

# **CHAPTER 1**

## **INTRODUCTION**

### **1.1 Background**

Chest trauma is a common presentation in the Emergency Department (ED). The United States of America statistics (USA) show that approximately 12 persons per 100 000 of the population per day experience chest injuries (1). About a third of chest trauma patients who present to the ED require hospital admission (1). Chest trauma accounts for 25% of all trauma deaths (1). Published international figures are that less than 10% of blunt chest trauma patients and up to 15 to 30% of penetrating chest trauma patients require surgical intervention by performing a thoracotomy (1, 2, 3). Those figures seem high according to local experience. The majority of chest trauma patients, just as any other trauma patient, is successfully treated in the ED by oxygen supplementation, ventilatory and circulatory support, and the insertion of an intercostal drain (ICD) when indicated (1, 2, 3). ICD insertion is therefore a necessary life-saving skill for all ED personnel (2, 4).

First described for the drainage of an empyema in 1876 by both Hewett in England and Bulau in Germany, the ICD consists of an intercostal tube and a drainage system (5, 6). The latter requires an underwater seal which acts as a one-way valve (7). Alternatively, a drainage bag which contains a flutter valve can be used as a drainage system (6). Both the underwater seal and the flutter

valve allow both air and fluid to drain out whilst simultaneously preventing the suction of air back into the pleural cavity (5). Emergency ICD insertion was not commonly performed until during the Korean War (5). By the time of the Vietnam War, however, ICD insertion had become standard procedure for the treatment of chest trauma (8).

The indications for emergency trauma related ICD insertion include the presence of a haemothorax and/or a pneumothorax (9, 10). In the case of a haemothorax, the ICD helps to quantitate the blood loss from the chest and therefore identifies patients who need a thoracotomy, in addition to evacuating blood. Thoracotomy is indicated if, (a) the blood drainage exceeds 1.5 to 2 litres on the initial insertion of the ICD or, (b) blood drainage exceeding 200 to 300 millilitres per hour for 2 to 4 hours combined with the persistent need for blood transfusions (4, 9).

However, a pneumothorax is the most common indication for ICD insertion (10). It is present in up to 41% of all chest injuries, in approximately 20% of blunt chest injuries and 21% of polytrauma patients who have chest injuries (10). In the case of a pneumothorax, the ICD is inserted, (a) if the pneumothorax is more than 2 cm wide on the chest X-ray (XR) (the distance between the thoracic wall and the collapsed lung on an anteroposterior view), (b) in the presence of a tension pneumothorax and, (c) for any pneumothorax in a patient undergoing positive pressure ventilation irrespective of its size (11).

Although commonly inserted in the 4<sup>th</sup> or 5<sup>th</sup> intercostal space just anterior to the mid-axillary line (lateral approach), the ICD can also be inserted in the second intercostal space in the midclavicular line (ventral approach) (4, 10). When the two approaches were compared to each other for the drainage of a pneumothorax, they were equally acceptable (10). The complication rates were 6.3% and 4.5% respectively. However, that was not the case for the drainage of a haemothorax where the ventral approach was ineffective (10). All the recorded complications from this study were from ICDs which were malpositioned.

Just as any other surgical procedure, the ICD should be inserted under sterile conditions. Both the Advanced Trauma Life Support (ATLS <sup>TM</sup>) manual for doctors (4) and the British Thoracic Society guidelines for the insertion of a chest drain (12) advocate the following interventions when inserting the ICD:

- a. The 4<sup>th</sup> or 5<sup>th</sup> intercostal space is chosen in order to avoid injuring the diaphragm and abdominal viscera. The diaphragm may rise to the 4<sup>th</sup> right intercostal space during expiration (1, 4, 12).
- b. The ICD should be inserted just above the rib which is situated below the chosen intercostal space. That is done in order to avoid injury to the neurovascular bundle which lies in the groove situated just below the rib (4).
- c. The use of a trocar is discouraged as its use is associated with intrathoracic visceral injury. A trocar is a sharp non-flexible metal rod

- which usually comes fitted in the hollow of a chest tube. The safe procedure involves blunt dissection using an artery forceps or a vascular clamp once the skin has been incised. That is advocated in order to avoid perforation of both thoracic and abdominal viscera (1, 4, 5).
- d. Once a thoracostomy is done by piercing the parietal pleura bluntly with the tip of a clamp, a 'finger sweep maneuver' is done. The technique involves the insertion of a finger through the thoracostomy incision in order to separate possible adhesions between the visceral and parietal pleura.
  - e. After the insertion of an appropriately sized clamped intercostal tube into the pleural cavity, the tube is secured to the skin with a non-absorbable suture and connected to an underwater drainage system.
  - f. A correctly positioned ICD should 'fog' when the warm air which is escaping from the pleural cavity condenses on the cold tube and the water level in the drainage system should swing with respiration (1, 4). In the case of a pneumothorax, 'bubbling' is observed in the underwater drainage system.
  - g. Although the ICD position is routinely confirmed by a post-insertion chest radiograph (XR), studies show that a chest computerized tomography scan (CT) defines the ICD position better than the chest XR (1, 3). The above-mentioned clinical criteria and the post-insertion chest XR suffice for the majority of South African hospitals which do not have a CT scan. The latter is currently not routine even when it is available due to high costs.

Although emergency ICD insertion is a relatively straight-forward procedure which is commonly performed in the ED, it is associated with many complications (13, 14). Complications are discussed in detail in Chapter 2 (Literature review).

## 1.2 Purpose

The purpose of this study was to improve the local body of knowledge around the insertion of intercostal drains in order to improve future practices.

## 1.3 Aim

The aim of this study was to study trauma intercostal drains at Tembisa Hospital from January 2008 to January 2010.

## 1.4 Objectives

The objectives were:

- (a) To determine the demographics of trauma ICD patients.
- (b) To determine if trauma ICD insertion is associated with complications.

Complications are defined in Chapter 2 according to the literature standards (8).

- (c) To compare those complications reported at Tembisa Hospital with the trauma ICD complications reported in Tygerberg Hospital (15).
- (d) To determine if the following variables are risk factors for developing the above-mentioned trauma ICD complications at Tembisa Hospital:

- (i) The mechanism of injury (blunt versus penetrating trauma).
- (ii) The indication for trauma ICD insertion (pneumothorax, haemothorax and haemopneumothorax).
- (iii) The time of day when the ICD was inserted (day versus night).
- (iv) The surgical team which inserted the ICD. There were 3 surgical teams which inserted ICDs during the study (teams 1, 2 and 3). They were comprised of a surgical intern and a surgical medical officer who were on call on those days.
- (v) The ICD duration.
- (vi) The length of hospital stay.
- (vii) The age of the patient.

### 1.5 The structure of the report

The subsequent chapters 2 to 7 consist of the literature review, methodology, results, discussion, conclusion and references respectively. Appendices are attached to the end of the report.

### 1.6 Summary

This chapter discussed the background information on the indications for trauma ICD insertion, the recommended safe technique of ICD insertion, the purpose, aim and objectives of the study.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### 2.0 Introduction

This chapter reviews the literature under the following topics: 2.1.1 trauma ICD indications, 2.1.2 the controversy of using a trocar, 2.1.3 ICD drainage systems, 2.1.4 the use of prophylactic antibiotics, 2.1.5 the fixation of the ICD to the skin, 2.1.6 ICD complications and, 2.1.7 who should insert the ICD.

#### 2.1 Literature review

##### 2.1.1 Trauma ICD indications

A pneumothorax width greater than 2 centimeters (cm) between the lung margin and the thoracic wall and a haemothorax extending over the 7<sup>th</sup> rib following chest trauma require the insertion of an ICD according to the British Thoracic Society (BTS) (16). On the other hand, the American College of Chest Physicians uses the 3cm limit for the pneumothorax which requires an ICD (17). One and 2cm width on the chest XR are estimated to correspond to approximately 25 and 50% of the volume of the hemithorax (16).

Although a symptomatic spontaneous pneumothorax (no obvious underlying lung pathology) can be successfully treated with needle aspiration, the role of that treatment modality in traumatic pneumothorax is not clear. Needle aspiration and ICD insertion were found to be equally effective in terms of immediate and 1 year

success rates for a spontaneous pneumothorax (17, 18, 19). If left untreated, the air in a pneumothorax would be absorbed at a rate of 1.25 to 1.8% per day (17). Thus small asymptomatic pneumothoraces do not require any medical intervention. It was however not clear how long the needle can be left in the chest before it can be safely removed in order to prevent a recurrence of the pneumothorax.

Fifty two to 63% of all trauma (20) and 80% of penetrating chest trauma (21) pneumothoraces are occult (not detectable) on the supine chest XR because the air lies anterior to the lung parenchyma (20). An erect chest XR reduces that figure to 8% because the air moves upwards and makes its detection easier (21). Alternatively, the pneumothorax can be detected on a CT scan (21). The former option is not feasible on patients who have a suspected cervical spine fracture who need to be immobilized. The latter strategy of chest CT scan has the added disadvantage in that the unstable patient needs to be moved from the ED to the XR department. An alternative strategy is an oblique supine chest XR. The XR beam, rather than the patient, can be positioned at an oblique angle in order to avoid moving a patient who has a suspected cervical spine fracture (20).

A haemothorax is found in a third of all chest trauma patients (22). Two hundred milliliters (ml) of blood obliterates the costophrenic angle while 500ml obscures the meniscus of the ipsilateral diaphragm on an erect chest XR (22). Its presence is suggested by a deep costophrenic angle ('sulcus' sign) and/or an ipsilateral

double lung-diaphragm interface ('double diaphragm' sign) on a supine chest XR (23). Blood loss of more than 300ml per hour (hr) in the first 3 hours and haemodynamic instability are indications for an emergency thoracotomy (16, 23). The haemothorax blood is unsuitable for auto-transfusion because of its low platelet, low fibrinogen and low haemoglobin (Hb) levels (24). A single unit of banked whole blood (+- 330ml) was found to be equivalent to 726ml of haemothorax blood in terms of the Hb content. However, that study was done on haemothorax blood that had been collected 4 hours earlier. The suggestion was that direct infusion of haemothorax blood may be useful for autotransfusion when banked whole blood is not available. Further studies are required to compare the quality of banked whole blood versus haemothorax blood, e.g. the oxygen carrying capacity (24).

The ICD can be safely removed when (a) the bubbling has stopped and the lung has expanded on the chest XR, (b) it drains less than 200ml/day and the patient is clinically stable. It can be removed at the end of either full inspiration (Valsalva manoeuvre) or expiration. Both methods are equally effective (25).

#### 2.1.2 Use of a trocar

ICD insertion can be done by either blunt dissection using an artery forceps/clamp or by the use of a trocar (8). The latter technique is controversial because it is associated with malpositioned ICDs (lying in the incorrect position) and insertional complications (8). Malpositioned ICDs are regarded by most

studies as a complication and will be regarded as such in this research project as well to maintain consistency with analysis (1, 8, 13, 14).

