

**Laparoscopy (to detect occult diaphragm injury)  
versus clinical and radiological follow up to detect  
diaphragm injury and herniation, in patients with  
asymptomatic left thoracoabdominal stab wounds**

**A prospective randomized controlled study**

**G.F. Malherbe MB.ChB. (U.F.S)**

MLHGID004

Submitted for completion of  
Master of Medicine (Surgery)

TRAUMA CENTRE  
DEPARTMENT OF SURGERY  
GROOTE SCHUUR HOSPITAL  
UNIVERSITY OF CAPE TOWN

2015



**Supervisors:**

**Professor PH Navsaria**

**Professor AJ Nicol**

The copyright of this thesis vests in the author. No quotation from it or information derived from it is to be published without full acknowledgement of the source. The thesis is to be used for private study or non-commercial research purposes only.

Published by the University of Cape Town (UCT) in terms of the non-exclusive license granted to UCT by the author.

## DECLARATION

I, Dr Gideon F Malherbe, hereby declare that the work on which this dissertation is based is my original work and that neither the whole work or any part of it has been, is being, or is to be submitted for another degree in this or any other university.

Signature: .....

Date:

## ABSTRACT

**Background:** The need to exclude occult diaphragmatic injury in left thoracoabdominal (TA) stab wounds continues to be controversial. Current trauma guidelines recommend either routine diagnostic thoracoscopy or laparoscopy and repair of an injury if found.

**Objective:** To determine if asymptomatic patients with left sided (TA) stab wounds can be safely treated with careful clinical and chest X-ray follow up to ascertain healing of occult injuries.

**Methods:** A parallel-group, prospective, randomized control study was conducted at the Trauma Centre at the Groote Schuur Hospital from 01 September 2009 through to 01 November 2014. All patients with asymptomatic left TA stab wounds included in the trial were randomized into two groups. Group A underwent diagnostic laparoscopy to exclude a diaphragm injury, and Group B underwent clinical and radiological follow up.

**Results:** Twenty seven patients were randomized to Group A (n=27) and thirty one to Group B (n=31). All patients were young males with a median age of 26 years (range from 18 to 48). The incidence of occult diaphragm injury in group A was 29%. Occult injuries found at laparoscopy were all repaired. All patients in group 2 had normal chest X-rays and no symptoms at their last visit. The mean follow up time was 24 months (range of 0 to 58). There was no morbidity nor mortality associated with the conservative management of occult diaphragmatic injuries. The mean hospital stay for the patients in Group A was 5 days (SD 1.3), compared to a mean hospital stay of 2.9 days (SD, 1.5)  $p < 0.001$ , in Group B.

**Conclusions:** Clinical and radiological follow up is feasible and appears to be safe in patients with occult diaphragm injuries after left TA stab wounds.

## AKNOWLEDGEMENTS

Many people have guided me and helped me through this entire process and I would like to express my sincere appreciation as follows:

- My supervisor Professor Pradeep Navsaria for his constant guidance and unlimited support
- My wife, Rene, for her encouragement.
- The staff of the Trauma Centre for creating an academic environment in and amongst a heavy clinical workload.
- The patients who were willing to take part in the study
- Professor Maria Krause for her help in the preparation of the manuscript.

# TABLE OF CONTENTS

## CHAPTER 1

### INTRODUCTION AND LITERATURE REVIEW

#### 1. INTRODUCTION

<b>1.1 Anatomy of the diaphragm</b>	<b>1</b>
<i>1.1.1 Surgical Embryology of the Diaphragm</i>	<b>1</b>
<i>1.1.2 Anatomy of the Thoracoabdominal Zone</i>	<b>1</b>
<b>1.2 Sharp-force Trauma in South Africa</b>	<b>2</b>

#### 2. LITERATURE REVIEW

<b>2.1 Overview of the Management of Thoracoabdominal Stab Wounds</b>	<b>3</b>
<b>2.2 Methods</b>	<b>5</b>
<i>2.2.1 Search Strategy</i>	<b>5</b>
<i>2.2.2 Selection criteria</i>	<b>6</b>
<i>2.2.3 Data Collection and Extraction</i>	<b>6</b>
<b>2.3 Results</b>	<b>6</b>
<i>2.3.1 Articles for inclusion</i>	<b>6</b>
<i>2.3.2 Qualitative Overview of Articles in Systematic Review</i>	<b>7</b>
<i>2.3.3 The Incidence of Diaphragm Injuries</i>	<b>8</b>
<i>2.3.4 Incidence of a Delayed Diaphragm Hernia</i>	<b>9</b>
<i>2.3.5 Complications of a Delayed Diaphragm Hernia</i>	<b>10</b>
<i>2.3.6 Natural course of diaphragmatic wounds</i>	<b>11</b>
<i>2.3.7 Financial implications of routine laparoscopy to diagnose injury of the diaphragm</i>	<b>13</b>
<i>2.3.8 Incidence of Diaphragm Injury in Trauma Patients with Asymptomatic Left Thoracoabdominal Stab Wounds</i>	<b>14</b>
<b>2.4 Summary of Review of Literature</b>	<b>20</b>
<b>2.5 Aims of the Study</b>	<b>21</b>
<b>3. REFERENCES</b>	<b>23</b>

## **CHAPTER 2**

### **PUBLICATION-READY MANUSCRIPT**

<b>2.1 Title page</b>	<b>29</b>
2.1.1 <i>Title of paper</i>	29
2.1.2 <i>Authors</i>	29
2.1.3 <i>Supplementary information</i>	29
<b>2.2 Mini abstract</b>	<b>30</b>
<b>2.3 Structured abstract</b>	<b>30</b>
<b>2.4 Main Paper</b>	<b>32</b>
<b>2.5 References</b>	<b>44</b>

## **CHAPTER 3**

### **APPENDIX**

<b>Appendix 1 - Literature review journal article data extraction form</b>	<b>48</b>
<b>Appendix 2 – Randomization table</b>	<b>49</b>
<b>Appendix 3 - Prospective data collection form</b>	<b>50</b>
<b>Appendix 4 - Clinic data collection form</b>	<b>53</b>
<b>Appendix 5 - Consent form</b>	<b>55</b>
<b>Appendix 6 - Information document</b>	<b>57</b>
<b>Appendix 7 - Departmental approval of study</b>	<b>58</b>
<b>Appendix 8 - Faculty of Health Sciences Human Research Ethics Committee approval</b>	<b>59</b>
<b>Appendix 9 – Annals of Surgery: Information for authors</b>	<b>60</b>

## **CHAPTER 1**

### **INTRODUCTION AND LITERATURE REVIEW**

#### **1. INTRODUCTION**

##### **1.1 Anatomy of the diaphragm**

###### *1.1.1 Surgical Embryology of the Diaphragm*

The embryological development of the musculotendinous diaphragm is complicated and still not fully understood. The musculotendinous diaphragm separates the thoracic and abdominal cavities and is formed by the following four embryologic entities:

- septum transversum
- pleuroperitoneal membranes
- mediastinum (dorsal mesentery of the esophagus)
- body wall muscles

These different components are not delineated precisely in the diaphragm, and additional detailed embryologic investigations of the role of the individual contributors, as mentioned above, are necessary <sup>1</sup>.

###### *1.1.2 Anatomy of the Thoracoabdominal Zone*

The diaphragm is a dome-shaped, musculotendinous structure representing the bottom of the pleural cavity and the roof of the abdominal cavity. It is composed of the muscular and tendinous parts <sup>1</sup>. The thoracoabdominal zone is defined as an area with the following boundaries:

1. The fourth intercostal space (anteriorly)
2. The sixth intercostal space (laterally)
3. The eighth intercostal space (posteriorly)
4. The costal margin (inferiorly)

The thorax region's boundaries are the nipple line, costal margins and scapulae and are similar to the area described above <sup>2</sup>.

The liver and spleen lie below this area and are protected by the ribs. The location of the diaphragm is variable as it depends on the extent of inhalation and exhalation, age and sex, momentary posture, extent to which the intestines are filled and general build of a particular person. Processes requiring volume in the pleural or peritoneal cavity may also cause considerable change in the shape and position of the diaphragm. At rest, the right dome is at the level of the fourth intercostal space, the left dome is 1 to 2 centimetres lower. After maximal inhalation, the right dome of the diaphragm is at the level of the cartilage-bone transition of the sixth rib, and the left dome is approximately at the level of the next lower intercostal space <sup>1</sup>. Hence a penetrating wound in the TA area could potentially injure the diaphragm or any thoracic viscera, in addition to the abdominal organs.

These multiple possibilities make initial diagnostic assessment in such cases challenging <sup>1,2</sup>.

## **1.2 Sharp-force Trauma in South Africa**

South Africa is a middle income country with one of the highest rates of violence in the world. The researcher have experienced that exact mortality rates are difficult to come by as

South Africa is a country where not all deaths are registered and misclassification of deaths often occurs.

The most recent national injury mortality surveillance system (NIMSS) report (10<sup>th</sup> Annual Report) reported on fatal injuries in South Africa for the period 1 January to 31 December 2008, 6083 non-natural deaths occurred in Cape Town out of a total of 10085 in the Western Cape and 36795 in South Africa <sup>3</sup>. In 2004, the leading external cause of death in South Africa was sharp force injury (13.6%) followed by firearms (10.8%) <sup>4</sup>. Sharp objects are the main cause of homicides in Cape Town, East London and Port Elizabeth, whereas the main cause of homicide in Pretoria, Johannesburg and Durban is due to firearms <sup>5</sup>.

From these statistics it is clear that sharp force injury is a common injury occurring in Cape Town corresponding to what is experienced at the Trauma Centre of Groote Schuur Hospital.

## **2. LITERATURE REVIEW**

### **2.1 Overview of the Management of Thoracoabdominal Stab Wounds**

The first diaphragmatic hernia described in Western literature was in 1541 by Sennertus <sup>6</sup>. In 1579 Ambrose Pare, a French surgeon, reported the first traumatic diaphragmatic hernia. The patient, a French artillery captain survived the hernia but died 8 months later from complications of a clamped, gangrenous hernia through a small diaphragmatic defect <sup>7</sup>.

Riolfi performed the first successful repair of a traumatic diaphragmatic hernia in a patient with omental prolapse in 1886 <sup>8</sup>. In 1888 Naumann repaired a hernia of the stomach into the left chest that was caused by trauma <sup>9</sup>.

Until the late 19<sup>th</sup> century penetrating abdominal trauma was managed conservatively, with rest, wound dressings, bloodletting and opium, with resultant high mortality rates <sup>10</sup>. In the early part of the 20<sup>th</sup> century around the time of World War I and the gradual improvement of general anaesthetic techniques, operative management became the accepted standard for penetrating wounds to the abdomen. It is now clear that not all penetrating abdominal wounds require surgery. Studies started appearing in the early 1960's suggesting that mandatory exploratory laparotomies are unnecessary in treating penetrating wounds to the abdomen <sup>11</sup>. Since the late 1980's selective non-operative management of abdominal stab wounds has become the standard of care around the world <sup>12</sup>.

The problem with selective non-operative management of TA stab wounds is that patients with isolated diaphragm injuries do not develop any peritoneal signs and may then develop a late diaphragm hernia if an injury to the diaphragm is missed. To overcome this it was initially proposed by Stylianos et al. <sup>13</sup> that all left side TA stab wounds should receive a laparotomy to rule out a diaphragm injury. During the mid 1990's, when videoscopes were introduced and popularised in other areas of surgery, numerous studies confirmed that laparoscopy and thoracoscopy are very sensitive and specific in detecting diaphragm injury. Even today with modern multidetector CT (MDCT) and magnetic resonance imaging, direct vision of the diaphragm with laparoscopy and thoracoscopy remain the gold standard of diagnosing a diaphragm injury <sup>14</sup>. However, controversy persists whether videoscopic assessment or clinical observation for asymptomatic patients is the best treatment.

We hypothesized that careful clinical and Chest X-ray (CXR) follow up of patients with potential occult diaphragm injuries is sufficient to prove healing. This systematic review was

conducted in order to interrogate the available literature and particularly to answer the following questions.

1. The incidence of diaphragm injuries
2. The incidence of a delayed diaphragm hernia
3. Complications of a delayed diaphragm hernia
4. Natural course of diaphragmatic wounds
5. Financial implications of routine laparoscopy to diagnose injury of the diaphragm
6. Incidence of diaphragm injury in trauma patients with asymptomatic left thoracoabdominal stab wounds

## **2.2 Methods**

### *2.2.1 Search Strategy*

A computerized search of the National Library of Medicine and the National Institutes of Health MEDLINE database was undertaken using the Entrez PubMed ([www.pubmed.gov](http://www.pubmed.gov)) interface. The primary search strategy was developed to retrieve English language articles focusing on occult diaphragm injuries on penetrating TA trauma starting from 1980 and continuing to 2014; articles related to paediatric trauma, blunt trauma, review articles, letters to the editor, editorials, other items of general commentary and case reports were excluded from the search. The systematic review search strategy is diagrammatically presented in table 2.1

**Table 2.1 Systematic Review Search Strategy**

	Search Text	Citations
1	Trauma	769103
2	Diaphragm	38664
3	Penetrating	30824
4	Trauma and diaphragm	3663
5	Penetrating and Diaphragm and Trauma	347

### 2.2.2 Selection criteria

Studies included in the systematic review pertaining to the management of penetrating TA trauma in adult populations were selected regardless of origin, hospital setting, or study design. In addition animal studies related to the natural healing of diaphragm injuries were included.

### 2.2.3 Data Collection and Extraction

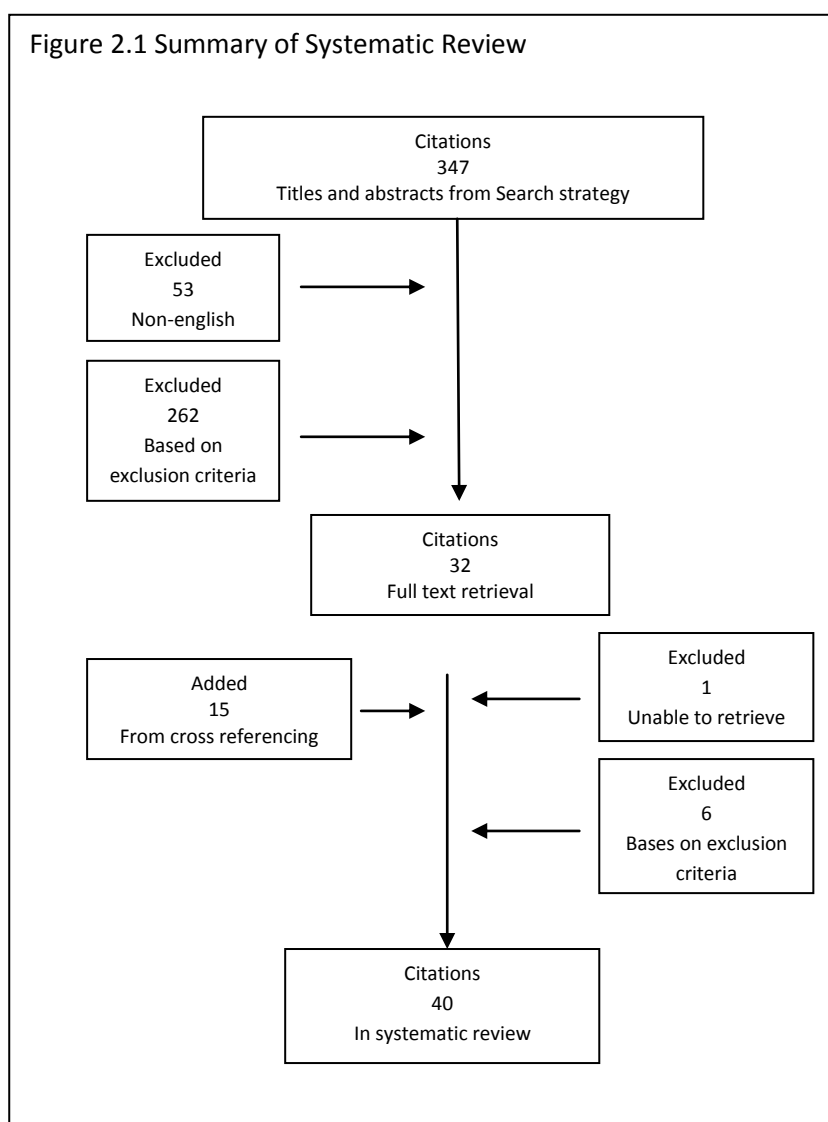
Data was collected and recorded on a data collection form (See Appendix 1). Extracted data included authors, year of publication, study design, country of study, hospital setting, number of subjects and outcome.

