

**REVISITING THE CRITICAL ROLE
OF MINIMAL INVASIVE SURGERY (LAPAROSCOPY)
IN THE MANAGEMENT OF TRAUMA PATIENTS
AT A DEDICATED TRAUMA UNIT
AT THE DR GEORGE MUKHARI ACADEMIC HOSPITAL,
PRETORIA, SOUTH AFRICA**

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of PhD in Surgery,
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Supervisors' approval

As the candidate's supervisor, I have approved this thesis for submission.

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As the candidate's co-supervisor, I have approved this thesis for submission.

Signed: _____ Name: **Professor T. Madiba** Date: 2018

DECLARATION

I, Modise Zacharia Koto, declare that:

The research reported in this dissertation, except where otherwise indicated, is my original work.

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DEDICATION

Dedicated to my beloved family for their loyal support, love and encouragement, without whom, this would not have been possible.

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ABBREVIATIONS

HIV: Human Immunodeficiency Virus

CT SCAN: Computerised Tomography Scan

PAT: penetrating Abdominal Trauma

LMIC: Lower Middle Income Countries

ATLS: Advanced Trauma Life Support

TB: Tuberculosis

FAST: Focused Assessment with Sonography in Trauma

SUMMARY OF THE WORK DESCRIBED IN THIS THESIS

ABSTRACT

Background

South Africa, as a low to middle income country (LMIC), is plagued by a quadruple burden on health-care, namely trauma; the human immuno-deficiency virus (HIV) with concomitant tuberculosis infection; maternal death; non-communicable diseases such as diabetes and hypertension. The impact of trauma on an already over-burdened public sector has been profound.

Improving surgical outcomes is a global health priority according to the Lancet commission. One of the World Health Organization (WHO) mandates is to improve surgical care across the globe. In addressing this question, the WHO has suggested what is referred to as a list of Bellwether procedures. This is a list of important and common procedures that account for major mortalities in developing countries. The main goal of the list is to build proficiency and dexterity in these procedures so as to reduce mortality. This includes trauma laparotomy and other surgical procedures in emergencies.

The traditional approach to managing trauma patients is premised on the well-established Advanced Trauma Life Support (ATLS) principles. This well documented approach has been shown to significantly improve health outcomes of trauma victims. Closely connected to this treatment pathway are surgical interventions that have also been shown to improve the health outcomes of trauma patients. At the heart of surgical intervention for abdominal trauma, is the tried and tested laparotomy. When one looks at this, from a health economics stand-point and a cost-effective platform, laparotomy has been shown to be cost-effective and life-saving. That said, laparotomy is not without major adverse outcomes; there has been significant morbidity and, in some cases, even mortality resulting from laparotomy reported by some investigators.

Laparoscopy started in earnest during the 1980s with the first laparoscopic cholecystectomy described by Muhë from Germany and later popularised by Phillip Mourret of France. This was the start of a major surgical revolution that engulfed the whole surgical community. Laparoscopic cholecystectomy became the pivot around which this revolution evolved and gathered momentum. Indeed, there has been a sea-change of surgical procedures carried out laparoscopically since its evolution and rapid development of laparoscopic cholecystectomy.

The benefits of laparoscopy and other minimally invasive procedures are well documented. Despite overwhelming evidence that supports the use of laparoscopy in surgery in general, there has been reluctance in the uptake of this procedure in trauma for a number of reasons; chief of which is the fear of missed injuries. This fear was fuelled by the publication by Ivatury and colleagues citing a high rate of missed small bowel injuries in trauma patients. Consequently, there was a large hiatus in the application of this technique in the management of trauma patients and, as expected, trauma has lagged behind in the uptake of laparoscopy and continues to do so today.

A great deal has happened since the publication of the work by Ivatury and colleagues. The quality of laparoscopic cameras has improved significantly and more importantly, the average surgeon's skills-set in laparoscopy has improved considerably.

The rationale for my research was to look critically at our experience with laparoscopy, appraise the available data and see how this would impact on the tried and tested practice prevalent in the trauma arena, leading to a new paradigm being set in the laparoscopic management of trauma patients that are hemodynamically stable in the South African milieu.