The surface marking of the transverse fissure of the lung extends from the 2<sup>nd</sup> thoracic vertebral body postero-superiorly to the 6<sup>th</sup> costal cartilage antero-inferiorly (8). The fissure is situated in close proximity to the ICD insertion site, hence the occurrence of intra-fissural and intra-parenchymal malpositioned ICDs when a trocar is used. A modified technique has been described where following blunt dissection into the pleural cavity and finger exploration, the chest tube is introduced into the pleural cavity with the use of a trocar and is directed towards the apex of the lung along the posterior chest wall. There were no malpositioned ICDs for the modified technique versus 25% for the blunt technique (26). However, ATLS<sup>TM</sup> guidelines on the technique of ICD insertion do not recommend the use of a trocar (4).

The use of a trocar is also associated with insertional complications (8), resulting in the perforation of thoracic viscera like the lung and the heart (27), especially in patients who have an anatomical abnormality. These patients include those who suffer from chronic obstructive pulmonary disease (28), are ventilated on high positive end expiratory pressure (29), and who have dilated cardiomyopathy (30). For these reasons a trocar should not be used (31).

### 2.1.3 ICD drainage systems

Once the chest tube has been inserted into the pleural cavity, it should be connected to a drainage system in order to collect the effluent and prevent air from leaking back to the pleural cavity. Drainage systems include either an under-water system or a plastic bag which is fitted with a flutter valve at its end. Both systems are equally effective in terms of the length of hospital stay (32), drainage volumes and need for suction (33).

Patients who had a bag and flutter valve mobilized 23 hours earlier compared to those who had an underwater drainage system (33). The disadvantages of the under-water drainage system are that it is bulky, it has to be kept upright in order to prevent water from spilling out and, it is suitable only for in-patients. The bag and flutter valve device is convenient for ambulatory patients and does not require clamping (33).

#### 2.1.4 Use of prophylactic antibiotics

Empyema complicated about 2% of all trauma ICDs (2, 3, 13). That figure can be as high as 25% (34). Some studies intentionally excluded infective complications (15) while others had none at all (35).

The use of prophylactic antibiotics prior to ICD insertion is not standard practice. Current ATLS<sup>TM</sup> guidelines do not recommend routine prophylactic antibiotic use before ICD insertion (4). It was not always clear from the literature whether prophylactic antibiotics were administered in other studies, as there was no

indication in their 'materials and method' sections whether antibiotics were given or not (36). In other instances the clinical setting made the administration of prophylactic antibiotics unnecessary. An example was the seriously ill Intensive Care Unit patient population which had already been started on parenteral antibiotics for other medical reasons and, therefore, made additional antibiotic administration redundant (37). *Staphylococcus aureus*, which is the most commonly isolated organism in thoracic empyema, is sensitive to cephalosporins (38).

There are several reasons why the use of prophylactic antibiotics in preventing infective complications following trauma ICD insertion is currently a controversial topic due to research results reported from small sample size studies. When meta-analysis was applied by the Eastern Association for the Surgery of Trauma (EAST) analysis of ICD insertions and the use of antibiotics, prophylactic antibiotics were found not to be useful in reducing the incidence of post-ICD empyema in trauma patients (38). In the contrary, a recent meta-analysis based on five previous randomized control trials demonstrated the usefulness of prophylactic antibiotics (39). When compared to placebo, cephalosporin use reduced the frequency of empyema and pneumonia from 7.6% and 16% to 1.1% and 6.6% respectively (39). However, that benefit seemed to be limited to the first 24 hours after which period the presence of a retained or undrained haemothorax was the determining factor for developing empyema (34). The reduction in pneumonia rate was not conclusively established because factors

other than chest trauma, e.g. ICU admission and endotracheal intubation contributed to its development (39).

Secondly, it has been argued that the term prophylactic antibiotic regarding ICD insertion following penetrating trauma is a misnomer because antibiotics are given after the initial assault which gave rise to the indication for the ICD insertion (38). Except for the non-trauma ICDs, it is impossible to give the antibiotic cover before the penetrating trauma.

Thirdly, recommendations for prophylactic antibiotic use should also take into consideration the length of hospital stay and total hospital costs in addition to a reduction in morbidity and mortality (34). The overall benefit should reduce the costs in addition to preventing infective complications. Therefore, even if the use of prophylactic antibiotics were proven to be beneficial, they should be given only to the subset of patients who are at high risk of developing empyema rather than be administered routinely to all patients requiring ICD insertion (34).

Several factors have been shown to increase the risk of developing infective complications, including: the duration of ICD stay, the length of ICU stay, the presence of a lung contusion, a retained haemothorax, penetrating trauma, the presence of associated injuries e.g. fractured ribs, and the performance of an emergency laparotomy for an associated injury (34).

Several potential sources were postulated to lead to pleural cavity contamination and therefore empyema development, including, (a) iatrogenic, (b) the penetrating trauma itself, (c) the abdomen in cases of thoraco-abdominal injuries where there was a perforated diaphragm, (d) the secondary infection of a retained haemothorax, (e) haematogenous and/ or lymphatic spread and finally, (f) parapneumonic spread from pneumonia, a lung contusion or Acute Respiratory Distress Syndrome (34, 38).

The diagnosis of empyema should be based on, (a) the observation of a grossly purulent ICD discharge, (b) microscopy and/ or culture and (c) biochemistry (Lactate Dehydrogenase > 1000 International Units /liter and glucose < 40milligrams/deciliter) (34). It is however not clear how many of those criteria are necessary in order to make the diagnosis of thoracic empyema.

#### 2.1.5 Fixation of the ICD to the skin

In general, a “loose” ICD is an uncommon but a well-documented complication in the literature. Some studies did not have this seemingly preventable complication at all (37), while others reported only 3 to 4% of their trauma ICDs having a ‘loose fixation” to the chest wall (36). ICD dislodgement was a common problem in a United Kingdom study (2). The same applied to the Tygerberg Hospital study where the ICD was not securely sutured to the chest wall in 12.5% of their complications (15).

The ATLS™ manual does not emphasize or give details on how the ICD should be secured to the skin (4). It is left to the discretion of the treating doctor. This is surprising because accidental removal of the drain has been documented to lead to severe surgical emphysema, culminating in upper airway obstruction (40, 41). Several techniques of securing the ICD to the chest wall have been described in the literature. Four techniques of ICD fixation to the chest wall are briefly described below.

#### Method 1:

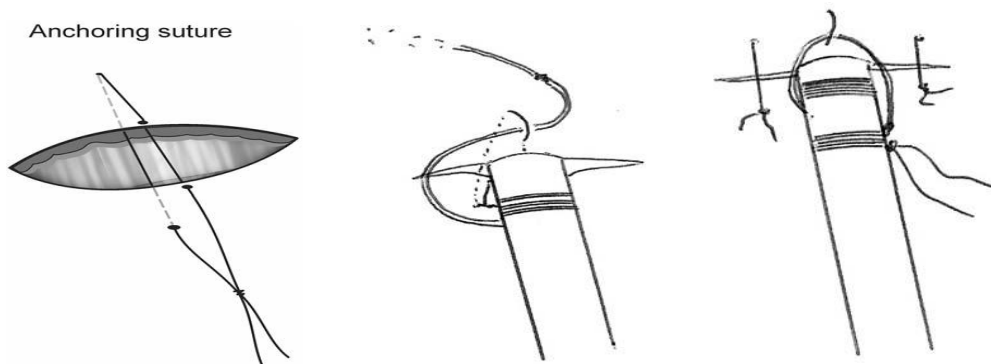


Fig. 2.1 Method 1 of securing an intercostal drain (42).

After administration of local anesthetic and draping the chest, a transverse incision is made in the fifth intercostal space just anterior to the mid-axillary line through the skin and subcutaneous tissue. This is done in such a way that the intercostal space is entered just above the located rib and not below any other. A skin flap is thus created. A nylon type thread, size 0 or 1 mattress type suture is inserted into the middle of the incision before the ICD is inserted in order to avoid damage to the plastic ICD tube. The suture is usually inserted from inferior to

superior. The mattress type suture should penetrate the incision wound margin on its return. Thereafter, the wound margins are approximated by tying the first knot. The free ends of the suture are then wound around the intercostal tube at the level of the skin. A second knot is tied at approximately 15cm from the first knot with the remainder passed under the first knot on the skin. The distal free ends of the nylon suture are then tied around the intercostal tube. The aim is that any traction on the tube will further tighten the knots. Other mattress sutures are inserted on either side of the intercostal tube if necessary. For removal, the nylon suture is cut just proximal to the second knot and the tube is pulled out. The first suture can then be tightened on the skin and extra knots are applied (42).

#### Method 2:

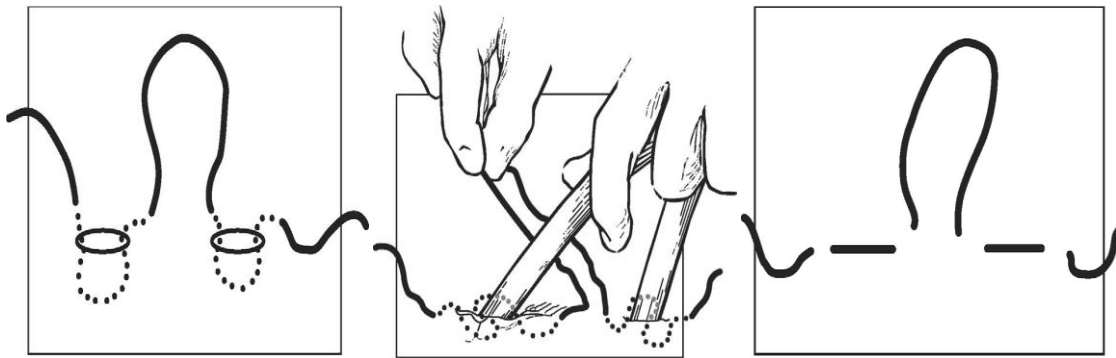


Fig. 2.2 Method 2 of securing an intercostal drain (43).

This technique requires the insertion of a Vicryl type, size 2-0 subcutaneous suture before the insertion of the intercostal tube. It is not necessary to tie off the free ends of the suture in this method. The ICD is then secured to the skin with a different silk size 2 - 0 suture. At the time of removal, the silk suture is cut and the

subcutaneous Vicryl suture is pulled at one end without tying it in order to approximate the wound margins. The wound can then be covered with Vaseline gauze and an adhesive tape. The Vicryl suture is removed a week later. The cosmetic results are reputed to be good. That technique is recommended especially for 2 ICDs inserted next to each other (43).