## 2.3 Results

### 2.3.1 Articles for inclusion

Figure 2.1 illustrates the results of the systematic review. Using the search strategy as explained above in 2.6.1, 347 titles and abstracts were found related to the management of penetrating TA trauma in adult populations. Two hundred and sixty two were rejected based on exclusion criteria. Fifty three articles were excluded because they were not English. The

remaining thirty two titles and abstracts were retrieved for full-text review. To these, thirty two titles, fifteen were cross-referenced to ensure a thorough review. From this, seven titles and abstracts were excluded, one because it was not accessible and six were excluded. In total forty full-text articles were extracted for the systematic review.



### 2.3.2 Qualitative Overview of Articles in Systematic Review

As mentioned previously this systematic review was conducted in order to interrogate the available literature and particularly to answer the following questions.

1. The incidence of diaphragm injuries
2. The incidence of a delayed diaphragm hernia
3. Complications of a delayed diaphragm hernia
4. Natural course of diaphragmatic wounds
5. Financial implications of routine laparoscopy to diagnose injury of the diaphragm
6. Incidence of Diaphragm Injury in Trauma Patients with Asymptomatic Left TA Stab Wounds

### *2.3.3 The Incidence of Diaphragm Injuries*

TA trauma is a term that can include a wide variety of causative trauma, while data is lacking in the literature and very often inconclusive. Dajee, et. al.,<sup>15</sup> (1981) estimated that the incidence of diaphragm injuries in patients with TA trauma is more than 5 per cent. The true incidence of diaphragm injuries in patients with TA trauma is not known. Most studies investigate a subgroup of patients and the exact incidence of diaphragm injuries in all patients with penetrating TA trauma is not known. If one looks at all patients presenting to a trauma unit with TA trauma, only one study could be found, which mention diaphragm injury in this group of patients. Rubikas, et al.,<sup>16</sup> reported on the incidence investigating two groups of patients. Looking at forensic data in a group of patients with penetrating TA trauma, diaphragm injury occurred in thirty one out of one thousand two hundred and ten patients which represent an incidence of 2.1 per cent. They also looked at one thousand seven hundred and forty nine patients with penetrating thoracoabdominal trauma on their trauma database which revealed sixty nine diaphragm injuries or an incidence of 3.9 per cent.

From this limited data it is apparent that the true incidence of diaphragm injuries, following trauma, is not known but is likely to be less than what is currently believed.

#### *2.3.4 Incidence of a Delayed Diaphragm Hernia*

Again there are very few studies investigating specifically delayed post traumatic diaphragm hernias. There seems to be uncertainty of what exactly constitutes the definition of a delayed hernia and the time elapsed before it can be called a delayed hernia.

Only 2 articles could be found that specifically addresses this question. The incidence of delayed diaphragm hernia based on published data by Feliciano, et.al. 1988<sup>17</sup> appears to be extremely rare. In this retrospective review, the author stated that during a 9 year period, during which 450-510 patients with penetrating chest trauma were seen, sixteen patients presented with delayed diaphragm hernias, which varied in time of presentation from hours to years. The sixteen patients equates to an incidence of 2.7% over 9 years or 0.3% per year. Unfortunately the problem with this data is that it does not state exactly how many of these patients with penetrating chest trauma stab wounds were specifically to the left TA region.

If one reviews a more select group of patients with left TA stab wounds, the incidence of delayed diaphragm hernia appears to increase. The only research describing delayed diaphragm hernia, in this select group of patients was done by Leppaniemi, et al.,<sup>18</sup>. Their data showed an incidence of 4% of a total of fifty patients in a retrospective analysis done on a group of patients that were followed up for 10 years. The time to delayed presentation varied from 2 to 23 months.

Other studies investigating delayed diaphragm hernias were mostly case series or case reports and it was not possible to ascertain an incidence in the study population. From the literature it can be concluded that the true incidence of diaphragm injury of all patients with left TA stab wounds is unknown.

The current best evidence studying long term follow up, although retrospective, show delayed presentation of diaphragm injuries in patients with stab wounds to the left diaphragm tend to occur within the first two years of follow up, however the level of evidence is poor.

### *2.3.5 Complications of a Delayed Diaphragm Hernia*

Madden et al.,<sup>2</sup> did a retrospective, single centre review looking at selected cases of delayed presentation of diaphragmatic injuries due to stab wounds. This sample included 28 patients, mean age of 32 years, with a mortality rate of 36%. Eighty five per cent, or six of the seven patients shown to have gangrenous viscera, died. Reber et. al.,<sup>19</sup> reported the treatment of 10 patients with late presentations of traumatic diaphragmatic hernias, eight patients sustained blunt trauma, and two were victims of penetrating injuries. Hernias were present on the left side and right side in eight and two patients, respectively. The time lapse between trauma and clinical presentation of delayed hernias ranged from 20 days to 28 years. All of these patients underwent laparotomies, and concomitant thoracotomies were necessary in two cases. Only one patient died (10% mortality), and three (30 %) sustained postoperative complications.

Degiannis et al.<sup>20</sup> analysed patients with delayed presentation of diaphragm hernia. Four patients (25%) died, but three of these patient sustained initial gunshot wounds.

Analysing data published after 2000<sup>18,20</sup>, a zero mortality rate can be seen. Both studies consisted of small numbers which probably represents an increased awareness of diaphragm injury and the low mortality could be attributed to better and improved trauma resuscitation and intensive care treatment.

In conclusion the high mortality initially reported in the 1970's and 1980's seems to be decreasing with modern management of trauma patients. This is probably due to a high index of suspicion, clinical awareness of the complications and modern state of the art intensive care facilities although, this is difficult to assess because of low patient numbers and poor level of documented evidence for this rare complication of diaphragm injuries.

#### *2.3.6 Natural course of diaphragmatic wounds*

It would seem that the natural history of diaphragm injuries has not been adequately studied in humans. Five animal studies have been published since 2001: all studying whether diaphragm injuries heal spontaneously<sup>21-25</sup>.

Perlingeiro et al.,<sup>23</sup> studied the course of diaphragmatic injuries in rats. The diaphragmatic tear was produced by a videolaparoscopy trocar under general anesthesia. Animals were observed for six months, and complete diaphragmatic healing was observed in approximately 90% of the animals, while diaphragmatic hernias were present in 10%.

A similar phenomenon was observed by Gamblin et al.,<sup>24</sup> who studied 48 rats in an experimental model of diaphragmatic injuries produced by a 16-gauge needle puncture or 2.7-mm aortic punch. Half the animals in each group were euthanized at one month and the other half at 10 months after the operative procedure. In only one animal, in the aortic punch group, a small hepatic herniation through the diaphragm (8%) was observed at 10 months. All other animals demonstrated no signs of herniation.

Shatney CH et al.,<sup>21</sup> did a study on 8 pigs with 1.5 to 2 centimetre lacerations to the diaphragm. After 6 weeks 15 out of 16 (93%) of the lacerations had healed.

Zierold et. al.,<sup>25</sup> studied seven pigs euthanized twelve weeks after a 3 centimetre diaphragm injury. All the diaphragm injuries healed if no herniation of omentum or abdominal visera, occurred during the healing process. Therefore, the pig diaphragm will heal if the edges are opposed during the healing period. A similar conclusion was made by Marray et. al.,<sup>22</sup> who approximated the edges of the diaphragm injury in a pig model with a laparoscopic stapling device. Of course, these studies do not pertain specifically to humans. The size of the diaphragmatic wound is a very important factor that cannot be controlled for in human trauma cases.

In conclusion, at least in animals, the reported data show that the diaphragm can heal without hernia development.

### *2.3.7 Financial implications of routine laparoscopy to diagnose injury of the diaphragm*

According to The Eastern Association for the Surgery of Trauma (EAST) guidelines<sup>26</sup> it recommends that all asymptomatic left sided TA stab wounds undergo a diagnostic laparoscopy to exclude or diagnose an occult diaphragm injury.

Demetriades et al.,<sup>27</sup> described an algorithm for treating haemodynamically stable patients sustaining TA wounds without peritoneal signs. In this protocol, videolaparoscopy is indicated if the wound is located on the left TA area. These researchers<sup>27</sup> accepted the risks associated if right diaphragmatic tears were not sutured, but active searching for left diaphragmatic lesions was routinely indicated. This approach has significant cost implication particularly in developing countries. A cost analysis done by Leppaniemi et al.<sup>18</sup> comparing laparoscopy with observation based strategies in all asymptomatic patients, with epigastric or TA penetrating trauma, showed adding laparoscopy to the diagnostic algorithm was significantly more expensive and increased hospital costs by approximately 1.000 EUR (R13000) per patient.

As deduced by the research team if one takes into account that the incidence of delayed diaphragm hernia in an asymptomatic population is 4 per cent<sup>18</sup> the cost to stop one delayed hernia from occurring would be 25.000 EUR. If converted to rand and inflation factored in at 5 percent per year, this would equate to R599741.00 at exchange rates in December 2014. This cost is not sustainable in a developing world health system.

### *2.3.8 Incidence of Diaphragm Injury in Trauma Patients with Asymptomatic Left*

#### *Thoracoabdominal Stab Wounds*

The incidence of diaphragmatic injuries depends mainly on the location of the wound and the mechanism of trauma. Among patients with penetrating TA trauma, who routinely undergo videolaparoscopy or videothoracoscopy, the incidence of diaphragmatic injuries ranges from 9% to 64%<sup>2, 18, 13, 28-44</sup>. These studies looked at a wide variety of patients and are difficult to compare. The included patients were, symptomatic or asymptomatic, had stab or gunshot wounds and had trauma to the left and/or right thoracoabdominal area. Table 2.3 represents an updated summary of all the studies investigating the incidence of diaphragm injury in patients with TA penetrating trauma.

LAPAROSCOPY (TO DETECT OCCULT DIAPHRAGM INJURY) VERSUS CLINICAL AND RADIOLOGICAL FOLLOW UP TO DETECT DIAPHRAGM INJURY AND HERNIATION, IN PATIENTS WITH ASYMPTOMATIC LEFT THORACOABDOMINAL STAB WOUNDS

A RANDOMIZED CONTROLLED STUDY

Malherbe GF

Table 2.3 Incidence of diaphragm injury in penetrating trauma

Citation	Study Design	Patient numbers	Incidence of Diaphragm injury	Outcomes examined	Conclusions	Limitations	Level of evidence
<b>Jackson et al. 1976</b> (39)	Prospective	11	18%	Effectiveness of thoracoscopy in diagnosis	Thoracoscopy safe and effective	Small number Site not well stated	4
<b>Madden et al. 1989</b> (2)	Retrospective	95	19%	Oculta diaphragmatic injury	Laparotomy should be considered for all thoracoabdominal stab wounds	Right and left sided Not Asymptomatic wounds	4
<b>Stylianios et al. 1992</b> (13)	Prospective	20	60%	Incidence of diaphragm injury at laparotomy	Laparotomy should be considered for all anterior thoracoabdominal stab wounds	Not asymptomatic Only anterior stabs Right and left sided	3
<b>Ivatory et al. 1992</b> (43)	Retrospective	34	20%	Laparoscopy in diagnosis	Laparoscopy safe and effective	Stab and GSW wounds Right and left sided	4
<b>Ochsner et al. 1993</b> (33)	Prospective	14	64%	Effectiveness Thoracoscopy in diagnosis	Thoracoscopy safe and effective	Not asymptomatic Right and left sided GSW and Stab wounds	4
<b>Uribe et al. 1994</b> (34)	Prospective	28	32%	Effectiveness Thoracoscopy in diagnosis	Thoracoscopy safe and effective	Not asymptomatic Right and left sided GSW and Stab wounds	4
<b>Nel et al. 1994</b> (38)	Prospective	55	40%	Effectiveness Thoracoscopy in	Thoracoscopy safe and effective	Anterior stab wounds only	4

**LAPAROSCOPY (TO DETECT OCCULT DIAPHRAGM INJURY) VERSUS CLINICAL AND RADIOLOGICAL FOLLOW UP TO DETECT DIAPHRAGM INJURY AND HERNIATION, IN PATIENTS WITH ASYMPTOMATIC LEFT THORACOABDOMINAL STAB WOUNDS**

**A RANDOMIZED CONTROLLED STUDY**

Malherbe GF

diagnosis							
<b>Ertekin et al. 1998</b> (41)	Prospective	51	50%	Laparoscopy in diagnosis and treatment	Laparoscopy safe and effective	Right and left sided GSW and Stab wounds Site not well stated	4
<b>Murray et al. 1998</b> (32)	Prospective	110	24%	Incidence of Occult diaphragm injuries	Incidence of injury high Laparoscopy should be considered for all left sided thoracoabdominal stab wounds	Stab and GSW wounds	4
<b>Marinez et al. 2001</b> (40)	Prospective	52	67%	Effectiveness Thoracoscopy in diagnosis and treatment	Thoracoscopy safe and effective	Right and left sided GSW and Stab wounds	4
<b>Morales et al. 2001</b> (42)	Longitudinal cohort study	82	63%	Effectiveness digital exploration in diagnosis	Digital exploration is a reliable method to diagnose injuries		4
<b>Freeman et al. 2001</b> (29)	Retrospective	171	35%	Effectiveness Thoracoscopy in diagnosis	Thoracoscopy safe	Right and left sided GSW and Stab wounds	4
<b>McQuay et.al 2003</b> (30)	Retrospective	80	27%	Effectiveness of diagnostic laparoscopy to diagnose diaphragm injury	Laparoscopy is safe and effective	Right and left sided GSW and Stab wounds Only anterior wounds	4
<b>Leppaniemi et al. 2003</b> (18)	Retrospective	47	9%	Incidence of occult diaphragm injuries	Laparoscopy should be considered for all thoracoabdominal stab wounds	Right and left sided Anterior stab wounds only	3
<b>Friese et al.</b>	Prospective	34	23%	Effectiveness laparotomy in	Laparoscopy is safe and effective	Right and left sided One GSW patient	4

**LAPAROSCOPY (TO DETECT OCCULT DIAPHRAGM INJURY) VERSUS CLINICAL AND RADIOLOGICAL FOLLOW UP TO DETECT DIAPHRAGM INJURY AND HERNIATION, IN PATIENTS WITH ASYMPTOMATIC LEFT THORACOABDOMINAL STAB WOUNDS**

**A RANDOMIZED CONTROLLED STUDY**

Malherbe GF

<b>2005 (31)</b>	case series			diagnosis			
<b>Paci et al. 2006 (35)</b>	Prospective	16	38%	Effectiveness Thoracoscopy in diagnosis	Thoracoscopy safe and effective	Right and left sided GSW and Stab wounds	4
<b>Powell et al. 2008 (28)</b>	Retrospective	108	20%	Effectiveness Thoracoscopy in diagnosis and treatment	Incidence of injury high Laparoscopy should be considered for all left sided thoracoabdominal stab wounds	Right and Left sided Stab and GSW	4
<b>Opasanon et al. 2009 (36)</b>	Prospective	24	17%	Role of laparoscopy in management	Laparoscopy is safe and effective	Right and left sided Site not stated	4
<b>Bagheri et al. 2009 (46)</b>	Prospective	30	16%	Effectiveness Thoracoscopy in diagnosis and treatment	Thoracoscopy safe and effective	Right and left sided	4
<b>Clarke et al. 2009 (37)</b>	Retrospective	13	38%	Spectrum of diaphragm injury	High index of suspicion for diaphragm injury Laparoscopy should be done for all left thoracoabdominal stabs	Small number Subgroup of retrospective database Site not well stated	4
<b>Mjoli et al. 2014 (44)</b>	Prospective	55	40%	Incidence of occult diaphragm injury and the feasibility of laparoscopic repair	Incidence occult diaphragm injury high and laparoscopy safe in repair and effective in diagnosis	GSW and stab wounds	4

**LAPAROSCOPY (TO DETECT OCCULT DIAPHRAGM INJURY) VERSUS CLINICAL AND RADIOLOGICAL FOLLOW UP TO DETECT DIAPHRAGM INJURY AND HERNIATION, IN PATIENTS WITH ASYMPTOMATIC LEFT THORACOABDONIMAL STAB WOUNDS**