Aims

The aim of this work was to critically evaluate the role and safety of laparoscopy in the management of stable trauma patients presenting at the dedicated trauma unit of the Dr George Mukhari Academic Hospital (DGMAH).

Objectives

We set out to investigate the role of laparoscopy in the following ways, in trauma scenarios:

- laparoscopy as a diagnostic tool and how the risk of missed injuries should be addressed and minimized;
- the role of laparoscopy in the management of thoraco-abdominal injuries, including right-sided injuries and also in patients with generalized peritonitis who are hemodynamically stable;
- the appropriate access technique by a way of randomized controlled trial when offering these patients laparoscopy;
- diagnostic accuracy of laparoscopy in trauma - how not to miss injuries;

laparoscopic-assisted techniques as a strategy to address multiple injuries and therefore address gaps in skills-set and shorten the operative time of these trauma victims;

- laparoscopic management of hemodynamically stable patients with blunt abdominal trauma;
- the role of laparoscopy in the management of penetrating retroperitoneal injuries in hemodynamically stable patients.

Methods

The Trauma Unit of DGMAH has a prospectively collected database which was used to peruse the records of recruited participants for this work. Permission was sought from the Institutional Review Board of the Sefako Makgatho Health Sciences University (SMU) in accordance with the Helsinki Declaration that guides the conduct of biomedical research. Inclusion criteria were set for the various objectives of the study. We investigated the cohort of patients where laparoscopy was used within the setting of diagnosis of abdominal injuries and identified defined primary endpoints and outcomes. We also analysed the interventional strategies that were employed to achieve the desired end result.

To begin with a laparoscope, the first step is safe access into the peritoneal cavity. A one-to-one computer-generated randomized study was carried out comparing the traditional laparoscopic access to peritoneal cavity using Veress needle with the open Hasson technique. Unlike other studies, in this series we included patients who had had a previous laparotomy to address the question of safe abdominal access during laparoscopic procedures. We identified all major and minor complications as the primary outcome.

We determined the outcomes of patients offered laparoscopic procedure in the following situations: thoraco-abdominal injuries where the primary focus was diaphragmatic injuries both on the left and right diaphragms. In this study we included patients with both peritonitis and right sided thoraco-abdominal injuries.

We studied the outcomes of laparoscopy in the case of blunt trauma, penetrating retroperitoneal injuries. We also investigated the role of laparoscopy in the context of diagnosis and specifically identified factors that mitigate against missing injuries and suggested a management pathway to minimize the incidence of missed injuries.

The overall primary outcome was all-cause mortality and complications.

Findings

Fifty (52%) patients were randomized to the closed Veress needle and 46 (48%) patients to the open Hasson technique. Six (6%) adverse events were recorded in the Veress needle arm ($p=0.03$). The Veress needle technique failed to establish pneumoperitoneum in three patients (6%), the port-site bleeding was observed in one (2%) and extraperitoneal insufflation in two (4%) patients. All patients with the adverse events had previous abdominal surgery. There were no adverse events in the open Hasson group.

In the work on laparoscopy and how not to miss injuries, out of 250 patients managed with laparoscopy for penetrating abdominal trauma (PAT), 113 (45%) underwent diagnostic laparoscopy (DL), of these 94 (83%) of patients underwent stab wounds. The penetration of the peritoneal cavity or retroperitoneal cavity or peritoneal cavity was documented in 67 (59%) of the patients. Organ evisceration was present in 21 (19%) of patients. Multiple injuries were present in 22% of cases. The chest was most common associated injury. Two (1,8%) iatrogenic injuries were recorded. There was conversion rate of 1,7% (2/115). The mean length of hospital stay was 4 days. There were no missed injuries.

Laparoscopic assisted approach (LAA) in multiple injuries is work aimed at addressing the problem of multiple injuries in laparoscopy. This work demonstrates the utility of laparoscopy in this setting. The procedure is to evaluate the effect LAA in multiple injuries. Over 2-year period 23 patients were managed with LAA and of these 13 were patients with stab wounds and 10 with gunshot wounds. Commonly performed procedure was repair of hollow viscus injury

For thoracoabdominal injury, a total of 83 patients with thoracoabdominal injuries met the selection criteria. The injury severity score (ISS) ranged from 8 to 24 with a median of 18. The incidence of diaphragmatic hernia was 54%. Majority (46,8%) had grade 3 (2-10cm) laceration. Associated injuries encountered requiring interventions we encountered in 28 (62%). At least 93,3% of the patients were treated exclusively with laparoscopy. The morbidity was encountered in 7 (16%) of the patients. The commonest was clotted hemothorax Clavian Dindo (ii)b, but only one patient required decortication. There was one procedure related mortality.