### Method 3:

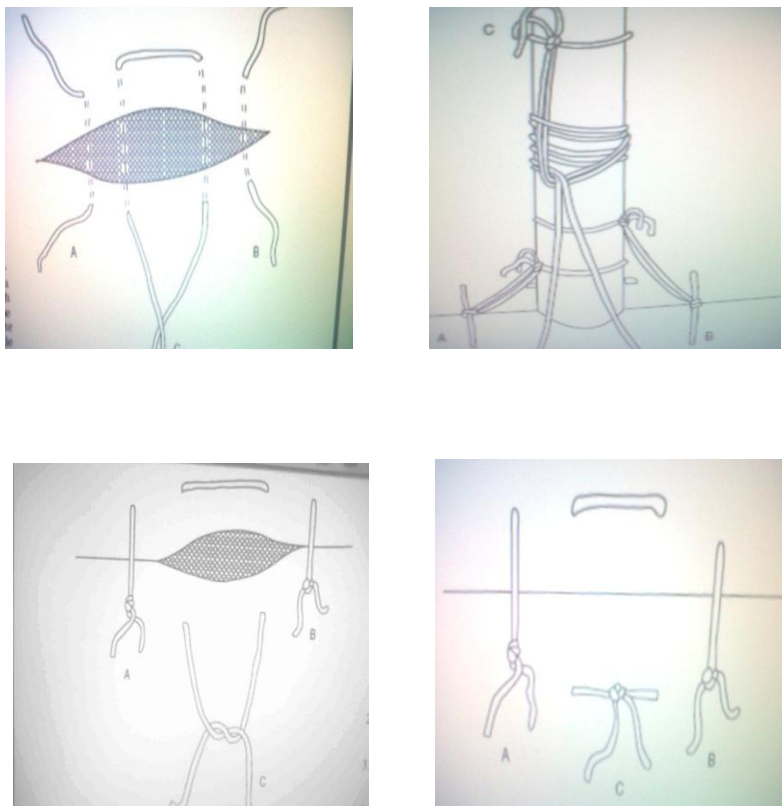


Fig. 2.3 Method 3 of securing an intercostal drain (44).

This technique involves inserting 2 simple sutures, 1 on either side of a horizontal mattress type suture which is placed in the middle of the incision. After intercostal

tube insertion, the 2 sutures are tied to approximate the skin margins. The free ends are tied around the ICD tube to secure it. The free ends of the mattress suture are wrapped several times around the intercostal tube above the knots of the lateral sutures, and then passed below the loop of the mattress suture before being tied to the intercostal tube. At the time of removal, the side sutures are cut above the knots on the skin while the middle mattress suture is cut below the knot. A new knot is tied after tube removal (44).

#### Method 4:

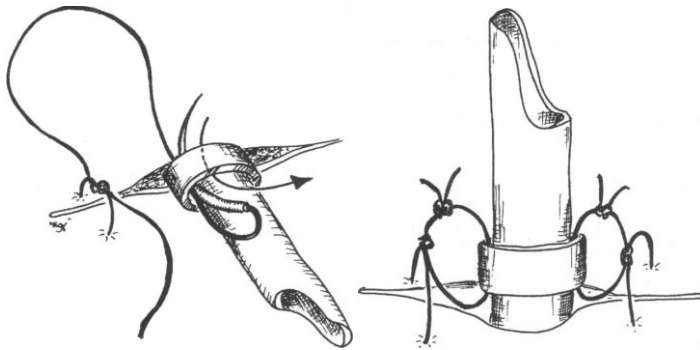


Fig. 2.4 Method 4 of securing an intercostal drain (45).

The method used at Tygerberg hospital involves the use of a plastic cuff around the intercostal tube. A 1cm cylinder is cut from the end of the tube which connects the intercostal tube to the under-water drainage system. That cylinder is placed around the chest tube after iodine lubrication. The tube is inserted in such a way that the cylinder lies on the skin just above the incision. Two mattress type sutures are placed on either side of the intercostal tube. After tying the knot,

the blunt end of the needle is passed under the cylinder away from the chest wall and a knot is made by using the free ends of the mattress suture. The procedure is done on each side of the tube. At the time of removal, the sutures are cut at the plastic cylinder, the drain is pulled out and a mattress suture is applied to approximate the skin margins (45). This procedure can be modified by pulling the chest tube to one end of the incision before securing it with sutures (46).

There is no evidence that any one of the methods of securing the chest drain described above is superior to any other. It has been suggested that the most common reason for the drain to slip out is an inadequate tissue bite using a suture of inadequate tensile strength rather than a poor knot and a specific anchoring technique (46).

#### 2.1.6 ICD complications

ICD insertion has complications just as any other surgical procedure.

Complications are traditionally categorized into 3 groups namely insertional, positional and infectious (2, 15).

Insertional complications (relating to the technique of insertion) include injury to the intercostal vessels, thoracic and abdominal organs, resulting in bleeding and re-expansion pulmonary oedema (47). A malpositioned ICD (in the incorrect place) may either be intrathoracic or extrathoracic. Ideally, the drain should be in the postero-superior position of the pleural cavity (48). The following positions,

which are defined by a CT scan, are regarded as complications: (a) intra-fissural (between the lung lobes, of which there are 2 on the left and 3 on the right), (b) intra-parenchymal (within the lung tissue), (c) extrathoracic (outside the pleural cavity in the subcutaneous tissue) and, (d) mediastinal and angulation (kinked ICD) (8). ICD malpositions occur in up to 30% of ICDs which are inserted in critically ill patients (49) of which 50 to 90% are missed on chest XR (50).

Bedside ultrasound was 100% specific and 100% sensitive for the detection of malpositioned ICDs in human cadavers (51). Whether this diagnostic modality can be extrapolated to living patients needs further studies but it would be valuable in many South African hospitals which cannot afford a CT scan. Malpositioned ICDs may be missed on chest XR despite a seemingly intra-thoracic position. Clinically, ICD malpositions present as non-functional ICDs which may require repositioning or re-insertion (26, 49). Like correctly positioned ICDs, they may 'bubble' upon insertion if they are intra-parenchymal and are communicating with the airway (false positive) (1). Incision wound infection, empyema, cellulitis and necrotizing fasciitis are examples of infective complications (8).

A United Kingdom (UK) study among chest physicians showed that 67% had encountered at least a single complication associated with ICD insertion over a six year period, resulting in 17 deaths from injury of blood vessels and viscera (52). Of those deaths, 2 resulted from ICDs which were inserted on the wrong

side (which is regarded as a complication on its own without any sequelae), 8 resulted from lacerations of the lung and 7 resulted from injuries to the oesophagus, inferior vena cava, colon, subclavian vessels, spleen and the heart. Seven fatalities from perforation of the heart have been reported in the literature to date (30). The UK National Patient Safety Agency has recorded 12 deaths linked to ICD insertion between January 2005 and March 2008 (53). A further 2 deaths resulting from 7 reported cases of organ perforation occurred before November 2009 (54).

The classification of ICD complications is too 'liberal' and includes what some clinicians would classify as failure of treatment (2). Failure of resolution (unresolved/ retained/ persistent pneumothorax and/or haemothorax) and re-accumulation of pneumothorax and/or haemothorax post-ICD removal are regarded as complications (50, 55), although a persistent pneumothorax may be due to a continuous non-healing air leak from a damaged airway. ICD dislodgement, insertion site outside the recommended 'safe' triangle and insertion on the wrong side are also classified under complications (8, 15). That triangle is bounded by the lateral border of the pectoralis major muscle medially, the medial border of the latissimus dorsi muscle laterally and the horizontal nipple line inferiorly. The apex of the triangle is facing the axilla (15).

Some complications, such as improper ICD handling and the complications which were mentioned in the preceding paragraph, are not classifiable in the

traditional way (36). In fact, the precise definition of complication varies in the literature (2). Other classifications include: (a) early (< 24hrs) versus late (> 24hrs) (37), (b) major (life-threatening) versus minor (non-life threatening) (56) and, (c) technical versus infective (8). In accordance with the literature, all the above-mentioned complications were classified as complications in the Tembisa Hospital study in order to facilitate comparison with other studies.

Although the British Thoracic Society quotes a rate of 3% under normal non-urgent conditions (12), the ICD complication rate reported in the literature varies between 1-36% (57). Besides the inconsistency in the definition of “complications” as explained above, the complications were expressed as the percentage of either patients or ICDs (58). The two figures usually differed because some patients required bilateral ICDs and ICD re-insertions. As a result, the total number of ICDs often exceeded the total number of patients.

Several risk factors for developing ICD related complications have been identified. They can be broadly classified as patient and doctor (technical) dependent. Patient dependent risk factors included polytrauma, the presence of hypotension on admission, Intensive Care Unit (ICU) admission, the need for mechanical ventilation and blunt chest trauma (3, 58, 59). These factors were present in critically injured patients in whom the ICD insertion probably had an inherent risk irrespective of the skill of the doctor who inserted it.

The complication rate was high if the ICD was inserted outside the ED by a non-surgical specialist compared to those ICDs which were inserted by a surgical specialist in the ED, with the former accounting for 90% of the total complications (15). The complication rate was low among surgical and high among emergency physician residents. The complication rates for ICDs which were inserted at a referring hospital before transfer to a teaching hospital, those ICDs which were inserted by emergency physicians in the ED and those ICDs which were inserted by surgeons were 38%, 13%, 6% respectively (58). When junior doctors were asked in a UK hospital survey to mark on a photograph the point at which they would insert the ICD, 45% to 55% were outside the safe triangle recommended by the British Thoracic Society. The most common error, in 24% of the cases, was the insertion site being too low (60, 61). However, that was not a true complication because there were no real patients involved. The findings were nevertheless of significant concern because it demonstrated that junior doctors were not familiar with the recommended landmarks of ICD insertion.

Research on the complications of ICDs done at Tygerberg Hospital demonstrated an overall complication rate of 9.5%. Category-specific rates were 27% and 73% for insertional and positional complications respectively (15). The most common complications in decreasing order were, (a) a superficial placement with the distal end of the ICD not deep enough in the pleural cavity, (b) an extrathoracic malposition, where the entire ICD was positioned outside the chest wall, in the subcutaneous tissue, (c) the ICD was not securely sutured to

the chest wall and (d) finally, the insertion site was outside the “safe triangle” (15). The empyema rate was unknown because infective complications were excluded from that study.

The lower than average ICD complication rate reported at Tygerberg Hospital could have been due to the fact that the ED is affiliated to Stellenbosch University and that the registrars were ATLS<sup>TM</sup>-trained. Peripheral hospitals were, on the other hand, staffed by locum doctors who were probably junior medical officers, were working unsupervised and were not ATLS<sup>TM</sup>-trained. However, restricting ICD insertion to senior doctors would be a dangerous policy because its advantages in saving lives outweigh the disadvantages of developing complications. The primary aim of inserting the ICD is chest decompression, drainage is secondary (1).

Research done at the Charlotte Maxeke Johannesburg Academic Hospital on whether the routine post-ICD chest XR is necessary showed that the chest XR changed the management of 1 out of every 5 trauma patients requiring the ICD to be repositioned or re-inserted due to malpositions or the patient required thoracotomy due to excessive bleeding into the ICD (62). Twenty two percent of ICDs were malpositioned and the ICD failed to drain the pneumothorax or haemothorax adequately in 14.2% of patients. Only 15.7% of ICDs required repositioning or re-insertion. Only clinically non-functional malpositioned ICDs required re-positioning or re-insertion. The remaining clinically functional but

radiologically malpositioned ICDs were treated conservatively. Although the study was not directly studying ICD complications, it indicated that ICD complications were common in that institution and, as a result, a routine post-insertional X-ray was necessary to detect those complications in addition to confirming its position. Post-insertion XR is currently recommended to confirm the ICD position (1, 4).