A RANDOMIZED CONTROLLED STUDY

Malherbe GF

**Table 2.4 Incidence of diaphragm injury in patients with stab wounds**

<b>Citation</b>	<b>Patient number</b>	<b>Incidence of Diaphragm injury overall</b>	<b>Left and right sided injuries</b>	<b>Left sided injuries</b>	<b>Comments</b>
<b>Sylianos et al. 1992 (13)</b>	20	64%		64%	Not asymptomatic
<b>Ochsner et al. 1993 (33)</b>	14	64%	63%	18%	Not asymptomatic
<b>Nel et al. 1994 (38)</b>	55	40%		40%	Anterior stab wounds only
<b>Uribe et al. 1994 (34)</b>	28	32%	37%		
<b>Murray et al. 1998 (32)</b>	110	24%		26%	Best data, Occult left TA stab wounds
<b>Morales et al. 2001 (42)</b>	82	63%		63%	Best data, Occult left TA stab wounds
<b>Freeman et al. 2001 (29)</b>	86	35%	23%		
<b>Leppaniemi et al. 2003 (18)</b>	47	9%	9%	6%	Anterior stab wounds only
<b>McQuay et.al 2003 (30)</b>	80	27.5%	18%		
<b>Friese et al. 2005 (45)</b>	34	23%	18%		
<b>Powell et al. 2008 (28)</b>	108	20%	23%		
<b>Clarke et al. 2009 (37)</b>	13	38%		38%	Occult left TA stab wounds, TA region not well defined
<b>Bagheri et al. 2009 (46)</b>	30	16%	16%		
<b>Mjoli et al. 2014 (44)</b>	55	40%		38%	Best data, Occult left TA stab wounds

Studies which excluded gunshot wounds and only include stab wound patients who were also symptomatic or asymptomatic and left and/or right TA injuries showed an incidence of diaphragm injury of 9% to 63%<sup>18, 13, 28-34, 37, 34, 44, 46</sup>. This is represented in Table 2.4

If one scrutinizes specifically asymptomatic patients with TA stab wounds, left and/or right, the incidence of diaphragm injury varies between 9% and 37%<sup>18, 28-30, 34,45,47</sup>. This is represented in Table 2.4

If the criteria is further narrowed down to occult left TA stab wounds, the incidence of diaphragm injury as diagnosed by laparotomy, laparoscopy or thoracoscopy is 28%, 38% and 63% in the 3 studies in the literature published on the subject<sup>32, 42, 45</sup>. These 3 papers are the only studies in the literature that report on the incidence of left sided occult diaphragm injuries after TA stab wounds comparable to the study undertaken by the research team. This is represented in Table 2.5.

**Table 2.5 Incidence of Occult Diaphragm Injury in Left Thoracoabdominal Stab Wounds**

Citation	Study design	Sample size	Left sided stab wounds
Murray et al. 1998 (32)	Prospective descriptive study	110	26%
Morales et al. 2001 (42)	Longitudinal cohort study	82	63%
Mjoli et al. 2014 (44)	Prospective consecutive case series	55	38%

#### 2.4 Summary of Review of Literature

The true incidence of diaphragm injuries in patients with penetrating TA trauma is variable and cannot be specifically determined. Likewise, the true incidence of delayed diaphragm hernia in patients with stab wounds to the left TA region is unknown, but from limited data it seems to be less than 5%. Mortality from delayed diaphragm hernia due to left TA stab wounds is reported to be high but the numbers in all case series are small and there seems to be an improvement in survival in reports published after 1990, probably mainly because of better intensive care facilities and treatment. The incidence of occult diaphragm injury due to left-sided TA stab wounds is between 28% and 63%. However less than 5% of patients present with delayed diaphragm hernia. This makes one wonder what happens to the other 23% to 58% of patients with injuries. The most likely answer is that they heal spontaneously as demonstrated in animal studies. To save one life, if one assumes that the mortality associated is as high as 25% one would need to spend R2 400 000 on hospitalisation which has to be questioned in the resource limited developing world.

## 2.5 Aims of the Study

Based on the above mentioned literature review, the non-operative management of patients with abdominal stab wounds, without obvious clinical or radiological signs of organ injury requiring surgical repair, has become a widely used therapeutic strategy<sup>24</sup>. The standard initial approach to haemodynamically unstable patients sustaining TA injuries is surgery (laparotomy and / or thoracotomy).

Laparotomy is preferred for injuries exhibiting clear signs of peritonitis. Operative treatment is also used in stable patients in whom a cardiac, major vascular or esophageal injury is detected on diagnostic imaging. These injuries are usually detected during a comprehensive diagnostic work-up, which depends on the suspected injury and may involve focused assessment with sonography for trauma (FAST), computed axial tomography (CT), angiography, and/or endoscopy. The most challenging diagnostic issue in this situation concerns asymptomatic patients. The diaphragm is an organ that is difficult to evaluate, because of low sensitivity and specificity of non-invasive diagnostic imaging. Therefore, without operative intervention, missing diaphragm injuries may have significant implications for long term morbidity and mortality. Unfortunately the natural history of diaphragm injuries is not well known. In a recent review by Parreira et. Al.<sup>47</sup> the author stated that some questions in the management of asymptomatic patients sustaining TA wounds remain unanswered:

1. Should these patients be systematically submitted to operative procedures such as laparoscopy or thoracoscopy in order to diagnose a possible diaphragmatic injury?
2. Should the diaphragmatic injury always be sutured?

3. Can these patients be safely initially observed, undergoing operative procedures only if a diaphragmatic hernia develops?
4. How high are the morbidity and mortality risks for delayed repair of diaphragmatic hernias?

This study will aim to address points number 1 to 3. The safety of clinical observation of occult diaphragm injuries in a group of patients presenting to the Groote Schuur Hospital Trauma Centre with left sided TA stab wounds will be evaluated when an expectant non operative management course is pursued. To evaluate this hypothesis a prospective randomized control trial was undertaken.

### 3 REFERENCES

1. Schumpelick V, Steinau G, Schlüper I, et al. Surgical embryology and anatomy of the diaphragm with surgical applications. *Surg Clin North Am* 2000;80(1):213-239.
2. Madden MR, Paull DE, Finkelstein JL, et al. Occult diaphragmatic injury from stab wounds to the lower chest and abdomen. *Journal of Trauma and Acute Care Surgery* 1989;29(3):292-298.
3. Donson H, Laher H, Goldberg D, et al. A profile of fatal injuries in South Africa 2008: Annual report of the national injury mortality surveillance system (NIMSS)2008. Cape Town: MRC/UNISA Crime, Violence and Injury Lead Programme Technical Report; 2009. Available at: [http:// www.mrc.ac.za/crime/nimss2008.pdf](http://www.mrc.ac.za/crime/nimss2008.pdf)
4. The Open Society Foundation for South Africa. Violence in South Africa: critical perspectives; 2004. Available at: [http:// osf.org.za/wp/wp-content/uploads/2012/09/Violence-in-South-Africa\\_Critical-perspectives\\_2004.pdf](http://osf.org.za/wp/wp-content/uploads/2012/09/Violence-in-South-Africa_Critical-perspectives_2004.pdf)
5. Leppäniemi AK, Haapiainen RK. Selective nonoperative management of abdominal stab wounds: prospective, randomized study. *World J Surg* 1996;20(8):1101-1106.
6. Schneider CF. Traumatic diaphragmatic hernia. *The American Journal of Surgery* 1956;91(2):290-297.
7. Paré A, Hamby WB, Malgaignes J. The case reports and autopsy records of Ambroise Paré. : Charles C. Thomas; 1960.
8. Hedblom CA. Diaphragmatic hernia: A study of three hundred and seventy-eight cases in which operation was performed. *J Am Med Assoc* 1925;85(13):947-953.
9. Naumann G. Diaphragmatic hernia. *Hygiea* 1888;5:524.

10. Loria FL. Historical aspects of penetrating wounds of the abdomen. *Int Abstracts Surg* 1948;87:521-49.
11. Shaftan GW. Indications for operation in abdominal trauma. *The American Journal of Surgery* 1960;99(5):657-664.
12. Robin AP, Andrews JR, Lange DA, et al. Selective management of anterior abdominal stab wounds. *Journal of Trauma-Injury, Infection, and Critical Care* 1989;29(12):1684-1689.
13. Stylianos S, King TC. Occult diaphragm injuries at celiotomy for left chest stab wounds. *Am Surg* 1992 Jun;58(6):364-368.
14. Stein DM, York GB, Boswell S, et al. Accuracy of computed tomography (CT) scan in the detection of penetrating diaphragm injury. *J Trauma* 2007;63(3):538-543.
15. Dajee A, Schepps D, Hurley EJ. Diaphragmatic injuries. *Surg Gynecol Obstet* 1981 Jul;153(1):31-32.
16. Rubikas R. Diaphragmatic injuries. *European journal of cardio-thoracic surgery* 2001;20(1):53-57.
17. Feliciano DV, Cruse PA, Mattox KL, et al. Delayed diagnosis of injuries to the diaphragm after penetrating wounds. *Journal of Trauma-Injury, Infection, and Critical Care* 1988;28(8):1135-1144.
18. Leppäniemi A, Haapiainen R. Occult diaphragmatic injuries caused by stab wounds. *Journal of Trauma-Injury, Infection, and Critical Care* 2003;55(4):646-650.

19. Reber P, Schmied B, Seiler C, et al. Missed diaphragmatic injuries and their long-term sequelae. *Journal of Trauma and Acute Care Surgery* 1998;44(1):183-188.
20. Degiannis E, Levy R, Sofianos C, et al. Diaphragmatic herniation after penetrating trauma. *Br J Surg* 1996;83(1):88-91.
21. Shatney CH, Sensaki K, Morgan L. The natural history of stab wounds of the diaphragm: implications for a new management scheme for patients with penetrating thoracoabdominal trauma. *Am Surg* 2003 Jun;69(6):508-513.
22. Murray JA, Cornwell III EE, Velmahos GC, et al. Healing of traumatic diaphragm injuries: comparison of laparoscopic versus open techniques in an animal model. *J Surg Res* 2001;100(2):189-191.
23. Perlingeiro JA, Saad R,Jr, Lancelotti CL, et al. Natural course of penetrating diaphragmatic injury: an experimental study in rats. *Int Surg* 2007 Jan-Feb;92(1):1-9.
24. Gamblin TC, Wall Jr CE, Morgan III JH, et al. The natural history of untreated penetrating diaphragm injury: an animal model. *Journal of Trauma-Injury, Infection, and Critical Care* 2004;57(5):989-992.
25. Zierold D, Perlstein J, Weidman ER, et al. Penetrating trauma to the diaphragm: natural history and ultrasonographic characteristics of untreated injury in a pig model. *Archives of surgery* 2001;136(1):32-37.
26. Como JJ, Bokhari F, Chiu WC, et al. Practice Management Guidelines for Selective Nonoperative Management of Penetrating Abdominal Trauma. *J Trauma* 2010;68 (3): 721-33

27. Demetriades D, Kakoyiannis S, Parekh D, et al. Penetrating injuries of the diaphragm. *Br J Surg* 1988;75(8):824-826.
28. Powell BS, Magnotti LJ, Schroepfel TJ, et al. Diagnostic laparoscopy for the evaluation of occult diaphragmatic injury following penetrating thoracoabdominal trauma. *Injury* 2008;39(5):530-534.
29. Freeman RK, Al-Dossari G, Hutcheson KA, et al. Indications for using video-assisted thoroscopic surgery to diagnose diaphragmatic injuries after penetrating chest trauma. *Ann Thorac Surg* 2001;72(2):342-347.
30. McQuay N, Jr, Britt LD. Laparoscopy in the evaluation of penetrating thoracoabdominal trauma. *Am Surg* 2003 Sep;69(9):788-791.
31. Friese RS, Coln CE, Gentilello LM. Laparoscopy is sufficient to exclude occult diaphragm injury after penetrating abdominal trauma. *Journal of Trauma-Injury, Infection, and Critical Care* 2005;58(4):789-792.
32. Murray JA, Demetriades D, Asensio JA, et al. Occult injuries to the diaphragm: prospective evaluation of laparoscopy in penetrating injuries to the left lower chest. *J Am Coll Surg* 1998;187(6):626-630.
33. Ochsner MG, Rozycki GS, Lucente F, et al. Prospective evaluation of thoracoscopy for diagnosing diaphragmatic injury in thoracoabdominal trauma: a preliminary report. *Journal of Trauma-Injury, Infection, and Critical Care* 1993;34(5):704-710.

34. Uribe RA, Pachon CE, Frame SB, et al. A prospective evaluation of thoracoscopy for the diagnosis of penetrating thoracoabdominal trauma. *Journal of Trauma and Acute Care Surgery* 1994;37(4):650-654.
35. Paci M, Ferrari G, Annessi V. The role of diagnostic VATS in penetrating thoracic injuries. *World Journal of Emergency Surgery* 2006;1:30.
36. Opananon S, Akaraviputh T, Keorochana K, et al. The role of laparoscopic management in suspected traumatic diaphragmatic injury patients: a tertiary care center experience. *Medical journal of the Medical Association of Thailand* 2009;92(7):903.
37. Clarke D, Greatorax B, Oosthuizen G, et al. The spectrum of diaphragmatic injury in a busy metropolitan surgical service. *Injury* 2009;40(9):932-937.
38. Nel J, Warren B. Thoracoscopic evaluation of the diaphragm in patients with knife wounds of the left lower chest. *Br J Surg* 1994;81(5):713-714.
39. Jackson A, Ferreira A. Thoracoscopy as an aid to the diagnosis of diaphragmatic injury in penetrating wounds of the left lower chest: a preliminary report. *Injury* 1976;7(3):213-217.
40. Martinez M, Briz J, Carillo E. Video thoracoscopy expedites the diagnosis and treatment of penetrating diaphragmatic injuries. *Surg Endosc* 2001;15(1):28-32.
41. Ertekin C, Onaran Y, Güloğlu R, et al. The use of laparoscopy as a primary diagnostic and therapeutic method in penetrating wounds of lower thoracic region. *Surgical Laparoscopy Endoscopy & Percutaneous Techniques* 1998;8(1):26-29.

42. Morales CH, Villegas MI, Angel W, Vásquez JJ. Value of digital exploration for diagnosing injuries to the left side of the diaphragm caused by stab wounds. *Archives of Surgery* 2001;136(10):1131-1135.
43. Ivatury RR, Simon RJ, Weksler B, et al. Laparoscopy in the evaluation of the intrathoracic abdomen after penetrating injury. *Journal of Trauma-Injury, Infection, and Critical Care* 1992;33(1):101-109.
44. Mjoli M, Oosthuizen G, Clarke D, et al. Laparoscopy in the diagnosis and repair of diaphragmatic injuries in left-sided penetrating thoracoabdominal trauma. *Surg Endosc* 2014:1-6.
45. Friese RS, Coln CE, Gentilello LM. Laparoscopy is sufficient to exclude occult diaphragm injury after penetrating abdominal trauma. *Journal of Trauma-Injury, Infection, and Critical Care* 2005;58(4):789-792.
46. Bagheri R, Tavassoli A, Sadrizadeh A, et al. The role of thoracoscopy for the diagnosis of hidden diaphragmatic injuries in penetrating thoracoabdominal trauma. *Interactive cardiovascular and thoracic surgery* 2009;9(2):195-198.
47. Parreira JG, Rasslan S, Utiyama EM. Controversies in the management of asymptomatic patients sustaining penetrating thoracoabdominal wounds. *Clinics* 2008;63(5):695-700.

## **CHAPTER 2**

### **PUBLICATION-READY MANUSCRIPT**

#### **2.1 Title page**

##### *2.1.1 Title of paper*

Laparoscopy (to detect occult diaphragm injury) versus clinical and radiological follow up to detect diaphragm injury and herniation, in patients with asymptomatic left thoracoabdominal stab wounds: A prospective randomized controlled study.