In laparoscopy management of retroperitoneal injuries in hemodynamically stable patients, of 284 with PAT 56 had involvement of the retroperitoneum. Stab wounds accounted for 62,5% of the patients. The mean ISS score was 7,4 (4-20). Amongst the retroperitoneal injuries the colon (27%) was the most commonly injured hollow viscus followed by the

duodenum (5%). The kidney (5%) and pancreas(4%) were the commonly injured solid organs. The conversion rate was 19,6% and this was mainly due to active bleeding. Significantly more patients were with GSW had their procedures converted to open laparotomy(38% vs 9%). Therapeutic laparoscopy was performed in 36% of the patients. There were no recorded missed injuries. Five (9%) patients developed Clavien-Dindo grade 3 complications, three were managed with reoperation, one with drainage and one with endovascular technique

In laparoscopy for blunt trauma, a challenging endeavour- Thirty-five stable patients underwent laparoscopy. The mean Injury Severity score was 12 (4-38). Therapeutic laparoscopy was performed in 15 (56%) and diagnostic in 12 (44%) patients. Eight (23%) patients were converted to therapeutic laparotomy. Intraoperative bleeding, complex injuries, visualization problem and equipment failure necessitated conversion.

Three (30%) patients with negative CT scan had therapeutic laparoscopy for mesenteric injuries. There were no missed injuries. The mean length of hospital stay was 11 days in both groups.

This series of studies shows that laparoscopy in all the stated objectives was safe and feasible. Multiple laparoscopic interventions in the different trauma scenarios have demonstrated the safety of laparoscopy in haemodynamically stable trauma patients.

Contrary to the suggestion by other investigators, that laparoscopy is contraindicated in retroperitoneal injuries, the current study in retroperitoneal trauma has shown that it was safe and accurate in this cohort of patients. Therapeutic laparoscopy was feasible in 36% of the patients and the conversion rate was 19%. Importantly there were no missed injuries or mortality when managing penetrating trauma patients with retroperitoneal injuries.

Therapeutic laparoscopy was feasible in thoraco-abdominal injuries and these patients were successfully managed, including those with generalized peritonitis. The study of thoracoabdominal injuries, including those with peritonitis, also included patients with injuries to the right side of the abdomen, as well as individuals with generalized peritonitis. We were able to offer therapeutic and diagnostic laparoscopy to this cohort of patients.

Conclusions

In conclusion, laparoscopy is feasible and safe in hemodynamically stable trauma patients in the context of thoraco-abdominal injuries, blunt abdominal trauma, in the presence of peritonitis as well as in laparoscopic-assisted setting, both as a strategy to reduce the incidence of non-remedial laparotomies as well as a diagnostic tool.

Keywords

Laparoscopy, blunt abdominal trauma, retroperitoneal injuries, thoraco-abdominal injuries, diagnostic laparoscopy.

PERSONAL CONTRIBUTION TO THE WORK DESCRIBED IN THIS DISSERTATION

I declare that my personal contribution to the work described in this thesis is as follows:

CONTRIBUTIONS OF AUTHORS

Chapter 2 Paper under peer review

Laparoscopic access in general surgery: the closed (Veress needle) technique versus the open (Hasson) technique: a randomised controlled trial.

M.Z. Koto, O.Y. Matsevych, T. Sumbana, S. Patel.

This concept was conceived by MZ Koto and the study proposal was done by T Sumbana. The data collection and analysis was done by T Sumbana, S Patel and MZ Koto. The actual write up was done by MZ Koto and O.Y. Matsevych. The literature review and critical review was done by O.Y. Matsevych

Chapter 3 Published article

Diagnostic Laparoscopy for Trauma: How Not to Miss Injuries.