An audit done at the Cardiothoracic Unit in Bloemfontein's Pelonomi Hospital demonstrated that thoracic empyema secondary to post-traumatic ICDs which had been left for too long accounted for the majority of the cases which were referred to that unit (63). Although those results suggest that ICD complications are common in South Africa, the actual frequency was not measured.

#### 2.1.7 Who should insert the ICD?

The trauma ICD is usually inserted by medical doctors in urgent or emergent settings in the ED, operating theatre, Intensive Care Unit and surgical wards (58). However, with appropriate training, it can be inserted by nursing staff in instances where there is a shortage of doctors (35). Advanced practice providers (registered nurses and physician assistants) in the USA are examples of non-medical health professionals who insert ICDs (35).

ICDs inserted by advanced practice providers were as good as those which were inserted by trauma surgeons in terms of complications and their quality.

Complications were defined as insertional (insertion site bleeding, re-expansion pulmonary oedema) and outcome-based (ICD slipping out and failure of treatment). Quality was assessed by the position of the intercostal tube on the chest XR (35).

That fact has relevance to South Africa where Clinical Associates have been recently introduced as health professionals. With proper training, they can assist in underserved areas where doctors are not available or are in shortage. It was estimated that observing ICD insertion and inserting 10 ICDs was enough to make one competent in that technique (35). ATLS™ is one course which trains doctors how to insert an ICD.

## 2.2 Summary

The insertion of the ICD, in addition to following Advanced Trauma and Life Support (ATLS™) resuscitation principles, is an important skill in the management of chest trauma patients in an ED. The procedure has insertional, positional, infective and other complications which may result in morbidity and mortality.

## **CHAPTER 3**

### **METHODOLOGY**

#### **3.0 Introduction**

This chapter describes how this research project was conducted at Tembisa Hospital. Tembisa Hospital is a 780 bed public hospital situated just north of the O.R.Tambo International Airport, Ekurhuleni in Gauteng. It services an estimated population of more than 2, 5 million people (64). Approximately 5000 patients per month are treated at the Emergency Department (ED), 25% of which are trauma patients. According to the Tembisa Hospital ED's register, trauma is classified as motor vehicle accidents, pedestrian vehicle accidents, gunshot wounds, stab wounds, burns, assault, soft tissue injuries and fractures. Blunt and penetrating injuries are not listed separately.

#### **3.1 Ethics**

Medical Ethical Clearance for the research project was obtained from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand (certificate number M110912).

#### **3.2 Design**

The research project was a retrospective, descriptive, transverse study of trauma ICDs inserted from January 2008 to January 2010. The study design has been previously described in the literature (2, 21, 35, 58). A prospective study design

was not preferable because it could have taken a longer time period to complete and it could have introduced bias if the doctors who were inserting ICDs were aware that complications were being recorded (36, 37, 56, 59).

### 3.3 Population

The study population consisted of all patients presenting initially to Tembisa Hospital ED post trauma and who had their initial intercostal drain (ICD) inserted in the ED.

### 3.4 Inclusion criteria:

- All trauma patients who had the initial ICD inserted in the ED.
- Patients who, having had their initial ICD inserted in the ED, had their ICD re-inserted due to (a) complications of the initial ICD (e.g. infections, accidental slipping out of the ICD, malpositions), and (b) failure of treatment of the initial ICD (non-resolving pneumothorax, haemothorax and haemopneumothorax). The ICD complication subset of patients was derived from the initial patient population. The ICD was re-inserted in the ED, surgical ward, operating theatre and Intensive Care Unit. The total number of ICDs exceeded the total number of trauma ICD patients.

### 3.5 Exclusion criteria:

- Patients who were transferred to Tembisa Hospital with the ICD already inserted by the referring clinic or hospital unless the ICD was re-inserted at Tembisa Hospital.
- Patients who had an ICD inserted for trauma but either died in hospital or were transferred to Steve Biko Pretoria Academic Hospital (referral hospital for Tembisa Hospital) before developing complications because they could not be followed up to determine if complications developed or not.
- Age less than 12 years.
- Patients who had an ICD inserted for non-trauma (medical) indications e.g. spontaneous pneumothorax, pleural effusion, Tuberculous thoracic empyema.
- Patients who had an ICD inserted for iatrogenic injuries e.g. following the insertion of a central venous catheter and from barotrauma in ventilated patients.

### 3.6 Data collection

- The monthly ED patient's register was checked for names and hospital numbers of patients (identifiers) whose diagnoses stated haemothorax, pneumothorax, haemopneumothorax following trauma. Details of the patients, whose reason for hospital admission did not include the above-mentioned diagnoses, but which suggested ICD insertion, e.g. stab chest, gunshot wound chest, blunt chest trauma, fractured ribs, empyema,

polytrauma, motor vehicle accident (MVA), pedestrian vehicle accident (PVA) and laparotomy or thoracotomy for trauma, were included in the search list.

- The lists were given to the surgical ward clerk, Miss Simangele Sibeko, who manually retrieved the requested files from the RECORDS DEPARTMENT. She was familiar with the filing system used at Tembisa Hospital.
- Doctors and nursing notes were checked for the following information: age, gender, type of injury, mechanism of injury, indication for the initial ICD, time of day when the ICD was inserted, surgical firm to which the doctor who inserted the ICD belonged, number of ICDs per patient, ICD complication, duration of the ICD, length of hospital stay and patient outcomes (see appendix 3).
- The patient identifiers (name and hospital file number) were not included in the data sheet. Instead, each patient was given a unique study number. A separate sheet which linked the identifiers to the study number was made in order to protect the patients' identities.
- XRs were not retrieved from the RADIOLOGY DEPARTMENT and reviewed for ICD complications. The complication mentioned by the treating doctor was accepted as final as previously described in the literature (2, 21, 36). Chest XRs were reviewed by radiologists for complications in one study. The aim of that study was to compare the ICD complications between those inserted by advanced practice providers and

those which were inserted by surgeons. However, how the difference in the speciality of the doctor who interpreted the XRs could have affected the results was not explored (35). Clinical notes were written in the hospital files by either a surgical intern or a surgical medical officer.

### 3.7 Data analysis

The help of a statistician, Prof Samuel Manda of the Medical Research Council in Pretoria was enlisted. Statistical analysis required at least 50 ICD complications. Based on the average literature complication rate of 20%, the sample size was calculated to be at least 250 patients. Categorical variables were summarized using frequencies and percentages while continuous variables were summarized using means or median with standard deviations. Associations between various risk factors and complication status (Yes/No) were investigated using the chi square test for independence and multivariate logistic model as previously described in the literature (35, 58, 59). The package STATA 11<sup>®</sup> was used for all the analyses.

### 3.8 Limitation

The ED's patient register for 3 of the 25 months during the study period could not be traced. Data for the months of February 2008, July 2008 and July 2009 was unavailable as a result. This loss of data contributed to information bias as explained in the last chapter of this research report.

### 3.9 Summary

This chapter detailed how the study was undertaken. The study population, size, inclusion criteria, exclusion criteria, data collection and limitations were discussed. The results are presented in the next chapter.

## CHAPTER 4

### RESULTS

#### 4.0 Introduction

This chapter presents the results under the following headings: 4.1 Descriptive data, 4.2 Intercostal drain (ICD) complications and, 4.3 Risk factors for developing ICD complications.

#### 4.1 Descriptive data

##### 4.1.1 Number of patients

Although the total number of trauma ICD patients was 251 (Table 4.1), the total number of trauma ICDs was 285 (Table 4.2). The reasons for that discrepancy were:

- (a) Eleven patients had 2 ICDs each, one on each side of the chest, and
- (b) Sixteen patients had the ICD inserted on the same side of the chest more than once because the previously inserted ICD had a complication which necessitated re-insertion. Of those 16 patients, 11, 3 and 2 patients had the ICD re-inserted once (2 ICDs each), twice (3 ICDs each) and three times (4 ICDs each) respectively.

Table 4.1 Trauma ICD patients

|  |           |
|--|-----------|
| Total no. of ICD patients              | 251 (100) |
| Bilateral ICD patients                 | 11 (4.4)  |
| Total no. who had ICD re-inserted      | 16 (6.4)  |
| No. who had one ICD re-insertion       | 11 (4.4)  |
| No. who had two ICD re-insertions      | 3 (1.2)   |
| No. who had three ICD re-insertions    | 2 (0.8)   |
| Percentages are in brackets            |           |
| ICD = intercostal drain, no. = number. |           |

#### 4.1.2 Number of ICDs

Table 4.2 Trauma ICDs

|  |            |
|--|------------|
| Initial no.                              | 251 (88.1) |
| Bilateral                                | 11 (3.8)   |
| Re-inserted                              | 23 (8.1)   |
| Total                                    | 285 (100)  |
| Percentages are in brackets              |            |
| ICDs = Intercostal drains, no. = number. |            |

#### 4.1.3 Gender

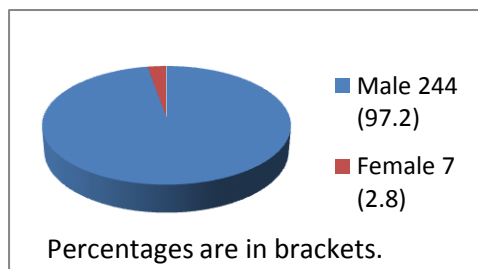


Fig. 4.1 Trauma ICD patient gender.

#### 4.1.4 Age

The ages of all the patients varied between 14 and 61 years, with a mean age of 28.77 years. The mean age of those patients who developed ICD complications was 29.02 years versus 28.7 years for those patients who did not develop ICD complications.

#### 4.1.5 Duration of the ICD

The duration of the ICD stay ranged from 1 to 35 days with a mean of 5 days.

Patients with and those without complications had a mean ICD duration of 7.53 and 4.32 days respectively.

#### 4.1.6 Length of hospital stay

The length of the hospital stay ranged between 1 to 68 days with a mean of 6.32 days for all patients. The length of the hospital stay was 11.38 and 5.18 days for patients with and those without complications respectively.