##### *2.1.2 Authors*

- Gideon F. Malherbe, FCS
- Pradeep H. Navsaria, FCS, MMed, FACS
- Andrew J. Nicol, FCS, PhD
- Sorin Edu, FCS

Trauma Centre, Department of Surgery, Groote Schuur Hospital, University of Cape Town, South Africa

##### *2.1.3 Supplementary information*

Corresponding author: Gideon F. Malherbe, FCS, Trauma Centre, Groote Schuur Hospital, University of Cape Town, Anzio Rd., Cape Town 7925, South Africa. E-mail: [francois.malherbe@uct.ac.za](mailto:francois.malherbe@uct.ac.za)

Reprints: No reprints

Disclosure: Supported by funding from the Medical Research Council of South Africa. The authors declare no conflict of interest.

## 2.2 Mini abstract

It is controversial whether all asymptomatic left thoracoabdominal stab wound patients with potential occult diaphragm injury should undergo routine diagnostic videoscopy. We show that it is safe to treat these patients with close clinical observation and chest X-ray follow up for a six week period while healing occurs.

## 2.3 Structured abstract

### ABSTRACT

**Background:** The need to exclude occult diaphragmatic injury in left thoracoabdominal (TA) stab wounds continues to be controversial. Current trauma guidelines recommend either routine diagnostic thoracoscopy or laparoscopy and repair of an injury if found.

**Objective:** To determine if asymptomatic patients with left sided (TA) stab wounds can be safely treated with careful clinical and chest X-ray follow up to ascertain healing of occult injuries.

**Methods:** A parallel-group, prospective, randomized control study was conducted at the Trauma Centre at the Groote Schuur Hospital from 01 September 2009 through to 01 November 2014. All patients with asymptomatic left TA stab wounds included in the trial

were randomized into two groups. Group A underwent diagnostic laparoscopy to exclude a diaphragm injury, and Group B underwent clinical and radiological follow up.

**Results:** Twenty seven patients were randomized to Group A (n=27) and thirty one to Group B (n=31). All patients were young males with a median age of 26 years (range from 18 to 48). The incidence of occult diaphragm injury in group A was 29%. Occult injuries found at laparoscopy were all repaired. All patients in group 2 had normal chest X-rays and no symptoms at their last visit. The mean follow up time was 24 months (range of 0 to 58). There was no morbidity nor mortality associated with the conservative management of occult diaphragmatic injuries. The mean hospital stay for the patients in Group A was 5 days (SD 1.3), compared to a mean hospital stay of 2.9 days (SD, 1.5)  $p < 0.001$ , in Group B.

**Conclusions:** Clinical and radiological follow up is feasible and appears to be safe in patients with occult diaphragm injuries after left TA stab wounds. (ClinicalTrials.gov Identifier: NCT01044550)

## 2.4 MAIN PAPER

### INTRODUCTION

Until the late 19<sup>th</sup> century penetrating abdominal trauma was managed conservatively <sup>1</sup>. In the early part of the 20<sup>th</sup> century around the time of World War I operative management became the accepted standard for penetrating wounds to the abdomen. Studies started appearing in the early 1960's suggesting that mandatory exploratory laparotomies are unnecessary in treating penetrating wounds to the abdomen <sup>2</sup>. Since the late 1980's selective non-operative management of abdominal stab wounds has become the standard of care around the world <sup>3</sup>.

The problem with selective non-operative management of TA stab wounds is that patients with isolated diaphragm injuries do not develop any peritoneal signs and may then develop a late diaphragm hernia if an injury to the diaphragm is missed. To overcome this it was initially proposed by Stylianos et al.<sup>4</sup> that all left side TA stab wounds should receive a laparotomy to rule out a diaphragm injury. During the mid 1990's, when videoscscopy was introduced and popularised in other areas of surgery, numerous studies confirmed that laparoscopy and thoracoscopy are very sensitive and specific in detecting diaphragm injury <sup>5-9</sup>. Even today with modern multidetector CT (MDCT) imaging, direct vision of the diaphragm with laparoscopy and thoracoscopy remain the gold standard of diagnosing a diaphragm injury <sup>10</sup>.

Current Eastern Association for the Surgery of Trauma (EAST) guidelines recommends that all patients with left sided penetrating thoracoabdominal trauma should undergo routine

diagnostic laparoscopy under general anaesthesia to exclude a diaphragm injury<sup>11</sup>. This management is not always feasible in a resource limited environment.

The purpose of this study was to establish the incidence of diaphragm injury in our local trauma population and to establish if close initial observation and subsequent follow up is a safe and feasible practice for this group of patients.

## METHODS

### Study design

The study was a single centre parallel-group study with equal randomization conducted at the Trauma Centre at the Groote Schuur Hospital from 01 September 2009 through to 01 November 2014. All patients aged between 18 and 60 years diagnosed with asymptomatic left TA stab wounds included in the trial were divided into two computer randomized groups.

Exclusion criteria included patients with obvious signs of diaphragm injury (either on imaging or clinically), hemodynamically unstable patients, previous penetrating injury to the left TA area, patients requiring early surgical exploration for injuries other than diaphragm injuries and positive pregnancy test. The study was approved by the Faculty of Health Sciences Research Ethics Committee of the University of Cape Town and registered at ClinicalTrials.gov NCT01044550.

### Management protocol

According to the trial protocol all patients with left TA stab wounds and suspected occult diaphragm injury were subjected to a 24 hour period of serial abdominal observations to

identify patients who required laparotomy for associated intra-abdominal injury. Patients with a pneumo- and/or hemothorax were managed with a chest drain. During the observation period patients were kept on nil per os and maintained on intravenous fluids. Analgesia alone with no antibiotics was administered. The patients were clinically reassessed every 6 hours. Patients who did not develop abdominal symptoms or signs of an acute abdomen after 24 hours were considered eligible for the trial. If they were willing to participate and after informed consent was taken, randomization was done as described below, into a treatment (Group A) and follow up group (Group B).

Group A underwent a diagnostic laparoscopy, with repair to injured diaphragm when present. This was done to ascertain the local incidence of diaphragm injury in this subset of trauma patients. Group B underwent no treatment except suturing of wounds and drainage of a hemo- / pneumothorax, if present. Participants in Group A were requested to attend a follow up clinic in 2 weeks. Participants in Group B were requested to attend a follow up clinic at 2 week, 4 week, 3 month, 6 month, 12 month and yearly intervals. During follow up a detailed history was taken and a chest X-ray performed. Patients were considered lost to follow up if they did not attend a follow up clinic appointment for six months. If they did not attend a follow up clinic an attempt was made to contact them telephonically if contact numbers were available. If this was not possible, a letter requesting return to hospital was posted by registered mail to their last known addresses.

### **Technique of Laparoscopy**

Under general anaesthesia, pneumo-peritoneum with CO<sub>2</sub> was introduced through an umbilical port placed according to the open Hassan technique. The intra-abdominal pressure

was monitored and maintained at  $< 15\text{mmHg}$ . A camera was introduced through a 10mm port placed at the umbilicus. To allow for better manipulation and improved exposure, a second 5mm port was introduced, unless the injury was anterior and vision adequate, in which case, the second port placement was omitted. If an injury was found, a third port was introduced to allow for laparoscopic suturing with a braided non-absorbable suture material. Consultants in the department or registrars supervised by consultants performed the procedures.

### **Randomization Process**

A computerized random number generator was used to generate a random number table with the numbers 1 and 2. These numbers was placed in a sealed envelope. If a patient was considered eligible to participate in the trial, informed consent was taken and the envelope was opened to reveal the group into which the patient fell.

### **Endpoints of study**

The primary endpoint was the demonstration of a diaphragmatic laceration at laparotomy or any evidence of diaphragmatic hernia during follow up. Secondary endpoints were length of hospital stay and complications.

### **Statistical methods**

Continues variables were compared with the use of the  $t$  test. Chi-square analysis and the Fisher exact test were used for the analysis of the categorical variables where appropriate. Confidence intervals were based on the normal approximation to the binominal distribution.

*P* values of less than 0.05 were considered to be significant. Statistical calculations were done using Statistica 12

### **Sample size**

Using a two-sided binomial test, a sample size of 100 achieves 83% power to detect a difference of 0.15 with a significance level of 0.035. These results assume that the population proportion under the null hypothesis is 0.5<sup>12-15</sup>.

## **RESULTS**

We identified 64 potentially eligible patients; of which, 62 met all eligibility criteria. Five patients were excluded, 2 patients did not meet the inclusion criteria and 3 declined to participate by refusing consent. The final sample group therefore consisted of 59 patients. After providing informed consent, they were subsequently randomized to 28 in group A and 31 in group B. We discontinued enrolment before reaching our sample size goal of 100 patients due to slow patient accrual. There were no protocol violations and one patient was excluded after randomization in Group A due to failed laparoscopy and laparotomy because of extensive adhesions (frozen abdomen) after a previous laparotomy. Therefore, 27 patients were analysed in Group A and 31 in group B. The enrolment and outcomes are presented in Figure 1 according to the Consort 2010 flow diagram<sup>16</sup>.

LAPAROSCOPY (TO DETECT OCCULT DIAPHRAGM INJURY) VERSUS CLINICAL AND RADIOLOGICAL FOLLOW UP TO DETECT DIAPHRAGM INJURY AND HERNIATION, IN PATIENTS WITH ASYMPTOMATIC LEFT THORACOABDOMINAL STAB WOUNDS

A RANDOMIZED CONTROLLED STUDY

Malherbe GF

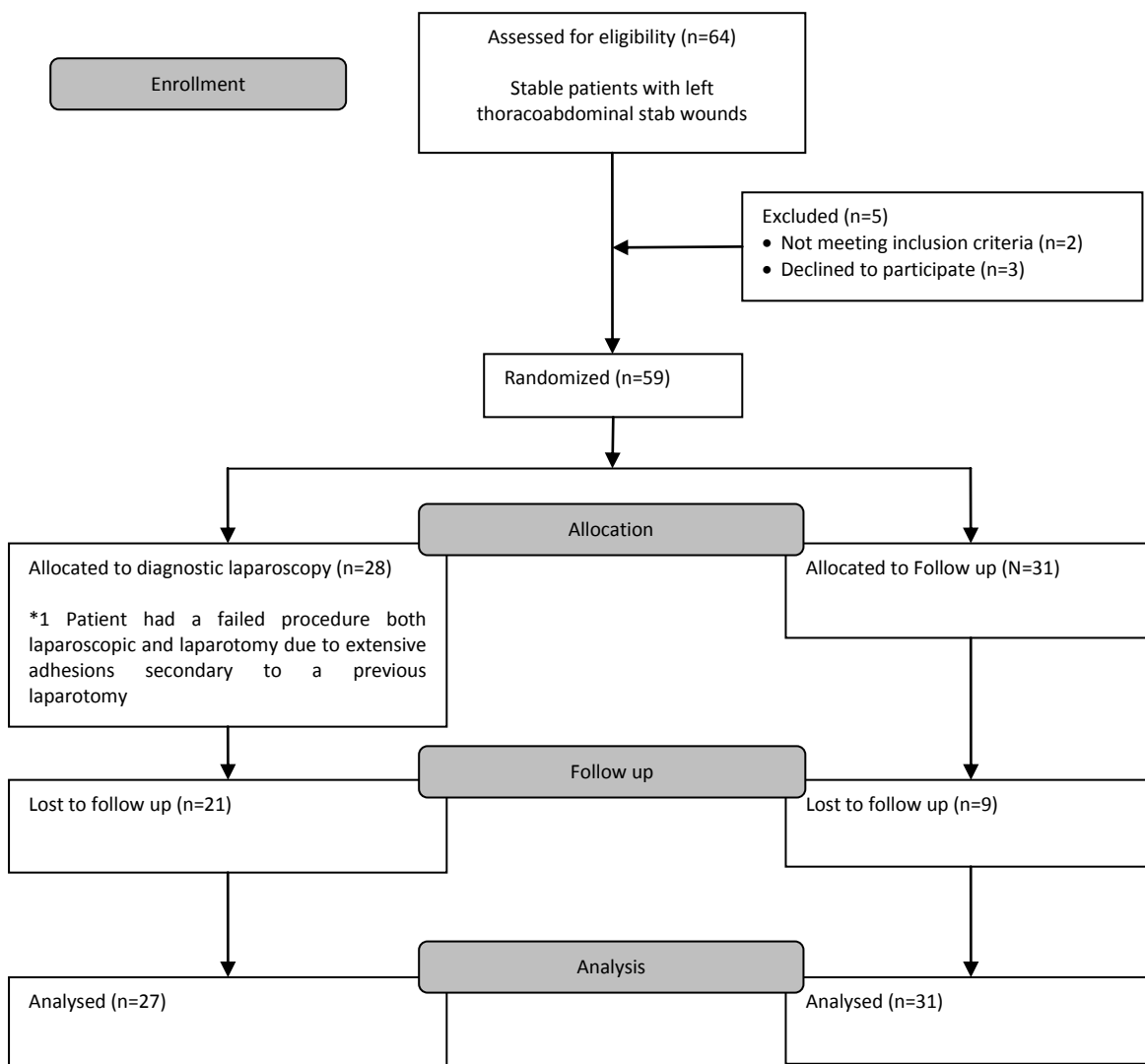


Figure 1 Enrolment and outcomes.

### Patient Characteristics

The 59 patients selected for the study were all stable on arrival. The baseline characteristics of the 2 groups were comparable in respect of age, haemoglobin level, mean arterial pressure, respiratory rate and revised trauma score. This is represented in Table 2

**Table 2 Summary of the patient characteristics**

Variable	Laparoscopy Mean (SD) (n=27)	Follow up Mean (SD) (n=31)	<i>P</i>
Age	27.1 (6.2)	27.7 (6.8)	0.73
Mean Arterial Pressure	94.7 (14.9)	91.4 (13.4)	0.50
Haemoglobin	12 (2)	12.7 (2.2)	0.25
Respiratory rate	17.8 (3.0)	18.4 (4.0)	0.60
Revised trauma score	7.84	7.84	1.00

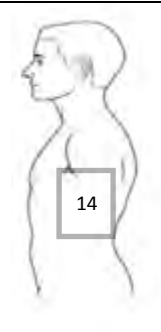
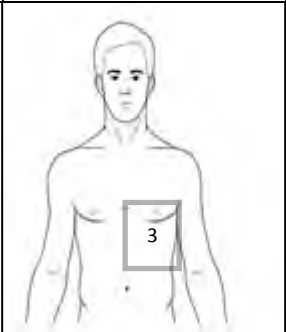
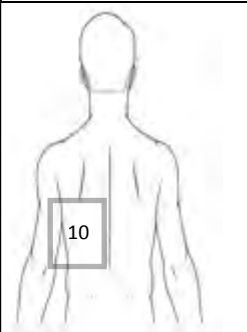
### Area of injury

The site of injury was recorded on a visual torso map and divided into lateral, anterior and posterior stab wounds. The lateral region is between the anterior and posterior axillary lines, the anterior territory is anterior to the anterior axillary line and the posterior territory is posterior to the posterior axillary line. Some patients presented with multiple stabs. The findings are represented in figure 2a and figure 2b.

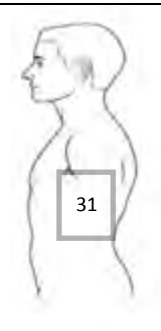
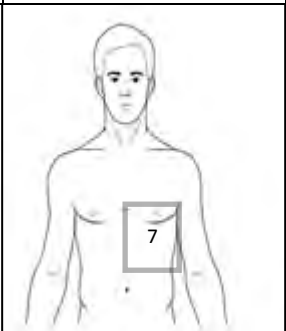
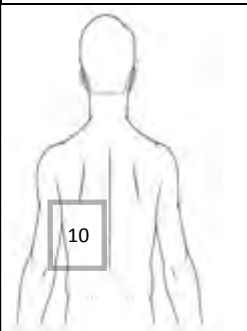
**LAPAROSCOPY (TO DETECT OCCULT DIAPHRAGM INJURY) VERSUS CLINICAL AND RADIOLOGICAL FOLLOW UP TO DETECT DIAPHRAGM INJURY AND HERNIATION, IN PATIENTS WITH ASYMPTOMATIC LEFT THORACOABDOMINAL STAB WOUNDS**

**A RANDOMIZED CONTROLLED STUDY**

Malherbe GF

Group A		
Lateral	Anterior	Posterior
		
<b>Number of confirmed diaphragm injuries per region</b>		
3	2	4

**Figure 2a Site of stab wounds for Group A**

Group B		
Lateral	Anterior	Posterior
		

**Figure 2b Site of stab wounds for Group B**

**Laparoscopy group (n = 27)**

The stab wounds penetrated the chest at various TA locations with no specific level associated with an increased likelihood of diaphragm injury. After all the patients were subjected to initial laparoscopy under general anaesthesia, 2 patients were converted to laparotomy and 1 patient to thoracotomy. The decision to convert was left to the operating surgeon, but conversion was done because of difficulty in visualising or repairing the

diaphragm. Three patients were converted to an open procedure, all of whom had a diaphragm injury. Eight (29%) out of 27 patients had a diaphragm laceration. Seventeen (62%) patients had an associated haemo- / pneumothorax managed with pleural drainage.