M.Z. Koto, O.Y. Matsevych, C. Aldous.

This study was a team effort. Prof M.Z. Koto was the main contributor to the study conception and design. The literature search and data collection, data analysis, data interpretation, and article preparation were done by Prof M.Z. Koto and Dr O.Y. Matsevych; critical review, revision of the article, and mentoring throughout the article preparation was done by Prof C. Aldous.

Chapter 4 Published article

Laparoscopic-Assisted Approach for Penetrating Abdominal Trauma: An Underutilized Technique

Z. Koto, O Matsevych, C Aldous.

Prof M.Z. Koto was the main contributor to the study conception and design. Dr O.Y. Matsevych assisted in refining the study conception and design. The data collection, analysis and interpretation was done by Prof M.Z. Koto and Dr O.Y. Matsevych. The draft was written by Prof M.Z. Koto. Dr O.Y. Matsevych was the corresponding author during the publication of the manuscript. The critical review and corrections were done by Dr O.Y. Matsevych and Prof C. Aldous.

Chapter 5 Published article

The Use of Laparoscopy in Managing Penetrating Thoracoabdominal Injuries in Africa: 83 cases reviewed.

Z. Koto, F. Mosai, O Matsevych.

Prof M.Z. Koto was the main contributor to the study conception and design. The data was collected and analysed by Prof M.Z. Koto and Dr O.Y. Matsevych. The critical review and revisions were done by Dr F. Mosai and Dr O.Y. Matsevych

Chapter 6 Published article

Laparoscopic management of retroperitoneal injuries from penetrating abdominal trauma in hemodynamically stable patients.

M.Z. Koto, O.Y. Matsevych, F. Mosai, M. Balabyeki

Prof M.Z. Koto was the main contributor to the study conception and design, the data collection and analysis. Dr O.Y. Matsevych contributed significantly to the data collection and analysis. Prof M.Z. Koto and Dr O.Y. Matsevych performed the literature search, preparation and revision of the manuscript. Dr F. Mosai, Prof M. Balabyeki and Prof C. Aldous provided the critical review of the manuscript.

Chapter 7 Paper under peer review

Laparoscopy for blunt abdominal trauma: a challenging endeavour

M.Z. Koto, O.Y. Matsevych, F. Mosai, S. Patel, C. Aldous, M, Balabyeki

(not yet published paper, paper under review)

Prof M.Z. Koto was the main contributor to the study conception and design, the data collection and analysis, and preparation of the manuscript. Dr O.Y. Matsevych and Dr F. Mosai contributed to critical review and the writing up of the manuscript. S. Patel contributed to the literature review. Prof C. Aldous and Prof M. Balabyeki contributed to critical review of the paper.

CHAPTER 1

Introduction

The challenges resulting from trauma continue to be a formidable problem in South Africa (SA) (1). Trauma has become a major concern in developing countries. The quadruple socio-economic burden on health-care in SA includes: trauma, HIV with concomitant tuberculosis infection, maternal death, and non-communicable diseases (2). The latter being the rising level of diseases such as diabetes and hypertension.

In most cases, trauma is related to interpersonal violence, road traffic accidents and is often associated with poor socio-economic factors. The key questions of concern are the way in which the challenges posed by trauma on the one hand are handled, whilst grappling with resource challenges on the other. A two-pronged solution is suggested – firstly immediate surgical therapy to reduce morbidity and mortality whilst secondly addressing the socio-economic imperatives of trauma.

The surgical management of trauma victims has always been premised on the Advanced Trauma Life Support (ATLS) principles of primary attention to life-threatening conditions and then prevention of secondary injuries. The immediate management of hemodynamically unstable patients has always been immediate surgical intervention. Surgical management has traditionally been open operation (laparotomy), considered to be the standard of surgical care (3). Imaging has been reserved for those patients who are hemodynamically stable (1).