#### 4.1.7 Type of injury

Table 4.3 Type of injury

|                                    |                  |
|------------------------------------|------------------|
| Stab wounds                        | 205 (81.6)       |
| Gunshot wounds                     | 31 (12.4)        |
| Assault (exact injury unspecified) | 5 (2)            |
| Sjambok injury                     | 2 (0.8)          |
| Motor vehicle accident             | 2 (0.8)          |
| Kicked                             | 2 (0.8)          |
| Fall from a height                 | 1 (0.4)          |
| Trauma (exact cause unspecified)   | 3 (1.2)          |
| <b>Total no. of patients</b>       | <b>251 (100)</b> |
| Percentages are in brackets        |                  |
| no = number.                       |                  |

#### 4.1.8 Mechanism of injury

Table 4.4 Mechanism of injury

|                              |                  |
|------------------------------|------------------|
| Penetrating injuries         | 236 (94)         |
| Blunt injuries               | 7 (2.8)          |
| Unknown                      | 8 (3.2)          |
| <b>Total no. of patients</b> | <b>251 (100)</b> |
| Percentages are in brackets  |                  |
| no = number.                 |                  |

#### 4.1.9 Indications for ICD insertion

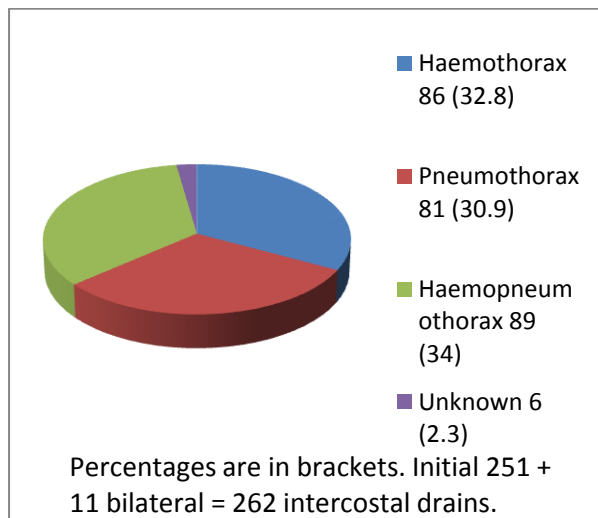


Fig. 4.2 Indications for trauma ICD insertion.

#### 4.1.10 Trauma teams

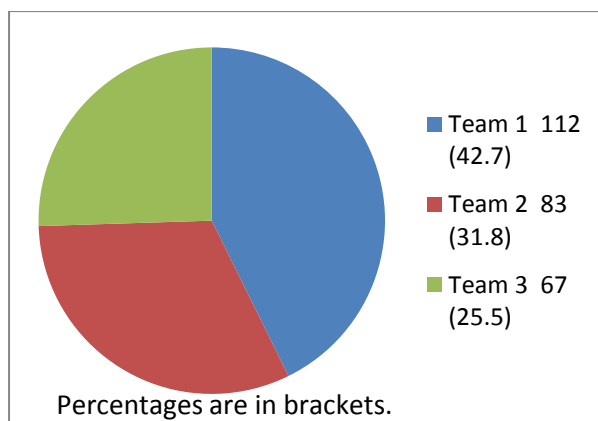


Fig. 4.3 Trauma ICD teams.

Trauma teams were defined according to the surgical team the medical officer who was on call belonged to. The discrepancy in the number of ICDs among the teams was due to the different number of extra calls medical officers did in a month.

#### 4.1.11 Time of day

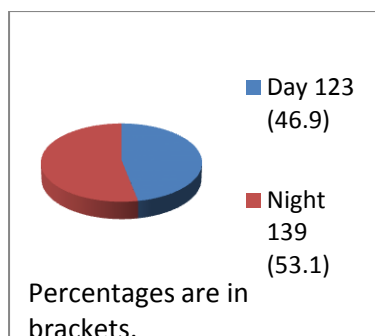


Fig 4.4 Time of day when trauma ICDs were inserted.

Day was defined as 06hr00 to 17hr59. Night was defined as 18hr00 to 05hr59.

#### 4.1.12 Patient outcomes

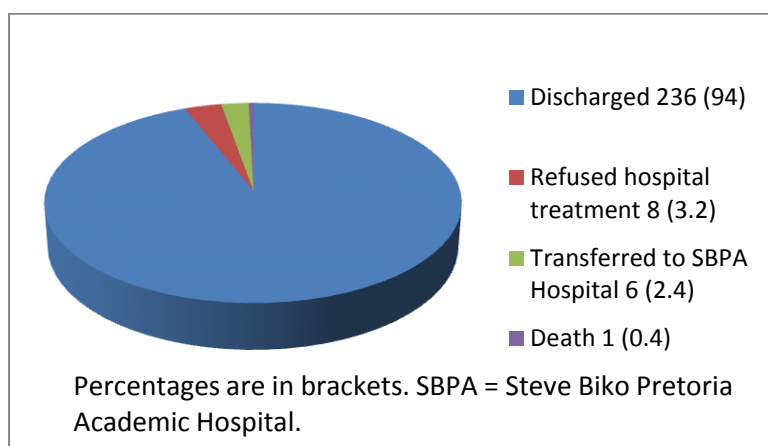


Fig. 4.5 Trauma ICD patient outcomes.

The only recorded death was one patient (0.4%) who succumbed to septic pressure sores which resulted from paraplegia following a gunshot wound to the spine. There was no death directly attributable to ICD insertion.

#### 4.2.1 Intercostal drain complications

**Table 4.5 Complications of trauma ICDs**

| Complication                  | Initial ICDs    | Re-inserted ICDs | Initial and re-inserted ICDs |
|-------------------------------|-----------------|------------------|------------------------------|
| Empyema                       | 10 (19.6)       | 6 (46.1)         | 16 (25)                      |
| ICD slipped out               | 10 (19.6)       | 3 (23.1)         | 13 (20.3)                    |
| ICD malpositions              | 8 (15.7)        | Nil (0)          | 8 (12.5)                     |
| Retained haemothorax          | 4 (7.8)         | 1 (15.4)         | 5 (7.8)                      |
| Persistent pneumothorax       | 4 (7.8)         | Nil (0)          | 4 (6.25)                     |
| Unresolving haemopneumothorax | 1 (2)           | 2 (15.4)         | 3 (4.7)                      |
| Wound sepsis                  | 3 (5.9)         | Nil (0)          | 3 (4.7)                      |
| ICD bottle empty of water     | 3 (5.9)         | Nil (0)          | 3 (4.7)                      |
| Bleeding                      | 2 (3.9)         | Nil (0)          | 2 (3.1)                      |
| Disconnected system           | 2 (3.9)         | Nil (0)          | 2 (3.1)                      |
| Tube not under water          | 2 (3.9)         | Nil (0)          | 2 (3.1)                      |
| Recurring pneumothorax        | 1 (2)           | Nil (0)          | 1 (1.6)                      |
| Emphysema                     | 1 (2)           | Nil (0)          | 1 (1.6)                      |
| Suture break                  |                 | 1 (7.7)          | 1 (1.6)                      |
| <b>Total</b>                  | <b>51 (100)</b> | <b>13 (100)</b>  | <b>64 (100)</b>              |

Percentages are in brackets

ICD = intercostal drain.

#### 4.2.2 Complication rate

Table 4.6 Complication rates

|  | Initial ICDs (including bilateral) | Re-inserted ICDs | Overall |
|--|------------------------------------|------------------|---------|
| No. ICD complications.                                 | 51                                 | 13               | 64      |
| No. patients with complications                        | 49                                 | 11               | 49      |
| Total no. ICDs   | 262                                | 23               | 285     |
| Total no. patients                                     | 251                                | 16               | 251     |
| No. patients with complications/total no. patients (%) | 19.5                               | 68.8             | 19.5    |
| No. ICDs complications/total no. ICD (%)               | 19.5                               | 56.5             | 22.5    |
| ICD = Intercostal drain, no. = number.                 |                                    |                  |         |

In Table 4.7 all the complications of the trauma ICDs are classified the traditional way into insertional (relating to the technique of insertion), positional (in the wrong place) and infective categories. Complications which could not be categorized the traditional way were included in the 'other' category.

Table 4.7 Category-specific trauma ICD complications

| INSERTIONAL                  |            | MALPOSITIONS                     |             | INFECTIONS      |            | OTHER                     |              |
|------------------------------|------------|----------------------------------|-------------|-----------------|------------|---------------------------|--------------|
| Bleeding                     | 2<br>(3.1) | Malpositions                     | 8(12.5)     | Empyema         | 16<br>(25) | Slipped out               | 13<br>(20.3) |
|                              |            | Retained<br>haemothorax          | 5 (7.8)     | Wound<br>sepsis | 3 (4.7)    | Bottle found<br>empty     | 3 (4.7)      |
|                              |            | Persistent<br>pneumothorax       | 4<br>(6.25) |                 |            | Disconnected<br>system    | 2 (3.1)      |
|                              |            | Unresolving<br>haemopneumothorax | 3 (4.7)     |                 |            | Tube not<br>under water   | 2 (3.1)      |
|                              |            |                                  |             |                 |            | Emphysema                 | 1 (1.6)      |
|                              |            |                                  |             |                 |            | Suture break              | 1 (1.6)      |
|                              |            |                                  |             |                 |            | Recurring<br>pneumothorax | 1 (1.6)      |
| TOTAL                        | 2/64       | TOTAL                            | 20/64       | TOTAL           | 19/64      | TOTAL                     | 23/64        |
|                              | (3.1)      |                                  | (31.3)      |                 | (29.7)     |                           | (35.9)       |
| Percentages are in brackets. |            |                                  |             |                 |            |                           |              |
| ICD = intercostal drain      |            |                                  |             |                 |            |                           |              |

#### 4. 3 Risk factors for developing trauma ICD complications

Table 4.8 Risk factors

| Variable   | Description       | mean  | median | Standard deviation | frequency | p value |
|--|-------------------|-------|--------|--------------------|-----------|---------|
| Age  | All patients      | 28.77 | 27.00  | 8.048              |           | 0.789   |
|  | +                 | 29.02 |        | 8.488              |           |         |
|  | –                 | 28.70 |        | 7.944              |           |         |
| ICD duration   | All patients      | 5.00  | 4.00   | 4.164              |           | 0.000   |
|  | +                 | 7.53  |        | 7.101              |           |         |
|  | –                 | 4.32  |        | 2.554              |           |         |
| Hospital stay  | All patients      | 6.32  | 5.00   | 6.708              |           | 0.000   |
|  | +                 | 11.38 |        | 8.768              |           |         |
|  | –                 | 5.18  |        | 5.574              |           |         |
| Mechanism  | Penetrating       |       |        |                    | 236       | 0.157   |
|  | Blunt             |       |        |                    | 7         |         |
| Indication   | Haemothorax       |       |        |                    | 86        | 0.108   |
|  | Pneumothorax      |       |        |                    | 81        | 0.061   |
|  | Haemopneumothorax |       |        |                    | 89        | 0.105   |
| Team   | 1                 |       |        |                    | 112       | 0.465   |
|  | 2                 |       |        |                    | 83        | 0.391   |
|  | 3                 |       |        |                    | 67        | 0.616   |
| Time   | Day               |       |        |                    | 123       | 0.677   |
|  | Night             |       |        |                    | 139       |         |
| + = complications, - = no complication. ICD = intercostal drain. |                   |       |        |                    |           |         |

#### 4.4 Summary

Stab wounds among young male patients were the common presentation of trauma ICD patients. Haemopneumothorax was the most frequent indication for ICD insertion. The average ICD duration and length of hospital stay were 5 and 6 days

respectively. More ICDs were inserted during the night. The overall complication rate was 19.5% of patients and 22.5% of all intercostal drains. Category-specific rates were 3.1%, 31.3%, 29.7% and 35.9% for the infective, positional, infective and 'other' complications respectively. The duration of the ICD and the length of the hospital stay were statistically shown to be risk factors for developing complications. The majority of patients were discharged from hospital.