### **Follow up group (n = 31)**

The mean follow up of patients allocated to Group B were 24 (range, 0 – 58, SD 21.4) months. Twelve (38%) patients had a pleural drain inserted for a haemo- / pneumothorax. At the last follow up, all chest X-rays were normal and all patients had a normal clinical examination with no persistent abdominal or thoracic symptoms. Five patients (16%) had no follow up and four (12%) patients had limited follow up ranging from 1 to 9 months before they were lost to follow up.

### **Morbidity and Mortality**

No patients died as a result of injuries sustained. Three patients had post-operative complications in Group A. The complications were superficial surgical site sepsis, pneumonia and prolonged post-operative paralytic ileus. The patient with surgical site sepsis was managed with suture removal and antibiotics. The patient who developed pneumonia was a patient converted to laparotomy and was managed with antibiotics, physiotherapy and mobilization. The patient with the prolonged ileus was managed conservatively, and the ileus resolved four days post-operatively. These complications are all grade II complications according to the Clavien-Dindo classification of surgical complications<sup>17</sup>. There was no morbidity in Group B.

## Hospital Stay

There was a statistically significant difference in hospital stay between the two groups. The mean hospital stay in the patients who underwent laparoscopy was 5 days (SD 1.3), compared to a mean hospital stay of 2.9 days (SD, 1.5)  $p < 0.001$

## DISCUSSION

Current EAST guidelines<sup>11</sup> strongly recommends diagnostic laparoscopy in all patients with penetrating trauma to the left TA area who have no other indications for laparotomy to ascertain and repair diaphragm injuries. The main aim of repairing diaphragm injuries is to prevent delayed diaphragm herniation which is reported to have a high associated mortality rate. Most studies quote this high mortality from a study done by Madden et al.<sup>18</sup> who reported a mortality rate of 36% in patients presenting with delayed herniation of abdominal contents into the chest. It is twenty five years since the article by Madden et al. was published and with modern Intensive Care practises, this high mortality rate is not observed any more. It is no longer standard practise at the Groote Schuur Hospital since an article published by Shaw et al.<sup>19</sup>, to do diagnostic laparoscopy on patients with left TA stab wounds. In this study it was found that persistent left upper quadrant tenderness, omental herniation through the stab wound and left shoulder tip pain were signs of occult diaphragm injury and only these patients currently undergo routine diagnostic laparoscopy.

From animal data it is known that diaphragm injuries heal spontaneously<sup>20-24</sup>, in 6 to 12 weeks, but it is difficult to extrapolate this data directly to humans. It must be true that a large percentage of diaphragm injuries heal, because studies found an occult diaphragm

injury rate in the left diaphragm stab wounds of 26 to 63 percent<sup>5,25,26</sup> and a rate of delayed diaphragm herniation of 2.7 and 4 percent<sup>27, 28</sup>. This difference in results can only be true if some of these injuries heal. We are of the opinion that if a hernia has not occurred within the first six weeks post injury, which is the time it takes the diaphragm to heal in animals, it is unlikely to occur because the diaphragm would have naturally healed.

From the evidence available, mortality of delayed diaphragm injury is over estimated and the incidence of delayed herniation is low, therefore many patients will undergo unnecessary surgery to find and repair diaphragm injuries that would never have resulted in a diaphragm hernia. This has significant cost implications in a resource limited environment as patients that undergo surgery have a significantly longer hospital stay 2.9 vs 5 days  $p = <0.001$  as well as the added procedural cost.

We are of the opinion that patients who present with a delayed diaphragm hernia most likely had a missed initial diaphragm injury that occurred within the first six weeks post injury. The initial injury presented late and if these patients were subjected to close follow up for six weeks after the injury these injuries would have been detected earlier. We can therefore claim that herniation is an early event and strangulation / complication is a delayed event because in patients who present with late complications, there are always signs of a chronic hernia at surgery. Established adhesions between the hernia sac and the diaphragm are a common finding at surgery pointing towards a chronic process. We undertook this study to firstly establish the incidence of occult diaphragm injury, in our patient population, and to follow up a randomised control group of patients which should have a similar incidence of occult diaphragm injuries. The patients were followed up to establish the incidence of

delayed diaphragm herniation in a truly asymptomatic group of patients and if a hernia was detected to establish the morbidity of early intervention. The incidence of diaphragm injury was 29% and it can therefore be assumed that the incidence of a diaphragm injury in Group B would be similar because the two groups were comparable in terms of patient characteristics. During the follow up period no delayed diaphragm hernias occurred, neither did any patient report any significant symptoms.

The limitation of this study was the number of patients lost to follow up, especially in Group B. Five patients (16%) had no follow up and four (12%) patients had limited follow up ranging from 1 to 9 months before they were lost to follow up. According to Leukhardt et al.<sup>29</sup> lower income, higher poverty rates, and lower education were significantly associated with failure to follow up. The patients included in this study meet the above criteria and that this would account for the high rate in failure to follow up despite every effort made to make contact with the patients who failed to attend follow up appointments. The number of patients lost to follow up does negatively impact on the study conclusions.

## CONCLUSION

In summary, the incidence of occult diaphragm injury in left sided TA stab wounds is high. In a highly selected group of asymptomatic patients who have undergone a period of abdominal observation it is safe to discharge these patients provided that they are followed up with clinical examination and a chest X-ray six weeks after discharge. They should be made

well aware that should any abdominal symptoms develop, even if years later, to report to a health facility stating that they sustained a left TA stab in the past.

## 2.5 References

1. Loria FL. Historical aspects of penetrating wounds of the abdomen. *Int Abstracts Surg* 1948;87:521-49.
2. Shaftan GW. Indications for operation in abdominal trauma. *The American Journal of Surgery* 1960;99(5):657-664.
3. Robin AP, Andrews JR, Lange DA, et al. Selective management of anterior abdominal stab wounds. *Journal of Trauma-Injury, Infection, and Critical Care* 1989;29(12):1684-1689.
4. Stylianos S, King TC. Occult diaphragm injuries at celiotomy for left chest stab wounds. *Am Surg* 1992 Jun;58(6):364-368.
5. Mjoli M, Oosthuizen G, Clarke D, et al. Laparoscopy in the diagnosis and repair of diaphragmatic injuries in left-sided penetrating thoracoabdominal trauma. *Surg Endosc* 2014:1-6.
6. Bagheri R, Tavassoli A, Sadrizadeh A, et al. The role of thoracoscopy for the diagnosis of hidden diaphragmatic injuries in penetrating thoracoabdominal trauma. *Interactive cardiovascular and thoracic surgery* 2009;9(2):195-198.
7. Opananon S, Akaraviputh T, Keorochana K, et al. The role of laparoscopic management in suspected traumatic diaphragmatic injury patients: a tertiary care center experience. *Medical journal of the Medical Association of Thailand* 2009;92(7):903.

8. Powell BS, Magnotti LJ, Schroepel TJ, et al. Diagnostic laparoscopy for the evaluation of occult diaphragmatic injury following penetrating thoracoabdominal trauma. *Injury* 2008;39(5):530-534.
9. Paci M, Ferrari G, Annessi V. The role of diagnostic VATS in penetrating thoracic injuries. *World Journal of Emergency Surgery* 2006;1:30.
10. Stein DM, York GB, Boswell S, et al. Accuracy of computed tomography (CT) scan in the detection of penetrating diaphragm injury. *J Trauma* 2007;63(3):538–543
11. Como JJ, Bokhari F, Chiu WC, et al. Practice Management Guidelines for Selective Nonoperative Management of Penetrating Abdominal Trauma *J Trauma* 2010 68 (3): 721-33
12. Fleiss, J. L., Levin, B., Paik, M.C. 2003. *Statistical Methods for Rates and Proportions*. Third Edition. John Wiley & Sons. New York.
13. Lachin, John M. 2000. *Biostatistical Methods*. John Wiley & Sons. New York.
14. Machin, D., Campbell, M., Fayers, P., and Pinol, A. 1997. *Sample Size Tables for Clinical Studies*, 2<sup>nd</sup> Edition. Blackwell Science. Malden, Mass.
15. Zar, Jerrold H. 1984. *Biostatistical Analysis (Second Edition)*. Prentice-Hall. Englewood Cliffs, New Jersey.
16. Schultz KF, Altman DG, Moher d, et al. CONSORT 210 statement: updated guidelines for reporting parallel group randomized trials. *BMJ (Clinical research Ed.)* 2010;340:c332.
17. Clavien PA, Barkun J, de Oliveira ML, et al. The Clavien-Dindo classification of surgical complications. *Annals of Surgery* 2009;250:187-196.

18. Madden MR, Paull DE, Finkelstein JL, et al. Occult diaphragmatic injury from stab wounds to the lower chest and abdomen. *Journal of Trauma and Acute Care Surgery* 1989;29(3):292-298.
19. Shaw JM, Navsaria PH, Nicol AJ. Laparoscopy-assisted repair of diaphragm injuries. *World J Surg* 2003;27(6):671-674.
20. Shatney CH, Sensaki K, Morgan L. The natural history of stab wounds of the diaphragm: implications for a new management scheme for patients with penetrating thoracoabdominal trauma. *Am Surg* 2003 Jun;69(6):508-513.
21. Murray JA, Cornwell III EE, Velmahos GC, et al. Healing of traumatic diaphragm injuries: comparison of laparoscopic versus open techniques in an animal model. *J Surg Res* 2001;100(2):189-191.
22. Perlingeiro JA, Saad R,Jr, Lancelotti CL, et al. Natural course of penetrating diaphragmatic injury: an experimental study in rats. *Int Surg* 2007 Jan-Feb;92(1):1-9.
23. Gamblin TC, Wall Jr CE, Morgan III JH, et al. The natural history of untreated penetrating diaphragm injury: an animal model. *Journal of Trauma-Injury, Infection, and Critical Care* 2004;57(5):989-992.
24. Zierold D, Perlstein J, Weidman ER, et al. Penetrating trauma to the diaphragm: natural history and ultrasonographic characteristics of untreated injury in a pig model. *Archives of surgery* 2001;136(1):32-37.
25. Murray JA, Demetriades D, Asensio JA, et al. Occult injuries to the diaphragm: prospective evaluation of laparoscopy in penetrating injuries to the left lower chest. *J Am Coll Surg* 1998;187(6):626-630.

26. Morales CH, Villegas MI, Angel W, Vásquez JJ. Value of digital exploration for diagnosing injuries to the left side of the diaphragm caused by stab wounds. *Archives of Surgery* 2001;136(10):1131-1135.
27. Leppäniemi A, Haapiainen R. Occult diaphragmatic injuries caused by stab wounds. *Journal of Trauma-Injury, Infection, and Critical Care* 2003;55(4):646-650
28. Feliciano DV, Cruse PA, Mattox KL, et al. Delayed diagnosis of injuries to the diaphragm after penetrating wounds. *Journal of Trauma-Injury, Infection, and Critical Care* 1988;28(8):1135-1144.
29. Leukhardt WH, Golob JF, McCoy AM, et al. Follow up disparities after trauma: a real problem for outcomes research. *The American Journal of Surgery* 2010;199: 348-353

## **CHAPTER 3**

### **APPENDIX**

#### **APPENDIX 1**

Literature review journal article data extraction form

<b>Data Extraction Form</b>		
1	Authors	
2	Publication year	
3	Country	
4	Study design	
5	Population	
6	Hospital	
7	Period of study	
8	Sample size	
9	Management analysis	
10	Outcomes Examined	
11	Quality of reference	

LAPAROSCOPY (TO DETECT OCCULT DIAPHRAGM INJURY) VERSUS CLINICAL AND RADIOLOGICAL FOLLOW UP TO DETECT DIAPHRAGM INJURY AND HERNIATION, IN PATIENTS WITH ASYMPTOMATIC LEFT THORACOABDONIMAL STAB WOUNDS

A RANDOMIZED CONTROLLED STUDY

Malherbe GF

APPENDIX 2

Randomization table

**Randomization table left thoracoabdominal stab wound study**

1	Laparoscopy	51	Follow up
2	Follow up	52	Laparoscopy
3	Laparoscopy	53	Follow up
4	Laparoscopy	54	Follow up
5	Laparoscopy	55	Follow up
6	Follow up	56	Laparoscopy
7	Laparoscopy	57	Follow up
8	Follow up	58	Laparoscopy
9	Laparoscopy	59	Laparoscopy
10	Follow up	60	Laparoscopy
11	Laparoscopy	61	Follow up
12	Follow up	62	Laparoscopy
13	Laparoscopy	63	Follow up
14	Follow up	64	Laparoscopy
15	Follow up	65	Follow up
16	Laparoscopy	66	Follow up
17	Laparoscopy	67	Laparoscopy
18	Follow up	68	Laparoscopy
19	Laparoscopy	69	Laparoscopy
20	Laparoscopy	70	Follow up
21	Follow up	71	Follow up
22	Laparoscopy	72	Laparoscopy
23	Follow up	73	Follow up
24	Follow up	74	Follow up
25	Follow up	75	Laparoscopy
26	Laparoscopy	76	Laparoscopy
27	Follow up	77	Follow up
28	Laparoscopy	78	Laparoscopy
29	Follow up	79	Follow up
30	Follow up	80	Laparoscopy
31	Follow up	81	Follow up
32	Follow up	82	Follow up
33	Laparoscopy	83	Laparoscopy
34	Follow up	84	Follow up
35	Follow up	85	Follow up
36	Follow up	86	Follow up
37	Laparoscopy	87	Laparoscopy
38	Laparoscopy	88	Laparoscopy
39	Laparoscopy	89	Laparoscopy
40	Laparoscopy	90	Follow up
41	Laparoscopy	91	Follow up
42	Laparoscopy	92	Laparoscopy
43	Follow up	93	Laparoscopy
44	Follow up	94	Follow up
45	Follow up	95	Laparoscopy
46	Laparoscopy	96	Laparoscopy
47	Follow up	97	Follow up
48	Follow up	98	Follow up
49	Laparoscopy	99	Laparoscopy
50	Laparoscopy	100	Laparoscopy

**LAPAROSCOPY (TO DETECT OCCULT DIAPHRAGM INJURY) VERSUS CLINICAL AND RADIOLOGICAL FOLLOW UP TO DETECT DIAPHRAGM INJURY AND HERNIATION, IN PATIENTS WITH ASYMPTOMATIC LEFT THORACOABDOMINAL STAB WOUNDS**

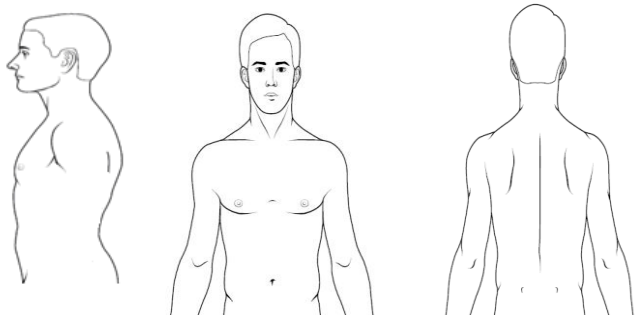
A RANDOMIZED CONTROLLED STUDY

Malherbe GF

**APPENDIX 3**

Prospective data collection form

**Data collection form for left thoracoabdominal stab wound study**

	Folder number		Variable		
Demographics	DOB		dd / mm / yy		
	Age		Years		
	Sex	<input type="checkbox"/> Male <input type="checkbox"/> Female		M = 1; F = 2	
	Primary language	<input type="checkbox"/> English <input type="checkbox"/> Afrikaans <input type="checkbox"/> Xhosa <input type="checkbox"/> Other		E = 1; A = 2; X = 3; O = 4	
	Residential area			Variable	
	Marital status	<input type="checkbox"/> Married <input type="checkbox"/> Single/Divorced <input type="checkbox"/> Co-habiting		M = 1; S/D =2; CH = 3	
	Race	<input type="checkbox"/> Black <input type="checkbox"/> White <input type="checkbox"/> Colored <input type="checkbox"/> Asian <input type="checkbox"/> Other		B = 1; W = 2; C =3; A = 4; O = 5	
Admission data	Date seen in trauma		dd / mm / yy		
	Date of Admission		dd / mm / yy		
	Date of Discharge		dd / mm / yy		
	Total hospital stay		Days		
Clinical findings on admission	Arrival	<input type="checkbox"/> Direct <input type="checkbox"/> Transferred <input type="checkbox"/> Other		D = 1; T =2; O = 3	
	HR :	BP :	RR :	Hb :	Variable
	Associated injury	<input type="checkbox"/> Hemothorax <input type="checkbox"/> Pneumothorax			H = 1; P = 2
	ICD inserted	<input type="checkbox"/> Yes <input type="checkbox"/> No			Y = 1; N = 2
	Previous stab to Left TA region	<input type="checkbox"/> Yes <input type="checkbox"/> No			Y = 1; N = 2
	Injuries to other organ systems	<input type="checkbox"/> Abdomen <input type="checkbox"/> Head injury <input type="checkbox"/> Other <input type="checkbox"/> None			A = 1; H = 2; O = 3; N = 4
	Please indicate stab wound position on picture :				
					