Development of laparoscopy

The first account of diagnostic laparoscopy dates as far back as Hippocrates in Greece in 460-375 BC. The first correctly recorded laparoscopic cholecystectomy was in 1985 by Eric Muhë from Germany (4). Dr Muhë was initially not recognized for his work by the German Surgical Society because it was felt that he had violated the established surgical principles of big incisions for better exposure (5). In 1987 a laparoscopic cholecystectomy was reported by Phillip Mourret, in France, whose work enjoyed more acceptance. This was the watershed period after which laparoscopy as a major surgical revolution unfolded. Since then there has been an increase in the application of laparoscopy in various aspects of surgery (6). The benefits of minimally invasive surgery have been reported and include shorter hospital stay,

less post-operative pain, less wound complication, earlier return to work, leading to overall improvement in health care costs (4).

While the role of laparoscopy is well-established in various fields of surgery and in some cases laparoscopy has become the standard of care (7), laparoscopy in trauma was initially met with great reservations. Ivatury et al (1994) reported a high rate (80%) of missed small bowel injuries when using laparoscopy in trauma (8). This led to surgeons believing that laparoscopy in trauma was not effective; the result of which was that for a number of years, many trauma surgeons avoided and actively discouraged laparoscopy in trauma. It is important to note that Ivatury published his findings 24 years ago and since then there has been much development in the field of laparoscopic surgery.

Laparoscopic imaging technology has been improving at a rapid rate, starting with a single chip camera in the nineties (when Ivatury published his findings) to high definition cameras and ultra-high definition camera systems today. The improvement in the quality of imaging has led to better visualization and therefore improved outcomes. The laparoscopic skills-set has improved to the extent that very complex operations are now successfully done laparoscopically, for example, the laparoscopic Whipple resection (pancreaticoduodenectomy) and laparoscopic total esophagectomy (6). These are major surgical procedures that illustrate the significant developments in minimally invasive surgery (5). The training in minimal access surgery has been formalized in some centres and has consequently improved the skills-set of surgeons, allowing the technique to be widely utilised.

As the applications of laparoscopy have expanded, more investigators have questioned the exclusion of laparoscopy in the treatment of trauma in hemodynamically stable patients. Recent reports have emerged demonstrating the safety of laparoscopy in abdominal trauma (9). Kawahara et al. have demonstrated that a well set-out, systematic laparoscopic examination of the abdominal cavity reliably decreases the incidence of missed injuries (10). Koto et al. have also showed that a systematic examination of the abdomen minimizes the chances of missed injuries (9). O'Malley et al., in a systematic review, have demonstrated the utility of laparoscopy in patients with abdominal trauma who are hemodynamically stable (11). The key question is whether laparoscopy is safe within the context of abdominal trauma in a resource constrained environment like South Africa.

New protocol in laparoscopy management

The use of laparoscopy in trauma has increased, with its role ranging from diagnostic to therapeutic (12). The majority of trauma surgeons worldwide use laparoscopy for the purpose of diagnosis (13). They use it for screening in penetrating abdominal trauma – to decide if there is a peritoneal breach in which case the patient's treatment would be converted to laparotomy. However, there are data showing that proceeding with therapeutic intervention once there are positive findings on diagnostic laparoscopy, reduces the incidence of laparotomies (12). This work has shown that laparoscopy is safe in the treatment of hemodynamically stable patients with penetrating abdominal trauma (9).

Laparoscopy as a diagnostic tool

The reliability of laparoscopy as a diagnostic tool was called into question by Ivatury et al. and Zanut et al. in their work (8,14). This caused concerns in the trauma surgery world and led to many leading trauma surgeons calling for caution in the use of laparoscopy in trauma (7,8). Many units across the world have serious reservations about using laparoscopy in trauma. The legacy of the work by Ivatury et al. has had a long-term negative impact on the development of laparoscopy as an intervention.

The literature is not clear about the difference between screening and diagnostic laparoscopy. Some investigators use these terms interchangeably. We are of the view that diagnostic laparoscopy is equivalent to diagnostic laparotomy with the propensity for the procedure to extend to therapeutic options, if indicated. It is against this background that we reported it in this thesis and suggested the need to contextualize the definition of diagnostic laparoscopy much more clearly. Some centres convert from laparoscopy to open laparotomy once there is a breach of the peritoneum (15). This approach decreases the rate of negative laparotomy procedures, but it still does not go the whole way in terms of maximizing the well-stated advantages of laparoscopic surgery (16). This work suggest that diagnostic laparoscopy should be carried out and considered in the context of the surgeon's readiness to proceed to full therapeutic mode if indicated. It would be remiss not to indicate that the proviso for this to be possible is adequate skill-set and dexterity in laparoscopy.