## **CHAPTER 5**

### **DISCUSSION**

#### 5.0 Introduction

The results are discussed under the following headings: 5.1 Patient demographics, 5.2 Complications of trauma ICDs, 5.3 Complication rate, 5.4 Comparison between the Tembisa Hospital and Tygerberg Hospital complications and finally, 5.5 Risk factors for developing complications.

#### 5.1 Demographics

The results indicate that the typical Tembisa Hospital post-traumatic patient who required ICD insertion was a young male who had been stabbed. Those results are in keeping with other published data which showed that young patients (56, 58, 65), particularly males (66, 67), require ICDs following chest trauma. Only one study population indicated a higher age, namely a mean age of 51 years, but it included ICU patients as well (37).

Up to 99% of chest trauma ICDs were inserted for blunt trauma in Australian patients where a pneumothorax was the commonest indication for ICD insertion (3, 65). In contrast, a haemo-pneumothorax was the commonest indication in the Tembisa Hospital patient presenting to the ED study. That fact was probably due to penetrating trauma (stab wounds) being far more prevalent in the Tembisa Hospital population. Tembisa Hospital is situated in a township where inter-personal violence is perceived to be rife, especially in the surrounding squatter camps like Winnie Mandela, Ivory Park and Diepsloot. Unlike in the study done in Nigeria where

gunshot wounds accounted for 60% of penetrating trauma (66), gunshot wounds to the chest were uncommon in our population probably because of the stringent laws of owning a gun.

## 5.2 Complications of trauma ICDs

### 5.2.1 Empyema

An empyema accounted for 25% of all the trauma intercostal drain (ICD) complications and 6.4% of all patients in this study. As a group, the infective complications added up to a sum of 29.7% when wound sepsis was included. Empyema complicates up to 25% of trauma ICDs (34). The average is 2% of all trauma ICD patients (2, 3, 13). The rate obtained in the Tembisa Hospital study was higher than the literature average.

The use of prophylactic antibiotics prior to ICD insertion is not standard practice. Current ATLS<sup>TM</sup> guidelines do not recommend routine prophylactic antibiotic use before ICD insertion (4). Therefore, the high infective complication rate obtained in the Tembisa Hospital study could not be solely attributed to the inconsistent administration of prophylactic antibiotics by the doctors who inserted the ICDs. Although some of those patients did receive initial antibiotic cover, the choice of antibiotic appeared incorrect. In many instances, Penicillin was given instead of a recommended Cephalosporins. The former antibiotic is not ideal for *Staphylococcus aureus* infections, which is the most commonly isolated organism in thoracic empyema (38, 39).

A retained haemothorax, the presence of an associated injury e.g. fractured ribs and the performance of an emergency laparotomy were among risk factors for developing a post ICD empyema (34). Pleural cavity contamination can also be iatrogenic in origin, i.e. from the procedure of ICD insertion (34, 38). One of the patients who developed a post ICD empyema in the Tembisa Hospital study had a suspected thoracic duct injury. It is possible that the resulting chylothorax was mistaken for pus. The microscopy, culture and sensitivity (M C & S) and biochemistry results of the draining fluid could possibly have made the distinction had they been done. The second patient had a thoraco-abdominal gunshot wound resulting in emergency laparotomy which revealed gastric and diaphragmatic perforations. It was thought that the gastric contents led to the contamination of the pleural cavity.

Of the 14 patients who developed a post ICD empyema, it was the only complication in 8 of these patients. Empyema co-existed with other complications in a total of 6 cases: with non-functional ICDs in 2 patients, a malpositioned ICD in 1 patient and, ICDs which had slipped out in 2 patients. One drain which complicated into an empyema was clinically non-functional and finally slipped out. All 6 ICDs had to be re-inserted. The multiple insertions could have predisposed patients to developing an empyema.

The current ATLS<sup>TM</sup> guidelines emphasize sterility during ICD insertion (4). The high infective complication rate in this study could have resulted from inadequate sterility in the ED. It is not uncommon to have a situation where the number of patients who require an ICD outstrips the number of available sterile ICD and suturing packs on weekends and public holidays in this institution, resulting in either the splitting of a

single ICD pack among several patients or delays while waiting for sterile packs. The situation was aggravated by the limited operational working hours of the Central Sterilizing Supply Department (CSSD) at Tembisa Hospital. It is not known how many of those empyema complications occurred among patients in whom the insertion of the ICDs was deemed an emergency when there was no time to prepare for sterility as opposed to a non-emergency. The former situation might not have afforded the ED doctor enough time to ensure sterility during the procedure.

#### 5.2.2 The slipping out of the ICD

The accidental displacement of the ICD was the second most common complication in this study, accounting for 20.3% of all complications. In general, this is an uncommon but a well-documented complication in the literature. Three to 4% of trauma ICDs were insecurely sutured on average (36, 58). ICD dislodgement accounted for 13% of complications in a UK study (2). Similarly, the Tygerberg Hospital research showed that the ICD was not securely sutured to the chest wall in 12.5% of their complications (15).

The Tembisa Hospital ICD displacement rate is above the quoted literature average. It is likely that a large proportion of ICDs in this study were inserted by medical interns or junior medical officers in possibly uncooperative, often inebriated patients during resuscitation. It would have been interesting to compare the frequency of this complication between elective medical (e.g. a pleural effusion) and trauma ICDs at Tembisa Hospital. However, that was not done as it was not one of the objectives of this study.

Whether the doctors who inserted the ICD were ATLS<sup>TM</sup>-trained could not be established from the hospital records, but that possibility seemed unlikely.

Furthermore, it was not documented in the hospital files whether the ICDs were inserted under the guidance of a senior medical officer or not. In addition, the exact suturing technique, the suturing material and the suture size were not described.

### 5.2.3 Non-functional and malpositioned ICDs

Whether failure of treatment (retained haemothorax, persistent pneumothorax and unresolving haemopneumothorax) should be regarded as an ICD complication is probably debatable. However, it is current practice to include ICD failure as a complication (3, 59). It was the third most common complication in this study, accounting for 18.7% of all trauma ICD complications.

There are several reasons why an ICD may be non-functional, i.e., the indication for the ICD persists despite the insertion of the ICD:

- (a) Six % of ICDs inserted by pulmonologists in a UK teaching hospital needed to be replaced because the ICD became non-functional due to intercostal tube clotting or kinking. The risk of tube kinking or clotting is inversely proportional to its diameter (37).
- (b) Malpositioned ICDs (e.g. intra-fissural) may not effectively communicate with the rest of the pleural cavity and may thus become non-functional (1, 8, 49).
- (c) In the case of a pneumothorax, an air-leak from the airway exceeding the rate at which the ICD is draining air, e.g. a broncho-pleural fistula. However, unlike in a kinked/clotted and malpositioned ICD which will stop bubbling, a significant air-leak

causes continuous ICD bubbling. That clinical sign helps to distinguish the two scenarios.

At 12.5% of all complications, malpositioned drains were the fourth commonest complication in this study. They are regarded as the commonest trauma ICD complication. Malpositioned ICDs were diagnosed in 30% of ICU patients (49). Some of those malpositioned ICDs remained functional and, therefore, did not need to be re-positioned or re-inserted. The ICDs were malpositioned in 22.1% of cases at the Charlotte Maxeke Johannesburg Academic Hospital. They had to be re-positioned in 15.7% of patients (62). Among ICDs in both the pre-hospital and in-hospital setting, 31% of the ICD complications were malpositioned (56). Only 17% of those malpositions were repositioned. Intra-thoracic malpositions were observed in only 5.6% of all ICDs inserted in a Jordan study (36). Tembisa Hospital study fell within this literature range.

All malpositions in this study were diagnosed on chest XR. However, they can be missed on routine chest XR. They are best detected by a chest CT scan (1, 49). Although a chest CT was available during the study, it was not and still is not standard practice to request a chest CT after ICD insertion at Tembisa Hospital. Such practice would be considered a waste of resources. Malpositions could therefore have been well underestimated in this study. A malposition could be suspected if the indication for the ICD insertion persisted despite the insertion of the drain. Some malpositioned ICDs were functional and were therefore missed clinically. ICDs which are malpositioned but remain functional are clinically insignificant (2, 49, 56).

#### 5.2.4 Other ICD complications

The rest of the trauma ICD complications in this study have been well-described in the literature. The finding of an empty under-water drainage system bottle, the tube being allowed to migrate above the water level in the collection chamber of the ICD, and the accidental disconnection of the drainage system were referred to as 'errors' or 'pitfalls' in the handling of the ICD. They were attributed to nursing staff error (15, 36). They are potentially dangerous because they may lead to a tension pneumothorax and cardiac arrest (36).

Bleeding from the ICD insertion site on the chest wall is a result of injuries to either the intercostal artery and vein or the scapular artery (8). It was almost always associated with the use of a trocar in the literature (36, 59). It was not known whether a trocar was used in the Tembisa Hospital study since this information was not recorded in the hospital file. The bleeding was simply managed by applying pressure or a figure-of-8 suture as previously described (3).

Emphysema following the insertion of an ICD is caused by air leaking from the ICD insertion site and spreading over the subcutaneous tissue of the chest wall. It is usually a cosmetic problem (5). However, severe cases of cervical surgical emphysema following accidental removal of the ICD leading to airway obstruction have been reported (40, 41).

#### 5.3 Complication rate

Comparison of trauma ICD complication rates obtained from different studies was made difficult by the following reasons.

Firstly, there is no standard definition of ICD complication rate. While other journal articles were referring to the percentage of ICDs which complicated (2, 15, 36, 37, 56), others were referring to the percentage of patients whose ICDs complicated (3, 58, 59). The two rates were not necessarily equal in the same study because some patients required more than one ICD insertion. The reasons were the following;

- (a) Some patients had bilateral ICDs inserted,
- (b) Other patients had to have their original ICDs re-inserted because of:
  - (i) ICDs accidentally displacing before the resolution of the pathology,
  - (ii) Those patients who had clinically non-functional malpositioned ICDs,
  - (iii) Those patients whose indication for ICD insertion recurred after the removal of the ICD.

The result was that the total number of ICD insertion procedures exceeded the total number of patients.

Secondly, the definition of complication was not standard. Several studies have questioned the definition of a complication (2, 36). For example, a radiologically detectable malpositioned ICD which was clinically functional was not necessarily a complication according to some publications (2). Only non-functional malpositions should be counted as complications because those ICDs required re-insertion.

Functional malpositioned ICDs were clinically irrelevant because they did not require the procedure to be repeated. By including functional malpositioned ICDs in the complications, one made the definition of complication too 'liberal' (2).