Surgery	Date of surgery			dd / mm / yy	
	Surgeon	<input type="checkbox"/> Navsaria <input type="checkbox"/> Nicol <input type="checkbox"/> Edu <input type="checkbox"/> Other		N = 1; Ni = 2; E = 3; O = 4	
	Anesthetist			Variable	
	Start time				
	End time				
	Surgical findings	<input type="checkbox"/> Diaphragm injury found <input type="checkbox"/> No diaphragm injury <input type="checkbox"/> Other injury			I = 1; N = 2; O = 3

**LAPAROSCOPY (TO DETECT OCCULT DIAPHRAGM INJURY) VERSUS CLINICAL AND RADIOLOGICAL FOLLOW UP TO DETECT DIAPHRAGM INJURY AND HERNIATION, IN PATIENTS WITH ASYMPTOMATIC LEFT THORACOABDONIMAL STAB WOUNDS**

**A RANDOMIZED CONTROLLED STUDY**

Malherbe GF

	Diaphragm repaired	<input type="checkbox"/> Laparoscopically	<input type="checkbox"/> Other	L = 1; O = 2
	Surgical procedure	<input type="checkbox"/> Laparoscopy <input type="checkbox"/> Thoracotomy	<input type="checkbox"/> Thoracoscopy <input type="checkbox"/> Laparotomy	LS = 1; TS = 2; TC = 3; LA = 4
Hospital Outcome	Complication			Variable
	Total # of hospital days			Days
	Morbidity	<input type="checkbox"/> Yes	<input type="checkbox"/> No	Y = 1; N = 2
	Mortality	<input type="checkbox"/> Yes	<input type="checkbox"/> No	Y = 1; N = 2

LAPAROSCOPY (TO DETECT OCCULT DIAPHRAGM INJURY) VERSUS CLINICAL AND RADIOLOGICAL FOLLOW UP TO DETECT DIAPHRAGM INJURY AND HERNIATION, IN PATIENTS WITH ASYMPTOMATIC LEFT THORACOABDOMINAL STAB WOUNDS

A RANDOMIZED CONTROLLED STUDY

Malherbe GF

APPENDIX 4

Clinic data collection form

**Clinic visit data collection form for left thoracoabdominal stab wound study**

Clinic visits	2 weeks	Date of visit		dd / mm / yy
		Symptoms	<input type="checkbox"/> Chest pain <input type="checkbox"/> Abdominal pain <input type="checkbox"/> Dyspnoea <input type="checkbox"/> Other <input type="checkbox"/> Nil	C = 1; A = 2; D = 3; D = 4; O = 5; N = 6
		Chest X ray	<input type="checkbox"/> Normal <input type="checkbox"/> Irregular hemi diaphragm left <input type="checkbox"/> Other	N = 1; I = 2; O = 3
		Complications	<input type="checkbox"/> Yes <input type="checkbox"/> No -----	Y = 1; N = 2
	6 weeks	Date of visit		dd / mm / yy
		Symptoms	<input type="checkbox"/> Chest pain <input type="checkbox"/> Abdominal pain <input type="checkbox"/> Dyspnoea <input type="checkbox"/> Other <input type="checkbox"/> Nil	C = 1; A = 2; D = 3; D = 4; O = 5; N = 6
		Chest X ray	<input type="checkbox"/> Normal <input type="checkbox"/> Irregular hemi diaphragm left <input type="checkbox"/> Other	N = 1; I = 2; O = 3
		Complications	<input type="checkbox"/> Yes <input type="checkbox"/> No -----	Y = 1; N = 2
	3 months	Date of visit		dd / mm / yy
		Symptoms	<input type="checkbox"/> Chest pain <input type="checkbox"/> Abdominal pain <input type="checkbox"/> Dyspnoea <input type="checkbox"/> Other <input type="checkbox"/> Nil	C = 1; A = 2; D = 3; D = 4; O = 5; N = 6
		Chest X ray	<input type="checkbox"/> Normal <input type="checkbox"/> Irregular hemi diaphragm left <input type="checkbox"/> Other	N = 1; I = 2; O = 3
		Complications	<input type="checkbox"/> Yes <input type="checkbox"/> No -----	Y = 1; N = 2
	6 months	Date of visit		dd / mm / yy
		Symptoms	<input type="checkbox"/> Chest pain <input type="checkbox"/> Abdominal pain <input type="checkbox"/> Dyspnoea <input type="checkbox"/> Other <input type="checkbox"/> Nil	C = 1; A = 2; D = 3; D = 4; O = 5; N = 6
		Chest X ray	<input type="checkbox"/> Normal <input type="checkbox"/> Irregular hemi diaphragm left <input type="checkbox"/> Other	N = 1; I = 2; O = 3
		Complications	<input type="checkbox"/> Yes <input type="checkbox"/> No -----	Y = 1; N = 2
	1 year	Date of visit		dd / mm / yy
		Symptoms	<input type="checkbox"/> Chest pain <input type="checkbox"/> Abdominal pain <input type="checkbox"/> Dyspnoea <input type="checkbox"/> Other <input type="checkbox"/> Nil	C = 1; A = 2; D = 3; D = 4; O = 5; N = 6
		Chest X ray	<input type="checkbox"/> Normal <input type="checkbox"/> Irregular hemi diaphragm left <input type="checkbox"/> Other	N = 1; I = 2; O = 3
		Complications	<input type="checkbox"/> Yes <input type="checkbox"/> No -----	Y = 1; N = 2
2 years	Date of visit		dd / mm / yy	

**LAPAROSCOPY (TO DETECT OCCULT DIAPHRAGM INJURY) VERSUS CLINICAL AND RADIOLOGICAL FOLLOW UP TO DETECT DIAPHRAGM INJURY AND HERNIATION, IN PATIENTS WITH ASYMPTOMATIC LEFT THORACOABDONIMAL STAB WOUNDS**

**A RANDOMIZED CONTROLLED STUDY**

Malherbe GF

		Symptoms	<input type="checkbox"/> Chest pain <input type="checkbox"/> Abdominal pain <input type="checkbox"/> Dyspnoea <input type="checkbox"/> Other <input type="checkbox"/> Nil	C = 1; A = 2; D = 3; D = 4; O = 5; N = 6
		Chest X ray	<input type="checkbox"/> Normal <input type="checkbox"/> Irregular hemi diaphragm left <input type="checkbox"/> Other	N = 1; I = 2; O = 3
		Complications	<input type="checkbox"/> Yes <input type="checkbox"/> No -----	Y = 1; N = 2

## APPENDIX 5

Consent form

### CONSENT TO PARTICIPATE IN RESEARCH

You have been asked to participate in a research study.

You may contact Dr GF Malherbe at 082 9562451 at any time if you have questions about the research or if you are injured as a result of the research.

You may contact the Secretariat of the Ethics Committee of the Faculty of Health Sciences, UCT at telephone number 021 4066492 if you have questions about your rights as a research subject.

Your participation in this research is voluntary, and you will not be penalized or lose benefits if you refuse to participate or decide to terminate participation. However we do urge you not to terminate your participation after the research has begun.

If you agree to participate, you will be given a signed copy of this document as well as the participant information sheet, which is a written summary of the research.

The research study, including the above information has been verbally described to me. I have had the opportunity to ask questions about the research and I understand what my involvement in the study means. I understand that I can withdraw from the study at any time and my treatment will not be affected. I voluntarily agree to participate

The research study, including the above information has been verbally described to me. I understand what my involvement in the study means and I voluntarily agree to participate.

\_\_\_\_\_  
Signature of Participant

\_\_\_\_\_  
Date

\_\_\_\_\_  
Signature of Witness  
(Where applicable)

\_\_\_\_\_  
Date

\_\_\_\_\_  
Signature of Translator

\_\_\_\_\_  
Date

(Where applicable)

**TOESTEMMING TOT DEELNAME AAN NAVORSING**

U is versoek om aan 'n navorsingstudie deel te neem.

U kan Dr GF Malherbe enige tyd kontak by 082 9652451 indien u vrae oor die navorsing het of as gevolg van die navorsing beseer is.

U kan die Sekretariaat van die Etiekkomitee van die Fakulteit Gesondheidsweteskappe, UK by telefoonnommer 021 4066492 kontak indien u enige vrae het oor u regte as 'n proefpersoon.

U deelname aan hierdie navorsing is vrywillig, en u sal nie gepenaliseer word of voordele verbeur as u weier om deel te neem of besluit om deelname te staak nie.

As u instem om deel te neem, sal 'n ondertekende kopie van hierdie dokument sowel as die deelnemerinligtingsblad, wat 'n geskrewe opsomming van die navorsing is, aan u gegee word .

Die navorsingstudie, insluitend die bogenoemde inligting is verbaal aan my beskryf. Ek begryp wat my betrokkenheid by die studie beteken en ek stem vrywillig in om deel te neem.

\_\_\_\_\_  
Handtekening van deelnemer

\_\_\_\_\_  
Datum

\_\_\_\_\_  
Handtekening van getuie  
(Waar van toepassing)

\_\_\_\_\_  
Datum

\_\_\_\_\_  
Handtekening van Vertaler  
(Waar van toepassing)

\_\_\_\_\_  
Datum

**Imvume yokuthabatha inxaxheba kuphando**

Uyacelwa ukuba uthabathe inxaxheba kwizifundo zophando.

Unganxibelelana no Dr. G F Malherbe ku 082 956 2451 nangaliphi ixesha xa unemibuzo ngophando, okanye wenzakele ngenxa yophando.

Ungaqhakamshelana noo-nobhala bekomiti yenzululwazi ngeenqobo emikhwa esesikweni, zesebe lemfundo, UCT kule nombolo 021 406 6492 ukuba unemibuzo ngamalungelo akho ophando.

Uyazithandela ukuthabatha inxaxheba koluphando, yaye awuyikohlwaywa okanye uphulukane namalungelo xa usala okanye uyeka ungagqibanga, kodwa siyacela ukuba ungayeki ukuthatha inxaxheba xa uphando seluqalile.

Ukuba uyavuma, uyakunikwa ikopi enyathelisiweyo, nomxwebhu olunenkcazelo ebhalwe ushwankathelo lophando.

Oluphando nenkcazelo engentla icacisiwe ngomlomo kum. Ndibe nalo nethuba lokubuza imibuzo malunga noluphando, ngoku ndiyazi nokuba ukuzifaka kwam kuthetha ntoni na. Ndiyaqonda ukuba ndingayeka nanini kodwa unyango aluyi kuchaphazeleka.

Ndiyazithandela ukuthabatha inxaxheba koluphando, nenkcazelo engentla icacisiwe kum ngomlomo. Ndiyakuqonda ukuthabatha inxaxheba kwam kuthetha ntoni na, kwaye ndiyazithandela ukuthabatha inxaxheba.

\_\_\_\_\_  
Sayina Mthathi-nxaxheba

\_\_\_\_\_  
Umhla

\_\_\_\_\_  
Sayina Ngqina

\_\_\_\_\_  
Umhla

\_\_\_\_\_  
Sayina Toliki

\_\_\_\_\_  
Umhla

## APPENDIX 6

### Information document

#### INFORMATION DOCUMENT

**Study title:** A randomized prospective study comparing non operative management with laparoscopic treatment in patients with diaphragm injury following left thoracoabdominal stab wounds.

**Introduction:** Dr G.F. Malherbe, an MMed Surgery student, is doing research on the clinical outcome of occult diaphragm injuries in patients with left sided thoracoabdominal stab wounds. Research is just the process to find the answer to a question. In this study we want to compare the clinical outcome of patients who undergoes a laparoscopy versus non operative management in patients with left thoracoabdominal stab wounds.

**Invitation to participate:** We are asking/inviting you to participate in the research study.

**What is involved in the study :** This study will be done by means of randomizing two study groups of 50 patients each to either undergo a laparoscopy to diagnose and treat potential diaphragm injury or undergo no treatment other than wound treatment and follow up. All information will be held confidential and the protocol will be approved by the Ethics Committee of UCT.

**Risks:** Treatment will be in line with what is currently recommended in the literature.

**Benefits:** The patient/caregiver will receive no incentives to be in this study. Trauma is a massive burden in the South Africa. This research is essential for trauma care in South Africa.

***The subject will be given pertinent information on the study while involved in the project and after the results are available.***

**Participation is voluntary,** and refusal to participate will involve no penalty or loss of benefits to which the subject is otherwise entitled; the subject may discontinue participation at any time without penalty or loss of benefits to which the subject is otherwise entitled.

**Confidentiality:** Efforts will be made to keep personal information confidential. Absolute confidentiality cannot be guaranteed. Personal information may be disclosed if required by law. Organizations that may inspect and/or copy your research records for quality assurance and data analysis include reputable groups such as the Ethics Committee.

If results are published, this may lead to individual/cohort identification.

**Contact details of researcher:** Dr G.F Malherbe  
Address: P.O. Box 44541, Claremont, 7735  
E-mail: marvel @doctors.org.uk  
Tel : 082 9562451

**Contact details of REC Secretariat and Chair:** Mr Xolile Fula  
Old main Building E 53-44.1  
Groote Schuur  
Faculty of Health Sciences  
Observatory  
7925  
Tel: 021 4066492  
Fax: 021 4066411

## APPENDIX 7

Departmental approval of study



**UNIVERSITY OF CAPE TOWN**

---

**Department of Surgery**

**Departmental Research Committee**  
**Professor Anwar Suleman Mall**  
J-45 Room Old Main Building, Groote Schuur Hospital,  
Observatory 7925, South Africa  
Tel (021) 406 6168/6232/6227 Fax (021) 448 6461  
Email: Anwar.Mall@uct.ac.za

1<sup>st</sup> September 2008  
**Dr A Prof PH Navsaria**  
Department of General Surgery  
Division of Surgery  
Groote Schuur Hospital  
University of Cape Town

Dear Dr Prof Navsaria

**RE: PROJECT 2008/060**

**PROJECT TITLE: Clinical outcome of 100 asymptomatic patients with left sided thoraco- abdominal stab wounds: A prospective, randomized study to determine the incidence of occult of occult diaphragm injuries and incidence of diaphragmatic herniation**

The above proposal was reviewed by the Department of Surgery Research Committee and I am pleased to inform you that the committee approved the study.

Please use the above project number in all future correspondence.

Yours sincerely

**PROF. A. MALL**  
CHAIRPERSON  
DEPARTMENTAL RESEARCH COMMITTEE  
DEPARTMENT OF SURGERY  
**PROFESSOR ANWAR S MALL**  
**CHAIRMAN: RESEARCH COMMITTEE**



"OUR MISSION is to be an outstanding teaching and research university, educating for life and addressing the challenges facing our society."

