitation protocols of trauma patients at KDH.
- For further research purposes, it would be beneficial to create a local and National Trauma Data Bank for PCIs, as South Africa has a high incidence of these injuries and can aid in valuable research in this field.

- An onsite blood bank at KDH or at another nearby district level hospital would be beneficial in acquiring blood products for timely resuscitation of PCI patients and could reduce transportation costs currently incurred by the hospital drivers.
- Education of doctors and nurses with regard to management and resuscitation of PCI patient should be a special focus in the emergency unit. It should be mandatory for the doctors/surgeon managing these patients in EC to have formal surgical training to perform a thoracotomy or a sternotomy. ATLS and ACLS courses should be mandatory as part of training of doctors and nurses working in EC.
- There should be regular teaching and training session by the specialists (visiting consultant surgeon) from level one-trauma centres at district level hospitals.
- Resuscitative fluids administered in preoperative phase needs to be limited and titrated according to every patient's physiological and ABG parameters. Resuscitation should be goal directed by targeting the end points mentioned in this audit.
- KDH would benefit from appointment of a consultant surgeon. Numerous factors described in literature influence the outcome of PCI patients. The appointment of a specialist trauma surgeon at KDH would not only help improve survival rates of PCI patients with complex/vascular injuries at KDH, but also be instrumental in surgical training and up skilling of junior doctors.
- KDH would benefit from a high-care unit for un-complicated PCI patients who only require a few hours of post-operative ventilation post transfer in ICU at tertiary hospital (cost-effectiveness need to be considered). Many such patients

are referred back to KDH within 24 to 48 hours of transfer, in a stable condition for further post-operative care.

- In my role as an anaesthetist working at a hospital with high number of penetrating cardiothoracic trauma, I deal with the resuscitation of these patients presenting with haemorrhagic shock on a fairly regular basis. I firmly believe that South Africa has high number of PCI as compared to some parts of the world and that our PCI statistics are under reported. PCIs often present in otherwise young healthy males, so it is important that these patients receive optimal care for a better outcome. This clinical audit was very important.

This clinical audit is the first of its kind conducted at KDH and also my first research project, a very exciting topic but challenging to execute. There was no existing framework for such research at KDH. Support from supervisors was instrumental. Although there are fewer ethical implications in conducting retrospective research, many variables influence the process at different levels. I found that proper planning was the most important variable to save time. Retrieving patient data was incredibly challenging and time consuming. It involved data collection at three different hospitals. I collected the data on my own, which was extremely tiring and frustrating especially at tertiary level hospitals. Incomplete and undocumented results, especially ABG in the folders, negatively impacted the audit outcomes. Although this audit did not produced statistically significant results, i am pleased that this audit will provide some framework for future research on PCI at KDH and also help improve resuscitation and management strategies regarding PCI patients.

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## **Annexures**



UNIVERSITY OF CAPE TOWN  
Faculty of Health Sciences  
Human Research Ethics Committee



Room E52-24 Old Main Building  
Groote Schuur Hospital  
Observatory 7925  
Telephone [021] 406 6338 • Facsimile [021] 406 6411  
Email: [sumayah.ariefdien@uct.ac.za](mailto:sumayah.ariefdien@uct.ac.za)  
Website: [www.health.uct.ac.za/fhs/research/humanethics/forms](http://www.health.uct.ac.za/fhs/research/humanethics/forms)

29 June 2015

**HREC REF: 349/2015**

**Dr M Miller**  
Anaesthesia  
Ward-D-23  
NGSH

Dear Dr Miller

**PROJECT TITLE: A RETROSPECTIVE CASE AUDIT ON OUTCOMES IN PENETRATING CARDIAC INJURIES AT A DISTRICT LEVEL HOSPITAL (MMed-candidate-Dr S Hameed-Ikram)**

Thank you for your response letter dated 24 June 2015, addressing the issues raised by the Human research Ethics Committee (HREC).

It is a pleasure to inform you that the HREC has formally approved the above-mentioned study.

**Approval is granted for one year until the 30th June 2016.**

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.

(Forms can be found on our website: [www.health.uct.ac.za/fhs/research/humanethics/forms](http://www.health.uct.ac.za/fhs/research/humanethics/forms))

Please quote the HREC reference no in all your correspondence.