Thirdly, some studies excluded other complications from their results. The Tygerberg Hospital study excluded infections (15). Fourthly, the classification of complications into categories was not standard. Although there was a traditional way of classifying ICD complications into insertional, positional and infective complications (2, 15), a classification had to accommodate complications which did not fit the traditional complications like an empty under-water drainage system.

Some studies simply classified their complications into early (those which occurred within 24hrs) and late (those which occurred after 24hrs) complications (37). Early complications were essentially insertional and positional in nature while the late ones were mainly infective. Another approach was grouping major (life-threatening) separately from minor (non-life-threatening) complications (56). Some studies circumvented that issue by classifying complications into the proper complications and 'mistakes' (36). Proper complications included clinically significant ones which necessitated further action like re-inserting the ICD, adjusting or repositioning it. As a result of the different classification methods, category-specific complication rates differed in the literature, making comparison impossible.

For the Tembisa Hospital study, all complications which were mentioned in the hospital file were included in the calculation of the complication rate. Furthermore, the complication rate was expressed in both ways; as the percentage of all patients and as the percentage of all ICD insertion procedures. The traditional method was used to classify trauma ICD complications. Complications which could not be included in any of the 3 categories were included in the 'other' category.

The overall complication rate of 19.5% of patients and 22.5% of ICDs obtained in the Tembisa Hospital study was in keeping with the international figures of less than 36% per procedure (57). The definition of complication in this study was 'liberal'. The complication rate would have been lower had our definition been strict.

#### 5.4 Comparison between the Tembisa Hospital and Tygerberg Hospital studies

Tygerberg hospital has a Trauma Unit which was affiliated to the Stellenbosch University Medical School at the time of their study (15). The Unit was staffed by ATLS<sup>TM</sup>- trained doctors who were stationed in the Surgery Department. In contrast, Tembisa Hospital is a regional hospital. It does not have a dedicated Trauma Unit. There is a single ED which catered for all emergencies irrespective of the medical speciality.

This ED is staffed by medical officers who are the first to attend to trauma patients. Thereafter, casualties are either discharged or referred to surgical interns.

Depending on the urgency of the situation, the ICD is inserted by either the medical officer if the procedure was deemed urgent or the surgical intern on call if the procedure was deemed non-urgent. It was not possible to determine from the hospital records how many of those doctors who inserted ICDs were ATLS<sup>TM</sup>-trained during the study period. It was not a condition of employment at that time for these ED doctors to be ATLS<sup>TM</sup>-trained although it was desirable. It seems likely though that only some of them had that certification. One would, therefore, expect more trauma ICD complications at Tembisa hospital compared to those at an academic institution like Tygerberg Hospital.

It should be borne in mind that the Tygerberg Hospital study sample consisted of both the patients who were referred by peripheral hospitals with an ICD already inserted and those patients whose intercostal drains were inserted at the academic hospital's Trauma Unit (15). Tygerberg Hospital contributed only 8% towards the ICD complications. The rest (92%), were those complications which arose in patients who were referred with an ICD *in situ* to Tygerberg Hospital.

Although it initially seemed unfair and inappropriate initially to compare Tembisa and Tygerberg hospitals, a comparison was not unreasonable given that the Tygerburg Hospital study included patients who were referred by other hospitals who, like Tembisa Hospital, were non-academic hospitals. Furthermore, both Tygerberg and Tembisa hospitals treated approximately a similar number of patients per annum during the period of the studies. The former hospital attended to approximately 15 000 trauma patients per annum (15). Tembisa Hospital's ED attended to approximately 60 000 patients per annum, 25 to 30% of which was trauma-related, according to patient registers. That figure translated to roughly 15 000 trauma patients per annum which was the same number as that of Tygerberg Hospital. It was, therefore, justifiable to compare the trauma ICD complications between the 2 institutions.

However, the study methods in the 2 hospitals differed. Tygerberg Hospital's study was a prospective study. Doctors were encouraged to report their ICD complications in a logbook (15). Tembisa Hospital's study was retrospective. Therefore, the

complication profiles could be expected to differ between the two health institutions as a result of the different study methods.

As an example, in a prospective study the exact ICD insertion site could be ascertained by a researcher and compared to the landmarks recommended in the ATLS<sup>TM</sup> guidelines (4). The ICD should be inserted in the 'safe triangle' according to the British Thoracic Society guidelines. Drains which were inserted outside the boundaries of that triangle were regarded as an insertional complication in the Tygerberg study (15). That information was not available in the Tembisa Hospital study and, therefore, that potential complication was missed.

Whereas the academic hospital's study intentionally excluded infective complications (15), the Tembisa Hospital study included all complications which were recorded in the hospital files. Empyema was the commonest complication in the latter hospital.

The Tygerberg Hospital study correctly provided the definitions of complications in its 'introduction' section. Insertional complications were defined as those complications which were related to the procedure of insertion. Malpositions were defined as ICDs which were in the wrong position (15). However, presenting in a table form which of the detected complications belonged to which complication category would have clarified their results better. Instead, category-specific complication rates were presented without showing how that figure was arrived at in a table form. Some results are not clear because of that omission.

As an example, it was not clear whether an extra-thoracic subcutaneous ICD was categorized as an insertional complication or as a malposition. It could have been classified as an insertional complication which arose as a result of a poor insertion technique. If the correct recommended technique of blunt dissection and 'finger sweep' were followed, the complication could not have arisen. The same ICD was lying in the wrong position (extra-thoracic) and could therefore have been reasonably classified as a malposition. Unfortunately we were not provided with the table detailing that clarification. In fact, the text referred to a table 4 which could not be found in the article (15). That could have been a publication error.

Similarly, it was not immediately clear in which category ICDs which accidentally slipped out were classified (15). One could have classified them as insertional complications because they arose from a poor suturing technique. One could also argue that such a tube ended up lying in a wrong position when the suture loosened and should therefore be classified as a malposition (2). It seemed that extra-thoracic ICDs were classified as insertional and that those ICDs which slipped out were classified as positional complications in the calculation of category-specific complications (15).

The Tygerberg Hospital study excluded infective complications. The top 3 complications in order of decreasing frequency were the following: (a) subcutaneous extra-thoracic position of the entire ICD, (b) the ICD lying superficially, i.e. the side portal of the chest tube was lying outside the pleural cavity but its proximal end was lying inside the pleural cavity and, (c) an equal number of chest tubes which were

insecurely sutured to the skin and those which were inserted outside the safe triangle (15).

In the contrary, infective complications topped the Tembisa hospital study list of complications. When empyema was excluded from the Tembisa Hospital study, the top 3 complications were the following; (a) ICDs which displaced because they were poorly secured to the skin, (b) failure of treatment, and (c) Malpositions. Poor suturing of the ICD to the skin and malpositioned drains were common complications in both health institutions.

The rest of the complications in the Tygerberg hospital research were insertion of the ICD (a) on the wrong side of the chest, (b) through the stab wound which caused the haemothorax or pneumothorax, (c) below the diaphragm in a patient who had a diaphragmatic hernia, and (d) the bottle of the under-water drainage system was found to be empty during the ward round. The last complication could have been a nursing error (15). Tembisa Hospital experienced more problems with the handling of the under-water drainage system (10.9% of all complications).

A recent study has studied 'mistakes' in the handling of the ICD (36). Although the most common error by far in that study was the inappropriate clamping of the chest tube during transportation of the patient, it had the same errors in the handling of the ICD as those listed in the Tembisa Hospital study. Those 'mistakes' were attributed to the poor training of the nursing staff (36). A summary of the major differences between the Tembisa Hospital and Tygerberg Hospital is presented in Table 5.1.

Table 5.1 Differences between Tembisa and Tygerberg hospitals' studies

|                           | Tembisa Hospital                   | Tygerberg Hospital   |
|---------------------------|------------------------------------|----------------------|
| Study                     | Retrospective                      | Prospective          |
| Infections                | Included                           | Excluded             |
| Institution level         | No dedicated Trauma Unit           | Academic Trauma Unit |
| Overall complication rate | 19.5% of patients<br>22.5% of ICDs | 9.5% of ICDs         |

### 5.5 Risk factors for developing complications

By statistically analyzing a multitude of factors for their association with developing complications following trauma ICD insertion, several risk factors have been identified in the literature. Those factors included the age of the patient, the length of hospital stay, the ICD duration, the use of prophylactic antibiotics, the time of the day when the ICD was inserted (day versus night) and, the speciality and seniority of the treating doctor (3, 58, 59).

The risk for developing trauma ICD complications has consistently been found to be increased in 2 general situations. Those situations could be classified as either patient or operator (doctor) dependent. Seriously injured patients and polytrauma posed a higher risk for developing ICD complications independent of the doctor who was inserting the ICD (58, 59).

The other major risk factor was the speciality of the doctor who inserted the ICD. ICDs which were inserted by the ED doctor had a significantly higher risk of developing complications when they were compared with those ICDs which were inserted by surgeons (3, 15). The risk for the surgeon was low irrespective of the hospital site in which the ICD was inserted (58). Doctors who were doing a non-surgical rotation at the time of ICD insertion have been consistently shown to be a risk factor in the literature (59). Non-surgical doctors increased the risk of ICD complication for both blunt and penetrating chest trauma tenfold when compared to their surgical counterparts (59). Therefore, ICD complications were either: (a) iatrogenic or technical in nature and depended mainly on the skill of the operator, and/or (b) inherent to the procedure itself. The latter depended on patient factors and were estimated at 25% (59)

The Tygerberg Hospital study found that 92% of the reported 26 trauma ICD complications occurred among those patients who were referred from a peripheral hospital to Tygerberg Hospital with the ICD *in situ*. Only 8% of the trauma ICD complications were attributed to the academic hospital Trauma Unit ATLS™-trained staff. That observation was attributed to the referring hospitals being probably staffed by junior staff. It was not known how many of those doctors were ATLS™-trained although the figure was thought to be low (15). It has been demonstrated before that those ICDs which were inserted in another hospital prior to referral to a Trauma Unit posed a high risk of developing complications (58, 59). Except for the speciality of the doctor who inserted the ICD, the Tygerberg research did not assess other risk factors for developing complications.

The mechanism of injury, the indication for ICD insertion, the time of the day when the ICD was inserted, the trauma team which performed the procedure, the duration of the ICD stay, the length of the hospital stay, and the age of the patient were all statistically assessed for their relationship with the development of complications in the Tembisa Hospital study. Of all the above-mentioned seven possible risk factors, only the duration of the ICD stay and the length of the hospital stay were shown to be statistically significant. The remaining five factors were shown not to have an effect on trauma ICD complications in our institution.

These results are similar to those reported before in the literature in terms of the mechanism of injury, the indication for the ICD insertion, the time of the day and the age of the patient. They were previously all shown not to be risk factors for developing trauma ICD complications (3, 10). The length of the hospital stay was previously shown not to be a risk factor (3, 10). In contrast, that was not the case in the Tembisa Hospital study where the duration of the ICD and the length of hospital stay were found to be risk factors.