## APPENDIX 8

Faculty of Health Sciences Human Research Ethics Committee approval



UNIVERSITY OF CAPE TOWN

Health Sciences Faculty  
Research Ethics Committee  
Room E52-24 Groote Schuur Hospital Old Main Building  
Observatory 7925  
Telephone [021] 406 6338 • Facsimile [021] 406 6411  
e-mail: lamecs.cmjedi@uct.ac.za

04 April 2009

REC REF: 492/2008

Dr GF Malherbe  
Surgery  
Trauma Centre

Dear Dr Malherbe

**PROJECT TITLE: LAPAROSCOPY (TO DETECT OCCULT DIAPHRAGM INJURY) VERSUS CLINICAL AND RADIOLOGICAL FOLLOW UP TO DETECT DIAPHRAGM INJURY AND HERNIATION, IN PATIENTS WITH ASYMPTOMATIC LEFT THORACOABDOMINAL STAB WOUNDS: A PROSPECTIVE RANDOMIZED CONTROLLED STUDY**

Thank you for your letter to the Research Ethics Committee dated 02 April 2009.

Study is approved for one year until 10 April 2010.

Please submit an annual progress report if the study continues beyond the approval period. Alternatively, please submit a brief summary of your findings so that we can close our file.

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

Please quote the REC. REF in all your correspondence.

Yours sincerely

A handwritten signature in black ink, appearing to be 'M Blockman'.

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

cmjedi

## APPENDIX 9

Annals of Surgery: Information for authors

### **Annals of Surgery Online Submission and Review System**

**Please see details below for information regarding Mandatory Clinical Trial Registration**

#### **SCOPE**

The *Annals of Surgery* is a monthly journal that considers for publication original articles in the field of surgery. It is the oldest continuously published journal in the English language solely devoted to the surgical sciences.

The Editorial Board considers only papers judged to offer significant contributions to the advancement of surgical knowledge. Such manuscripts may report original clinical or laboratory studies, new surgical techniques, or comprehensive reviews on timely surgical topics.

Case reports are rarely accepted and will be considered only if they present breakthrough or otherwise compelling surgical events.

#### **SUBMITTING MANUSCRIPTS ELECTRONICALLY**

**To submit a manuscript electronically, please go to our website, <http://www.editorialmanager.com/annsurg> and follow instructions.**

You will first be asked to register, which will require you to provide contact information, including your telephone and fax numbers and your e-mail address. Please do not register in the system more than once as this will create duplicate profiles within the system and may cause technical difficulties in accessing the online system.

The system will assume that you are the designated corresponding author and all communications concerning the manuscript will then be directed to you. If you are not the designated corresponding author, please note that only the designated corresponding author will have access to the manuscript through the *Annals of Surgery* online system.

Please consult our detailed instructions for Randomized Controlled Trials as well as our instructions on Ethical and Humane Considerations. Please also note our policy and requirements regarding clinical trials, which was detailed in a Consensus Statement on Mandatory Clinical Trial Registration published in the April 2007 issue.

Signed Transfer of Copyright statements are required from the author and all coauthors by the publisher as a condition of publication and should be submitted electronically with the manuscript or by fax.

## SUBMITTING MANUSCRIPTS

**The *Annals of Surgery* requires all manuscripts to be submitted electronically.** If, for some reason, you are experiencing difficulty in submitting a manuscript through our online system, please contact our Editorial office by e-mail, telephone or fax and we will assist you in submitting your paper.

## ARTICLE TYPES

**ORIGINAL STUDY.** These are full-length original research articles, representing substantial, novel research in general surgery. **Word and reference limits:**Text: 3,500 words, excluding abstract, references, tables, and figures; Abstract: 250 words; References: 50 maximum. A maximum combined number of 7 tables & figures may be included for publication in print. Additional tables and figures may be included as online-only supplemental data content.

All clinical trials that prospectively assign human subjects to medical interventions, comparison groups, or control groups must be registered in one of several free, publicly accessible, non-profit electronically searchable databases. Trials can be registered retroactively and submitted manuscripts must include the unique registration number in the abstract as evidence of registration. See below for more details.

**RANDOMIZED CONTROLLED TRIALS.** Authors of will be required to fill in a 10-item "Submission CONSORT" questionnaire as part of the submission process. If the paper receives a decision of "Revise," then the authors must include the a completed copy of the full CONSORT checklist and flow chart, designated as supplemental digital content items. Please follow the guidelines in the current CONSORT statement (Consolidated Standards of Reporting Trials), which you can access via the following website <http://www.consort-statement.org/>. **Word and reference limits:** Text: 3,500 words, excluding abstract, references, tables, and figures; Abstract: 250 words; References: 50 maximum. A maximum combined number of 7 tables & figures may be included for publication in print. Additional tables and figures may be included as online-only supplemental data content.

**REVIEW PAPER.** These articles are state-of-the-art reviews on specific topics within surgery. **Word and reference limits:** Text: 7,000 words, excluding abstract, references, tables, and figures; Abstract: 250 words; References: 75 maximum. A maximum combined number of 7 tables & figures may be included for publication in print. Additional tables and figures may be included as online-only supplemental data content.

**META-ANALYSIS.** These articles are systematic, critical assessments of current literature pertaining to clinical topics, emphasizing factors such as cause, diagnosis, prognosis, therapy, or prevention. All articles should be searched for and selected systematically for inclusion and critically evaluated, and the search and selection process should be described in the manuscript. The specific type of study or analysis should be described for each article or data source.

We encourage authors of meta-analyses of clinical trials to submitted the [PRISMA flow diagram and checklist](#). Authors of meta-analyses of observational studies are encouraged to submit the [MOOSE checklist](#). The PRISMA and MOOSE items should be designated as supplemental digital content items. **Word and reference limits:** Text: 5,000 words, excluding abstract, references, tables, and figures; Abstract: 250 words; References: 75 maximum. A maximum combined

number of 7 tables & figures may be included for publication in print. Additional tables and figures may be included as online-only supplemental data content.

**SURGICAL TECHNIQUE.** These are brief articles that highlight a new surgical technique or an extension or modification of a current surgical technique. The technique should be explained in detail, and the discussion should include a robust explanation of the benefits of the new technique compared to other surgical interventions. **Word and reference limits:** Text: 3,000 words, excluding abstract, references, tables, and figures; Abstract: 200 words; References: 30 maximum. A maximum combined number of 5 tables & figures may be included for publication in print. Additional tables and figures may be included as online-only supplemental data content. Video demonstrations of the technique would be particularly appropriate.

**SURGICAL RETROSPECTION (HISTORICAL).** These articles tell the story of a pioneering surgeon or surgical practice or event that helped reshape the practice of surgery and set new directions for the profession and clinical practice. **Word and reference limits:** Text: 5,000 words, excluding abstract, references, tables, and figures; Abstract: 250 words; References: 50 maximum. A maximum combined number of 7 figures may be included for publication in print. Additional figures may be included as online-only supplemental data content.

**SURGICAL PERSPECTIVES.** Surgical Perspective is a new feature in *Annals of Surgery* beginning in 2014. As opposed to standard editorials or letters to the editor, these short articles are not a commentary on specific papers published in the *Annals of Surgery* but rather address important issues relevant to healthcare or medicine in general and which are of specific interest to the profession of surgery. The topics of these articles may include surgical quality or safety, surgical reimbursement, surgical education, or other issues facing the profession. Like all papers published in the *Annals of Surgery*, these papers will be peer-reviewed and, if accepted, they will be published both in print and online with free access to all. **Word and reference limits:** Text: 1,500 words, excluding title page and references; References: 10 maximum; Figures and Tables: 1.

#### **LETTER TO THE EDITOR.**

##### **Letters about published articles in *Annals of Surgery*.**

Letters commenting on papers published in the *Annals of Surgery* are welcome. They should contain substantive ideas and commentary supported by appropriate data and references. Please be sure to cite the original paper published in *Annals of Surgery* in the references. Whenever possible, they will be published with the reply of the published paper's author. **Word and reference limits:** Text: 1,000 words, excluding title page and references; References: 10 maximum; Figures and Tables: 0.

##### **Letters about new techniques or preliminary research.**

Letters describing preliminary research or of alternative techniques may also be accepted. In the case of such letters, they should contain substantive ideas and commentary supported by appropriate data and references. Whenever possible, they will be published with a commentary by a senior member of the reviewer or editorial board. **Word and reference limits:** Text: 1,000 words, excluding title page and references; References: 10 maximum; Figures and Tables: 1.

#### **DUPLICATE PUBLICATION**

Manuscripts are reviewed for possible publication with the understanding that they are being

submitted only to the *Annals of Surgery* and have not been published, simultaneously submitted, or already accepted for publication elsewhere.

This does not preclude consideration of a manuscript that has been rejected by another journal or a complete report that follows publication of preliminary findings elsewhere, usually in the form of an abstract. *Copies of any possibly duplicate published material should be submitted with the manuscript under consideration, with a statement in the cover letter as to why the manuscript currently being submitted is not a duplicate publication.*

### **DISCLOSURE OF CONFLICTS**

Authors must state all possible conflicts of interest in the manuscript, including financial, consultant, institutional and other relationships that might lead to bias or a conflict of interest. If there is no conflict of interest, this should also be explicitly stated as none declared. All sources of funding should be acknowledged in the manuscript. All relevant conflicts of interest and sources of funding should be included on the title page of the manuscript with the heading "Conflicts of Interest and Source of Funding:". For example: Conflicts of Interest and Source of Funding: A has received honoraria from Company Z. B is currently receiving a grant (#12345) from Organization Y, and is on the speaker's bureau for Organization X - the CME organizers for Company A. For the remaining authors none were declared.

In addition, each author must complete and submit the journal's copyright transfer agreement, which includes a section on the disclosure of potential conflicts of interest based on the recommendations of the International Committee of Medical Journal Editors, "Uniform Requirements for Manuscripts Submitted to Biomedical Journals" ([www.icmje.org/update.html](http://www.icmje.org/update.html)). The form is readily available on the manuscript submission page and can be completed and submitted electronically. Please note that authors may sign the copyright transfer agreement form electronically. For additional information about electronically signing this form, go to <http://links.lww.com/ZUAT/A106>.

Authors must submit a separate Transfer of Copyright statement for each author/coauthor with their manuscripts. The appropriate form can be downloaded in PDF format from our website at <http://edmgr.ovid.com/annsurg/accounts/copyrightTransfer.pdf> or by linking to **Author & Reviewer Info** on the *Annals of Surgery* website at <http://www.annalsofsurgery.com>.

### **COMPLIANCE WITH NIH AND OTHER RESEARCH FUNDING AGENCY ACCESSIBILITY REQUIREMENTS**

A number of research funding agencies now require or request authors to submit the post-print (the article after peer review and acceptance but not the final published article) to a repository that is accessible online by all without charge. As a service to our authors, LWW will identify to the National Library of Medicine (NLM) articles that require deposit and will transmit the post-print of an article based on research funded in whole or in part by the National Institutes of Health, Wellcome Trust, Howard Hughes Medical Institute, or other funding agencies to PubMed Central. The revised Copyright Transfer Agreement provides the mechanism.

### **PATIENT ANONYMITY AND INFORMED CONSENT**

It is the author's responsibility to ensure that a patient's anonymity be carefully protected and to verify that any experimental investigation with human subjects reported in the manuscript was performed with informed consent and following all the guidelines for experimental investigation

with human subjects required by the institution(s) with which all the authors are affiliated. Authors should mask patients' eyes and remove patients' names from figures unless they obtain written consent from the patients and submit written consent with the manuscript.

### **PERMISSIONS**

Authors must submit written permission from the copyright owner (usually the publisher) to use direct quotations, tables, or illustrations that have appeared in copyrighted or published form elsewhere, along with complete details about the source. Any permissions fees that might be required by the copyright owner are the responsibility of the authors requesting use of the borrowed material, not the responsibility of Lippincott Williams & Wilkins.

### **AUTHORSHIP**

The *Annals of Surgery* discourages the practice of "guest authorship" (giving co-authorship to individuals who have made no substantive contribution to the work being reported). All persons listed as authors are assumed to have been actively involved in one or more key aspects of the reported study.

The following guidelines should be used to identify individuals whose work qualifies them as authors as distinct from those who are contributors to the work. In general, each author should have participated sufficiently in the work to take public responsibility for appropriate portions of the content.

Individuals claiming authorship should meet all of the following 3 conditions:

1. Authors make substantial contributions to conception and design, and/or acquisition of data, and/or analysis and interpretation of data;
2. Authors participate in drafting the article or revising it critically for important intellectual content; and
3. Authors give final approval of the version to be published.

Acquisition of data, contributing cases, or general supervision of the research group, of itself does not qualify for authorship. When a large, multi-center group has conducted the work, the group should identify the individuals who accept direct responsibility for the manuscript. These individuals should fully meet the criteria for authorship defined above.

Groups of persons who have contributed materially to the paper but whose contributions do not justify authorship may be listed under a heading such as "clinical investigators" or "participating investigators," and their function or contribution should be described -- for example, "served as scientific advisors," "critically reviewed the study proposal," "collected data," or "provided and cared for study patients." Because readers may infer their endorsement of the data and conclusions, all persons listed as contributors must give written permission to be acknowledged.

Other contributors should be listed in an acknowledgments section. Examples of those who might be acknowledged include a person who provided purely technical help, writing assistance, or a department chair who provided only general support. Financial and material support should also be acknowledged.

### **PREPARATION OF MANUSCRIPT**

Type manuscript, *double-spaced throughout*, with margins of 2.5 cm (1 inch) on all sides. Pages

must be numbered, starting with the Structured Abstract and continuing through the references. Place the number in the upper right-hand corner of each page. Please be sure to add a formal Title page to the manuscript. (See below for details)

### **MANDATORY CLINICAL TRIAL REGISTRATION**

As of July 1, 2007, *Annals of Surgery* requires all clinical trials that prospectively assign human subjects to medical interventions, comparison groups, or control groups for the purpose of examining the potential health effects of such interventions, to be registered in one of several free, publicly accessible, non-profit electronically searchable databases such as the one administered by the National Library of Medicine (NLM), which is located at <http://www.clinicaltrials.gov>. Trials can be registered retroactively and submitted manuscripts must include the unique registration number in the abstract as evidence of registration.

For details regarding the required minimal registration data set, please go to the International Committee of Medical Journal Editors (ICMJE) site at [http://www.icmje.org/#clin\\_trials](http://www.icmje.org/#clin_trials).

Authors submitting manuscripts reporting on unregistered clinical trials may request consideration of their papers if they can provide sufficient evidence of merit, although we anticipate that all clinical trials will be registered after July 1, 2007.

For more information, please see the Consensus Statement on Mandatory Clinical Trial Registration, adopted by the members of the Surgery Journal Editors Group, published in the April 2007 issue of the *Annals of Surgery* (245(4): 505-506), which is available online at <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1877041>

Currently, there are six registries approved by the ICMJE:

[clinicaltrials.gov/](http://clinicaltrials.gov/)

[www.ISRCTN.org](http://www.ISRCTN.org)

[www.who.int/ictrp/about/details/en/index.html](http://www.who.int/ictrp/about/details/en/index.html)

[www.umin.ac.jp/ctr/index/htm/](http://www.umin.ac.jp/ctr/index/htm/)

[www.trialregister.nl/trialreg/index.asp](http://www.trialregister.nl/trialreg/index.asp)

[www.anzctr.org.au/default.aspx](http://www.anzctr.org.au/default.aspx)

### **MANUSCRIPT GUIDELINES**

For study types other than Randomized Controlled Trials, the Editors request that you please check the following guidelines prior to submitting your manuscript to ensure that the highest ethical standards for research are maintained.

- PRISMA Checklist and Flow Diagram: for Meta-Analyses and Systematic Reviews of Randomized Controlled Trials. <http://www.prisma-statement.org>
- STROBE CHECKLIST: (from the *Bulletin of the World Health Organization* | November 2007, 85 (11)) for Observational Studies. Link: <http://www.strobe-statement.org/Publications.htm>
- MOOSE Guidelines: (PDF document ref JAMA, April 19, 2000-Vol 283, No. 15) - for Meta-Analyses and Systematic Reviews of Observational Studies. Please see Table 1 for the checklist.

## MANUSCRIPT COMPONENTS

**Transfer of Copyright Form** - the appropriate form can be downloaded as a PDF from the Instructions for Authors web page at <http://edmgr.ovid.com/annsurg/accounts/copyrightTransfer.pdf>. Each author/coauthor of a manuscript must fill out and sign a separate Form, which may be submitted by fax or mail after manuscript submission.

**Cover letter** - The cover letter, from the author responsible for all correspondence regarding the manuscript, should contain a statement that the manuscript has been seen and approved by all authors. If color figures have been submitted, a statement should be included as to whether the authors are willing to meet possible costs of color reproduction.