To address the fundamental concern of missed injuries raised by Ivatury et al. (8), Kawahara et al. (10) suggested a systematic and a carefully considered approach in the laparoscopic examination technique of the abdomen. This examination technique by Kawahara and colleagues has led to a significant improvement in the accuracy of diagnostic laparoscopy in trauma and reduced the rate of missed injuries significantly.

Kawahara et al. pointed out some of the “blind spots” that can be encountered during diagnostic laparoscopy, such as the splenic flexure, the bare area of segment six and seven of the liver and the retroperitoneum (10). These investigators pointed out that these injuries involving the blind spots should be carefully evaluated and, in some cases, laparoscopy should actually be converted to laparotomy in order not to miss any injuries.

We have proposed an equally systematic examination of the abdomen (17). Kawahara et al. have suggested “blind spot” areas, that make it difficult for the trauma surgeon to accurately assess during laparoscopy, we suggested an approach which entails a complete mobilisation of these blind spots area to enable their meticulous examination to avoid missed injuries. This involves mobilisation of the splenic flexure, hepatic flexure, complete Kocherisation of the duodenum and complete mobilisation of the liver attachment (the falciform and triangular ligaments) to access these injuries for meticulous inspection. This manoeuvre requires proficiency in advanced laparoscopic skills.

In our opinion, the surgeon achieves a better view with laparoscopy than during open surgery because of better clarity and magnification of the image (high-definition) obtained with the newer generation laparoscopic cameras.

In the evaluation of solid organs, laparoscopy has been shown to be reliable (13,18,19). This applies to therapy as well as diagnosis (20). The thesis shows that liver suturing is feasible and can be safely applied laparoscopically; the spleen can equally be handled very well laparoscopically, it can be mobilised and splenic salvage techniques can be applied including laparoscopic splenectomy (9).

The retroperitoneal organs can be handled laparoscopically. This requires extensive mobilisation of the colon and duodenum which may include medial and lateral rotation of the bowel. This is often facilitated by gravity retraction by changing the position of the operating table to examine the area of interest. This allows the retroperitoneum to be exposed adequately to visualise the kidneys, the ureters, the retroperitoneal portion of the colon, and the great vessels (21).

There is concern about the role and safety of laparoscopy in retroperitoneal injuries. There is not much work done on the role of laparoscopy in the management of retroperitoneal injuries. Retroperitoneal injuries are diverse and include retroperitoneal colonic injuries, pancreaticoduodenal injuries, pancreas injuries, mesenteric injuries, renal injuries, posterior abdominal wall and major vessels injury. The challenge is mainly around the management of great vessels which always require open operation. The duodenal injuries can pose a major challenge to manage laparoscopically. The management of duodenal injuries requires advanced suturing skills with a great precision. Part of the work in this thesis was an attempt to specifically address the role of laparoscopy in managing retroperitoneal injuries (21). This work has demonstrated that laparoscopy is feasible, safe and accurate in hemodynamically stable patients with retroperitoneal injuries (21).

Thoraco-abdominal injuries are challenging and often difficult to treat. They involve more than one cavity as well as the diaphragm. The diagnosis of occult diaphragmatic injuries can be challenging even with the modern imaging modalities, but laparoscopy has been shown to be very reliable in the diagnosis. Mjoli et al. in their publication based on their work done in Pietermaritzburg, Kwazulu-Natal, demonstrated the safety and accuracy of laparoscopy in detecting and treating left sided diaphragmatic injuries (22). These authors did not look at injuries on the right side of the abdomen and, very importantly, they excluded all those patients who had signs of peritonitis. In contrast, this thesis demonstrates that laparoscopy is feasible and safe in thoraco-abdominal injuries, even in patients with generalized peritonitis including those with right-sided thoraco-abdominal injuries. Part of the work in this thesis reviewed 83 cases with penetrating thoraco-abdominal injuries who were hemodynamically stable, including those with peritonitis (23). Patients with both left and right sided diaphragmatic injuries, including other intraabdominal injuries were successfully treated laparoscopically. Contrary to the view by other investigators that it is not necessary to repair right sided diaphragmatic injuries (as the liver will buttress the hole and prevent herniation into the chest cavity), our view is that diaphragmatic injuries on the right should be repaired as these do complicate over time and patients may return with major complications, such as strangulations respiratory failure and mortality in some cases. The mortality may occur infrequently.