***We acknowledge that the following student:- Dr Hameed-Ikram is also involved in this project.***

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Yours sincerely

**PROFESSOR M BLOCKMAN**  
**CHAIRPERSON, FHS HUMAN ETHICS**

Federal Wide Assurance Number: FWA00001637.  
Institutional Review Board (IRB) number: IRB00001938

Hrec/ref:349/2015



Western Cape  
Government

Health

TYGERBERG HOSPITAL  
REFERENCE: **Research Projects**  
ENQUIRIES: **Dr GG Marinus**  
TELEPHONE: **021 938 6267**

Ethics Reference: **HREC REF: 349/2015**

**TITLE:** A Retrospective case audit on outcomes in penetrating cardiac injuries at a District Level Hospital. (MMed-candidate-Dr S Hameed Ikram)

Dear Dr M Miller

**PERMISSION TO CONDUCT YOUR RESEARCH AT TYGERBERG HOSPITAL.**

In accordance with the Provincial Research Policy and Tygerberg Hospital Notice No 40/2009, permission is hereby granted for you to conduct the above-mentioned research here at Tygerberg Hospital.

**DR D ERASMUS**  
**CHIEF EXECUTIVE OFFICE**

**Date:** 9 September 2015

Administration Building, Francie van Zijl Avenue, Parow, 7500  
tel: +27 21 938-6267 fax: +27 21 938-4890

Private Bag X3, Tygerberg, 7505  
[www.capegateway.gov.za](http://www.capegateway.gov.za)



Western Cape  
Government  
Health

Cell: 084 297 0169

Email: rosie@polka.co.za



Khayelitsha Hospital

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28 November 2016

To whom it may concern:

The following research study was approved by the Khayelitsha Hospital Research Committee on 10 September 2015:

A retrospective case audit on outcomes in penetrating cardiac injuries at a district hospital in Cape Town, South Africa.

Dr Sarwat Hameed-Ikram, Department of Anaesthetics, Khayelitsha Hospital

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yours sincerely,

Dr Rosie Burton

Infectious Diseases Specialist and Physician

Former Chairperson of Research Committee

Corner Walter Sisulu and Steve Biko, Khayelitsha  
Tel: +27 21 360 4419  
Liesel.Rossouw@pgwc.gov.za

## Audit Check List

<b>Patient surname &amp; initials</b>			
<b>Folder No</b>			
<b>Age</b>			
<b>Sex</b>			
<b>Date &amp; time of arrival/ Mode of Transport</b>			
<b>PHYSIOLOGICAL PARAMETERS ON ARRIVAL</b>			
BP SYSTOLIC >90mmHg			
<90mmHg			
Pulse: Palpable/ non Palpable			
GCS			
RR			
Spontaneous ventilation/intubation			
<b>FRT and Outcome</b>			
<b>ABG parameters (EMERGENCY UNIT)</b>	<b>ABG: 1</b>	<b>ABG: 2</b>	<b>ABG: 3</b>
Time			
PH/Pao2/Pco2			
Lactate			
SHCO3			
BE			
Hb			

<b>RESUSCITATION fluid (Type and amount)</b>			
CRYSTALLOIDS			
COLLOIDS			
<b>BLOOD RODUCTS</b>			
Packed cells			
Platelets			
Platelets			
<b>TYPE OF INJURY</b>			
Stab wound			
GSW			
Associated injuries			
<b>Cardiac US and findings (E-FAST)</b>			
<b>THEATRE DATA</b>			
Date and time of arrival			
Type and time of General Anesthesia			
Time of surgery			

<b>Surgical Findings:</b>			
Cardiac chamber involved			
Vascular Injury			
Associated Injuries			
<b>FLUIDS (type and Quantity)</b>			
Crystalloids			
Colloids			
Blood products			
Packed Cells			
Platelets			
FFP's/ Cryoprecipitate			
Complications in theatre.			
Time and Location of Transfer			
<b>ABG PARAMETERS (Theatre)</b>			
Time			
PH/Pao2/Pco2			
Lactate			
SHCO3			
BE			
Hb			
<b>TERTIARY LEVEL (ICU) PARAMETERS</b>			
Hospital Transferred			
Date &time of Arrival			
Ventilated (yes/No)			
Duration			
Extubation (Date/ time)			
Surgical Intervention			
<b>ICU FLUIDS</b>			
Crystalloids			

Colloids			
Blood PRPDUCTS			
PRE and post transfusion Hb			
ABG Parameters (ICU)			
Time			
PH/Paco2/Paco2			
Lactate			
SHCO3			
BE			
Hb			
Complications in ICU			
Outcome: Died			
Survived			
No of days in ICU			