In one study, almost all the observed trauma ICD complications were attributed to the use of a trocar during insertion (36). ICDs which were inserted in the operating theater under direct vision following a thoracotomy did not have any complications at all. All the reported complications occurred among the ICDs which were inserted in a hospital site outside the operating theater (36). That observation was explained by the fact that the procedure of ICD insertion outside the operating theatre is a blind technique. The use of the trocar has long been discouraged (1, 4). It could not be

established how many ICDs were inserted by using a trocar in the Tembisa Hospital study.

The currently recommended technique involves blunt dissection of the intercostal muscles. The intercostal tube can then be safely inserted after the 'finger sweep' of the pleural cavity (1, 4). Doctors who were in a surgical rotation or were ATLS<sup>TM</sup>-trained emergency physicians seemed to be practicing the proper ICD insertion technique (15).

## 5.6 Summary

The overall complication rate of 19.5% of patients and 22.5% of ICDs was within the literature range of less than 36%. Empyema complicated 8.07% of all patients. Malpositions occurred in 7% of cases. Those results were acceptable given that the reported literature rates were as high as 25% (37) and 31% (26, 56) respectively. However, our complication rate was higher than the 9.5% reported at Tygerberg Hospital. The reasons were: (a) unlike the Tygerberg Hospital study, this audit included infections. Infections were the commonest post ICD complication. (b) "liberal" use of the term "complication" in this audit, which, included failure of treatment and 'errors' in handling the ICD.

## **CHAPTER 6**

### **CONCLUSION**

#### 6.0 Introduction

This chapter covers the following headings: 6.1 Conclusion, 6.2 Recommendations, 6.3 Sources of bias, and 6.4 Summary.

#### 6.1 Conclusion

The typical patients who presented to Tembisa Hospital following chest trauma were young males who had been stabbed. ICD insertion following blunt trauma was uncommon. On average, those patients had an ICD for 5 days and spent 6 days in hospital. The most common indication for the ICD was a haemo-pneumothorax . The majority of ICDs were inserted during the night enforcing the commonly held belief that trauma is a nocturnal disease.

The overall complication rates of 19.5% of patients and 22.5% of trauma ICDs showed that the insertion of ICDs was not a completely harmless procedure.

Although it is a relatively simple procedure, ICD insertion could be associated with a high morbidity.

Although insertional complications contributed 3.1% towards total complications, the Tembisa Hospital study did not have any mortality which was directly attributed to the procedure of ICD insertion. That was a positive finding because most insertional complications are attributed to the use of the trocar in the literature (36). Fatalities occurred when thoracic and abdominal viscera were perforated by the use of the

trocar (8, 30, 52). That fact explains why its use is no longer recommended in the literature (1, 4). It could not be determined from the hospital records whether the trocar was actually used or not in this study. Both intercostal tubes with and without the trocar were available for use at the time of the study. The use of a trocar was ultimately left to the discretion of the doctor who was performing the procedure.

The most common trauma ICD complications were empyema, ICDs which accidentally slipped out, failure of treatment and malpositions in order of decreasing frequency. Together they accounted for 76.6% of ICD complications. That finding is of great concern because those ICDs needed to be replaced. That may have caused patient discomfort, prolonged ICD duration, extended hospital stay and high hospital costs.

Errors relating to the handling of the ICD by the nursing staff were uncommon in this audit. Of all the tested variables, only the ICD duration and the length of the hospital stay were found to be risk factors for developing trauma ICD complications.

## 6.2 Recommendations

It is highly recommended that medical personnel attend the ATLS™ course and that ICDs be inserted under the supervision of a senior doctor. ICDs which were placed in the incorrect position, just like insertional complications and drains which accidentally slipped out before the indication for the ICD insertion was resolved, were due to a poor technique. Our hospital management has allocated funds to pay for doctors to attend that course but the latter seem not to have taken advantage of

the offer. Attending the course would probably reduce the frequency of those technical complications.

The current ATLS<sup>TM</sup> guidelines on ICD insertion include blunt dissection (the use of a trocar is not recommended) and a finger exploration of the pleural cavity in order to separate the lung from the parietal pleura. If those steps are followed, the perforation of viscera and injury to the intercostal vessels could be avoided. Eliminating the use of trocar and directing the chest tube towards the lung apex along the anterior surface of the posterior chest wall could reduce the number of malpositions.

It is, however, unlikely that those so-called ‘technical’ complications could have been completely eradicated by proper training. ICD insertion is an invasive procedure. It probably has intrinsic complications which are unrelated to the skill of the doctor who is inserting the ICD just as any other surgical procedure. An example of an intrinsic complication is tube migration (49). A tube which is properly inserted may migrate and end up lying in the incorrect position, rendering the ICD non-functional.

A number of ICDs accidentally slipped out before the decision to remove them was made. Suggestions are that the ICD anchoring technique should be standardized in the institution and that workshops should be done to teach doctors the proper suturing technique and the appropriate suturing material. That complication should be avoidable.

Errors in handling the ICD accounted for 10.9% of the complications. Teaching the nursing staff of the proper handling of the ICD should be made a priority. Checking

for the correct water level, ascertaining that the tube is under the water level and ensuring that the chest drain does not disconnect from the under-water drainage system by the doctor during a ward round could eliminate those complications.

A residual haemothorax is a known risk factor for developing an empyema. Of the 9% of patients who developed an empyema, 33% of those patients who had a residual haemothorax developed an empyema compared to only 2% of those patients who did not have a residual haemothorax (68). Once a residual haemothorax develops, replacing the initial ICD does not seem to be a helpful clinical decision. That is unfortunately exactly how retained haemothoraces following ICD insertion were dealt with in this institution. Studies have demonstrated that either open thoracotomy or VATS (Video-Assisted Thoracoscopic Surgery) were a better treatment option compared to ICD re-insertion. When performed within 3 days following ICD insertion, they reduced further complications and the length of hospital stay when compared to the combination of lytic therapy and the re-insertion of the ICD (68). VATS was shown to be more cost-effective compared to ICD re-insertion and streptokinase in terms of the duration of the ICD, the duration of ICU and hospital stay (69).

Therefore, the recommendation is that Tembisa Hospital should adopt the above-mentioned protocol. Failure of the ICD to resolve a haemothorax and a haemo-pneumothorax should be treated by surgical intervention rather than having the ICD re-inserted in order to minimize the risk of empyema formation.

The duration of the ICD stay was a risk factor for developing complications at Tembisa hospital following trauma. Appropriate steps should be taken to reduce the duration of the ICD. That would translate to reducing the duration of the hospital stay. Ultimately hospital costs would come down. Reasonable steps include removing the ICD as soon as possible. The current practice at Tembisa hospital is to do a chest XR before and after ICD removal. There is usually a time delay before those XRs are done once they have been requested. That is especially the case over weekends where an XR which is requested for an in-patient may be delayed until Monday morning. It is suggested that XRs should be done speedily and that the ICD be removed immediately where clinically indicated in order to reduce the duration of ICD stay. Alternatively, the ICD should be removed as soon as it is declared clinically non-functional without having done XRs. An XR can then be done after ICD removal. The drain can be re-inserted if indicated. The majority of ICD complications in the Tembisa Hospital audit are preventable with appropriate training of the medical and nursing staff.

### 6.3 Sources of bias

There were several shortfalls with this study which contributed to systematic error.

Firstly, there was selection bias because the study sample consisted of the first consecutive 251 patients who presented between January 2008 and January 2010. The selection of the sample was not random. That could have been avoided by collecting the data over a longer time period and randomly choosing 251 patients from that bigger patient sample. However, this was not done due to time constraints.

Secondly there was information bias for three reasons:

(a) Some hospital data was missing. The ED's patient register for 3 months during the 25 month period of the study could not be found in the Records Department. There was nothing that could have been done except to exclude that data from the study and accept that the results would be biased.

(b) The study was a retrospective study. Chest X-Rays were not reviewed. Instead this study completely relied on the records of the treating doctor. Theoretically, doctors could therefore have intentionally under-reported their own complications. However, this could not have happened to a large extent because it is unlikely that the patient was treated by one individual doctor from the day of admission until the patient was discharged. The other colleagues belonging to the same team could have reported any ICD complications. However, that possibility could not be completely ruled out.

(c) The nature of the study also inherently missed some complications. Complications which were deemed to be clinically irrelevant could have been intentionally left out by the treating doctor. Examples include the wrong anatomical position of the insertion site. That common complication was clearly missing from this study. The ideal insertion site should be within the 'safe' triangle which is recommended by the British Thoracic Society in their guidelines on ICD insertion technique.

Finally, there was confounding bias in this study. The duration of the ICD stay was shown to be an independent risk factor for developing complications. It was assumed that the patient population was homogenous. The patients who did not develop

complications were assumed to be the same as those who developed complications. However, this might not have been the case. Patients who developed complications might have been more seriously injured compared to those who did not develop complications. The severity of their injuries could have confounded the results and not necessarily the duration of ICD stay *per se*. Those patients who developed complications might have been urgent versus those who were non-urgent cases. The former group could not have afforded the clinician enough time to conduct the procedure safely and under sterile conditions.

One way of reducing confounding bias in this study would have been to demonstrate that the two groups were not statistically different. Available tools were comparing the APACHE (Acute Physiology and Chronic Health Evaluation) or the Injury Severity Score of the two groups. However, the two scores could not be calculated because some of the clinical data which was required to calculate them was not in the hospital records. For example, the APACHE score relies on arterial blood, urea and creatinine results (70). This data was not always available.

#### 6.4 Summary

This research project studied trauma ICDs at Tembisa Hospital. The common presentation was a young male who had been stabbed. ICD insertion following blunt trauma was uncommon. A haemo-pneumothorax was the commonest indication for ICD insertion. More ICDs were inserted during the night. The average ICD duration and length of hospital stay were 5 days and 6 days respectively. Most patients recovered and were discharged from Tembisa Hospital.

Complication rates were 19.5% of patients and 22.5% of ICDs. The most common complications were empyema (25%), ICD dislodging from the chest wall (20.3%), failure of the ICD (persistent pneumothorax and haemothorax) (18.75%), ICD malpositions (12.5%) and poor ICD handling (10.9%) in decreasing order of frequency. The ICD duration and the length of hospital stay were shown to be risk factors for developing complications.

Much emphasis has been placed on the proper teaching of ICD operators in order to minimize trauma ICD complications (15, 38). The teaching should be both cognitive and practical in order to reduce trauma ICD complications (3, 38). It has been demonstrated that advanced practice providers (advanced registered nurse practitioners and physician assistants) could successfully take the role of inserting trauma ICDs in areas which have a shortage of trauma surgeons in the UK (38). When assessed by radiologists, the quality of trauma ICDs which were inserted by those appropriately trained advanced practice providers were found to be as good as those which were inserted by trauma surgeons. Similarly the complications of the two groups were comparable (38). The results of the Tembisa Hospital study seem to support the notion that ICD complications may be minimized by proper training.

## CHAPTER 7

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