**Title page** - Place as the first page of the manuscript text file. The Title Page should not be included in the word count. The title page should contain the following information:

- Title of paper including a description of the type of study conducted.
- Full name of each author (first name, middle initial and last name) followed by each author's *highest academic degree(s)*. Name of department(s) and institution(s) with which each author is affiliated and to which work should be attributed.
- Name, address, telephone number, fax number, and E-mail (if available) of author responsible for correspondence concerning the manuscript.
- Name, address, and telephone number of author to whom requests for reprints should be addressed, or a statement that reprints will not be available from the author(s).
- Cite all sources of support for the work being reported, including grants, equipment, and drugs.
- A short running head of no more than 40 characters, including spaces, placed at the bottom of the title page.

The title page must also include disclosure of funding received for this work from any of the following organizations: National Institutes of Health (NIH); Wellcome Trust; Howard Hughes Medical Institute (HHMI); and other(s).

**Mini-Abstract** - The mini-abstract should be a short description of the study, no longer than about three sentences or 50 words. This will appear in the Table of Contents under the title of the paper.

**Structured Abstract** - The purpose of the structured abstract is to concisely present the data contained in the manuscript in an easily understood and comprehensive summary of about 250 words. The format should consist of:

**Objective:** one or two sentences.

**Summary Background Data:** a short paragraph describing the scientific context for the study.

**Methods:** a statement of the plan and/or methods used in conducting the study.

**Results:** a concise summary of findings, as verified by the data.

**Conclusions:** a brief statement of what can be deduced from the findings of the study.

**Text of the paper** - Original papers are usually but not necessarily divided into sections with the following headings: Introduction, Methods, Results, and Discussion. Subheadings are often helpful in clarifying the content. Please format main headings as bold, capital text; secondary headings as italics; and third-level headings as plain text.

**Introduction:** Clearly state the purpose of the article. Summarize the rationale for the study or observation, providing the scientific context for the study being reported. Give only strictly pertinent references, and do not review the subject exhaustively.

**Methods:** Clearly describe your selection of the observational or experimental subjects (human or nonhuman). Identify the methods, apparatus (manufacturer's name and address in parentheses) and procedures in sufficient detail to allow other workers to reproduce the results. Give the references to established methods, including statistical analyses. Provide references and brief descriptions of methods that have been published but are not well known. Describe new or substantially modified methods, give reasons for using them, and evaluate their limitations.

Include numbers of observations and the statistical significance of findings, when appropriate. For studies involving living subjects, please see section, below, on *Ethical and Humane Considerations* and the information regarding mandatory clinical trial registration.

**Results:** Present results using text, tables, and illustrations. Use the format that most concisely and clearly presents the information. Data in table or illustration form should be referenced in the text, not repeated (eg, detailed information should not be given in text and tables).

**Discussion:** Emphasize new and important findings and aspects of the study, and the conclusions to be drawn. Include implications of the findings and the limitations, and relate the observations to other relevant studies. Link your conclusions with the study's goals. Avoid unqualified statements, and allusions to work that has not been completed. State new hypotheses when appropriate, but clearly label them as such. Recommendations, when called for, should be included.

**Acknowledgments** - Acknowledge those who contributed to the manuscript, but who do not qualify for inclusion as authors. For example, those who provided purely technical help or writing assistance, or who provided only general support. Financial and material support should also be acknowledged.

**References** - The authors are responsible for the accuracy of the references. Place the references (double-spaced) at the end of the manuscript. Cite the references numerically in the text in the order of appearance. Cite unpublished data, such as papers submitted but not yet accepted for publication or personal communications, in parentheses in the text. If there are more than three authors, name only the first three authors and then use "et al". Refer to the List of *Journals Indexed in Index Medicus* for abbreviations of journal names, or access the list at [http://www.nlm.nih.gov/tsd/serials/terms\\_cond.html](http://www.nlm.nih.gov/tsd/serials/terms_cond.html). Sample references are given below.

#### *Journal article*

1. Tafra L, Lannin DR, Swanson MS, et al. Multicenter trial of sentinel node biopsy for breast cancer using both technetium sulfur colloid and isosulfan blue dye. *Ann Surg*. 2001; 233: 51–59.

***Book chapter***

2. Tisi PV, Shearman CP. Systemic consequences of reperfusion. In: Grace PA, Mathie RT, eds. Ischaemia-reperfusion injury. London: Blackwell Science; 1999:20–30.

***Entire book***

3. Lippincott Williams & Wilkins; 1999.

***Electronic Pre-print article***

4. Author. Article title. Journal title. Year Month Day; [Epub ahead of print]. Accessed on mm/dd/yyyy. Available at: website (exact website, or enough to lead the reader to the link).

***Software***

5. *Epi Info* [computer program]. Version 6. Atlanta: Centers for Disease Control and Prevention; 1994.

***Online journals***

6. Friedman SA. Preeclampsia: a review of the role of prostaglandins. *Obstet Gynecol* [serial online]. January 1988; 71:22-37. Available from: BRS Information Technologies, McLean, VA. Accessed December 15, 1990.

***Database***

7. CANCERNET-PDQ [database online]. Bethesda, MD: National Cancer Institute; 1996. Updated March 29, 1996.

***World Wide Web***

8. Gostin LO. Drug use and HIV/AIDS [JAMA HIV/AIDS web site]. June 1, 1996. Available at: <http://www.ama-assn.org/special/hiv/ethics>. Accessed June 26, 1997.

**Tables** - Each table, complete with title and footnotes, should be on a separate page, and should be constructed using the table function within a Word type document in order to prevent displacement of the data during print production. Submit tables separately from the manuscript text file.

Like figures, tables should be cited consecutively in the text and numbered in that order. Each must include the table title, appropriate column heads, and explanatory legends (including definitions of any abbreviations used). Tables should not be embedded within the body of the manuscript. They should be self-explanatory and should supplement, rather than duplicate, the material in the text. At the discretion of the editor, long tables may be reclassified as Supplemental Digital Content (online-only).

**Illustrations or Figures**

**A) Creating Digital Artwork**

1. Learn about the publication requirements for Digital Artwork: <http://links.lww.com/ES/A42>
2. Create, Scan and Save your artwork and compare your final figure to the Digital Artwork Guideline Checklist (below).
3. Upload each figure to Editorial Manager in conjunction with your manuscript text and tables.

## B) Digital Artwork Guideline Checklist

Here are the basics to have in place before submitting your digital artwork:

- Artwork should be saved as TIFF, EPS, or MS Office (DOC, PPT, XLS) files. High resolution PDF files are also acceptable.
- Crop out any white or black space surrounding the image.
- Diagrams, drawings, graphs, and other line art must be vector or saved at a resolution of at least 1200 dpi. If created in an MS Office program, send the native (DOC, PPT, XLS) file.
- Photographs, radiographs and other halftone images must be saved at a resolution of at least 300 dpi.
- Photographs and radiographs with text must be saved as postscript or at a resolution of at least 600 dpi.
- Each figure must be saved and submitted as a separate file. Figures should not be embedded in the manuscript text file.

### Remember:

- Cite figures consecutively in your manuscript.
- Number figures in the figure legend in the order in which they are discussed.
- Upload figures consecutively to the Editorial Manager web site and enter figure numbers consecutively in the Description field when uploading the files.
- **Do not** send original drawings or roentgenograms.
- Figures should be professionally drawn and photographed; freehand or typewritten lettering is unacceptable. Again, convert figures to electronic TIFF or EPS format for submission. Photomicrographs must have internal scale markers. Symbols, arrows, or letters used in the figures should contrast with the background.
- If photographs of persons are used, the subjects must not be identifiable, or their pictures must be accompanied by written permission to use the photograph.
- If a figure has been previously published, acknowledge the original source and submit written permission from the copyright holder to reproduce the material. Permission is required, regardless of authorship or publisher except for documents in the public domain.
- At the discretion of the editor, figures may be reclassified as Supplemental Digital Content (online-only).

**Color figures:** The journal accepts for publication color figures that will enhance an article. Authors who submit color figures will receive an estimate of the cost for color reproduction. If they decide not to pay for color reproduction, they can request that the figures be converted to black and white at no charge.

**Supplemental Digital Content (SDC)** - Authors may submit SDC via Editorial Manager to LWW journals that enhance their article's text to be considered for online posting. SDC may include standard media such as text documents, graphs, audio, video, etc. On the Attach Files page of the submission process, please select Supplemental Audio, Video, or Data for your uploaded file as the Submission Item. If an article with SDC is accepted, our production staff will create a URL with the

SDC file. The URL will be placed in the call-out within the article. SDC files are not copy-edited by LWW staff, they will be presented digitally as submitted. For a list of all available file types and detailed instructions, please visit <http://links.lww.com/A142>.

### **SDC Call-outs**

Supplemental Digital Content must be cited consecutively in the text of the submitted manuscript. Citations should include the type of material submitted (Audio, Figure, Table, etc.), be clearly labeled as "Supplemental Digital Content," include the sequential list number, and provide a description of the supplemental content. All descriptive text should be included in the call-out as it will not appear elsewhere in the article.

Example:

We performed many tests on the degrees of flexibility in the elbow (see Video, Supplemental Digital Content 1, which demonstrates elbow flexibility) and found our results inconclusive.

### **List of Supplemental Digital Content**

A listing of Supplemental Digital Content must be submitted at the end of the manuscript file. Include the SDC number and file type of the Supplemental Digital Content. This text will be removed by our production staff and not be published.

Example:

Supplemental Digital Content 1.wmv

### **SDC File Requirements**

All acceptable file types are permissible up to 10 MBs. For audio or video files greater than 10 MBs, authors should first query the journal office for approval. For a list of all available file types and detailed instructions, please visit <http://links.lww.com/A142>.

**Legends for illustrations:** Legends must be submitted for all figures. They should be brief and specific, and they should appear on a separate manuscript page after the references. Use scale markers in the image for electron micrographs, and indicate the type of stain used.

## **ETHICAL AND HUMANE CONSIDERATIONS**

The *Annals of Surgery* is dedicated to the humane and ethical conduct of all studies involving living subjects. All clinical trials involving human subjects must be registered, retroactively if necessary, to be considered for publication. (Please see the information regarding [mandatory clinical trial registration](#)).

In studies with human subjects, indicate in the Methods section whether the procedures, including obtaining informed consent, were conducted in accord with the ethical standards of the Committee on Human Experimentation of the institution in which the experiments were done or in accord with the ethical standards of the Helsinki Declaration of 1975.

For experiments with animal subjects, briefly explain the measures taken to insure compliance with established guidelines for humane use and care of laboratory animals, citing the origin of these guides (e.g. institution's Animal Care Committee, US Dept. Agriculture, NIH, National Research Council, other).

## **ABBREVIATIONS**

Use only standard abbreviations for units of measurement, and approved abbreviations when

citing journals in your manuscript's Reference section. The following sources contain complete listings of abbreviations.

- American Medical Association (AMA) Manual of Style.
- List of Serials Indexed for Online Users, published by The National Library of Medicine

Click on the heading titled "Databases and Resources", and then on the subheading "LocatorPlus".

## **APPENDICES**

*Annals of Surgery* does not generally publish appendices. They may be included as supplementary material for review purposes, but appendices should be removed or converted to tables and numbered consecutively with any other tables included with the manuscript if accepted for publication.

## **MANUSCRIPT SUBMISSION REQUIREMENTS**

Address questions about submissions to:

Steve Cavanaugh

Managing Editor

*Annals of Surgery*

[managingeditor@annalsofsurgery.org](mailto:managingeditor@annalsofsurgery.org)

Phone: (774) 240-0065

Fax: (617) 934-7786

## **AFTER ACCEPTANCE**

### **Open access**

LWW's hybrid open access option is offered to authors whose articles have been accepted for publication. With this choice, articles are made freely available online immediately upon publication. Authors may take advantage of the open access option at the point of acceptance to ensure that this choice has no influence on the peer review and acceptance process. These articles are subject to the journal's standard peer-review process and will be accepted or rejected based on their own merit.

Authors of accepted peer-reviewed articles have the choice to pay a fee to allow perpetual unrestricted online access to their published article to readers globally, immediately upon publication. The article processing charge for *Annals of Surgery* is \$3,100. The article processing charge for authors funded by the Research Councils UK (RCUK) is \$3900. The publication fee is charged on acceptance of the article and should be paid within 30 days by credit card by the author, funding agency or institution. Payment must be received in full for the article to be published open access.

### **Authors retain copyright**

Authors retain their copyright for all articles they opt to publish open access. Authors grant LWW a license to publish the article and identify itself as the original publisher.

### **Creative Commons license**

Articles opting for open access will be freely available to read, download and share from the time of publication. Articles are published under the terms of the Creative Commons License

Attribution-NonCommercial No Derivative 3.0 which allows readers to disseminate and reuse the article, as well as share and reuse of the scientific material. It does not permit commercial exploitation or the creation of derivative works without specific permission. To view a copy of this license visit: <http://creativecommons.org/licenses/by-nc-nd/3.0>.

Authors funded by RCUK and The Wellcome Trust must sign a license giving the publisher the right to publish the article. The authors retain copyright but anyone may reuse the article and create derivatives, even for commercial purposes, with proper attribution to *Annals of Surgery* as the original publisher. Authors will be required to publish, as per the RCUK mandate and the Wellcome Trust policy, under the Creative Commons: Attribution (CC-BY) License.

### **Compliance with NIH, RCUK and other research funding agency accessibility requirements**

A number of research funding agencies now require or request authors to submit the post-print (the article after peer review and acceptance but not the final published article) to a repository that is accessible online by all without charge. As a service to our authors, LWW identifies to the National Library of Medicine (NLM) articles that require deposit and transmits the post-print of an article based on research funded in whole or in part by the National Institutes of Health, Howard Hughes Medical Institute, or other funding agencies to PubMed Central. The revised Copyright Transfer Agreement provides the mechanism. LWW ensures that authors can fully comply with the public access requirements of major funding bodies worldwide. Additionally, all authors who choose the open access option will have their final published article deposited into PubMed Central.

RCUK funded authors can choose to publish their paper as open access with the payment of an article process charge, or opt for their accepted manuscript to be deposited (green route) into PMC with an embargo.

With both the gold and green open access options, the author will continue to sign the Copyright Transfer Agreement (CTA) as it provides the mechanism for LWW to ensure that the author is fully compliant with the requirements. After signature of the CTA, the author will then sign a License to Publish where they will then own the copyright.

It is the responsibility of the author to inform the Editorial Office and/or LWW that they have RCUK funding. LWW will not be held responsible for retroactive deposits to PMC if the author has not completed the proper forms.

### **FAQ for open access**

<http://links.lww.com/LWW-ES/A48>

**Page proofs and corrections:** Corresponding authors will receive electronic page proofs to check the copyedited and typeset article before publication. Portable document format (PDF) files of the typeset pages and support documents (eg, reprint order form) will be sent to the corresponding author via e-mail. Complete instructions will be provided with the e-mail for downloading and printing the files and for faxing the corrected pages to the publisher. Those authors without an e-mail address will receive traditional page proofs. It is the author's responsibility to ensure that there are no errors in the proofs. Changes that have been made to conform to journal style should be allowed to stand if they do not alter the authors' meaning. Authors may be charged for alterations to the proofs beyond those required to correct errors or to answer queries. Proofs must

**LAPAROSCOPY (TO DETECT OCCULT DIAPHRAGM INJURY) VERSUS CLINICAL AND RADIOLOGICAL FOLLOW UP TO DETECT DIAPHRAGM INJURY AND HERNIATION, IN PATIENTS WITH ASYMPTOMATIC LEFT THORACOABDONIMAL STAB WOUNDS**

**A RANDOMIZED CONTROLLED STUDY**

Malherbe GF

---

be checked carefully and corrections faxed within 24 to 48 hours of receipt, as requested in the cover letter accompanying the page proofs.

**Reprints:** Authors will receive a reprint order form and a price list with the page proofs. Reprint requests should be faxed to the publisher with the corrected proofs, if possible. Reprints are normally shipped 6 to 8 weeks after publication of the issue in which the item appears. Contact the Reprint Department, Lippincott Williams & Wilkins, 351 W. Camden St., Baltimore, MD 21201 with any questions. Fax: 410-528-4434.

**Publisher's contact:** Direct requests for reprint order forms, and any other related materials to *Annals of Surgery* at <http://www.editorialmanager.com/annsurg>