The practice of trauma surgery has always been viewed as the kindergarten of surgical skills training. This is where novice surgeons practise the art of surgery and develop practical operating skill and dexterity in open procedures. The same principle holds in laparoscopic skill

training. The trauma cases are fairly common and the trainee surgeon gets ample opportunity to hone in their advanced laparoscopic skills under strict supervision. This is where up and coming surgeons can learn how to operate laparoscopically.

Laparoscopy in blunt abdominal trauma

The role of laparoscopy in blunt abdominal trauma is developing. Focused Assessment with Sonography in Trauma (FAST) is a simple bedside examination of the abdomen to detect the presence of fluid in the peritoneal cavity following trauma. This investigation, even though it is readily available, requires skills and is operator dependent. Branney et al. found that a volume of 619ml is required in order to be detected by FAST (24). Fluid volumes higher than this have been missed by FAST (24). Dolich et al. found that 1,7% of patients with significant intraabdominal injuries had negative FAST results (25). In a recent American study (26), the sensitivity of FAST was found to be as low as 22% and the authors suggested that, based on their results, FAST should be bypassed and the trauma surgeon should go straight to computerised tomography (CT) scan of the abdomen in hemodynamically stable patients. CT scan has its role and limitations. Although a CT scan of the abdomen is considered the cornerstone of management of blunt abdominal trauma in hemodynamically stable patients. The challenge with CT scans is its low sensitivity in detecting hollow viscus injuries. Laparoscopy in this subgroup of patients can be very useful and help avoid delay in the treatment of these patients. A delay of a few hours in trauma can result in significant morbidity.

The benefits of laparoscopy are well documented. In this work assessing the role of laparoscopy in blunt abdominal trauma (BAT), 23% of laparoscopic procedures were converted to open laparotomy. This is a high conversion rate compared to the 11.7% conversion rate for penetrating abdominal injuries reported in our previous study (27). The reported conversion rate in the literature ranges from 8.5% to 35% depending on the selection criteria used and the expertise of the treating surgeon. Our conversion rate seems higher in comparison to penetrating injuries which is a reflection of the severity of the injuries that occur in blunt abdominal trauma patients.

The traditional way of managing BAT has involved the use of the abdominal CT scan. The role of laparoscopy in this cohort of patients remains undefined. Pochu Lee et al. compared laparoscopy and open laparotomy (28). A total of 62 patients underwent exploratory

laparotomy and 59 underwent laparoscopy. These investigators found that there was significantly shorter hospital stay (mean 11.0 days vs 17.6 days; $p < 0.001$) in the group that had laparoscopy. They also found significantly lower wound infection rate in the laparoscopic group; mean 5.1% vs 16.1%; $p = 0.049$). The conversion rate in the laparoscopic group to laparotomy was 8,5%. The patients in the laparoscopic group had advantages over their open operation counterparts (28). These results show a clear advantage of laparoscopy over laparotomy which compare with results from our study (9)

Laparoscopy in retroperitoneal injuries

Laparoscopy in retroperitoneal injuries poses challenges and potential hazards. The traditional way of investigating these hemodynamically stable patients has been to use the triple contrast multi-detector CT scan. This approach allows one to detect the tract and trajectory of the injury. The findings on CT scan are not always very definitive, but often indirect; some of the features of hollow viscus injuries are nonspecific. The decision to proceed to laparotomy must always be balanced against the ever present threat of missed hollow viscus injuries, including the colon. Missed colon injury in the retroperitoneum may potentially result in severe necrotizing infection which, in some instances, may lead to mortality. The aggressive approach is therefore justified in this setting. That said, laparotomy is not necessarily a benign intervention. One must always bear in mind the potential complications of laparotomy.

Retroperitoneal injuries are by their nature very challenging to manage. The clinical assessment of these patients has always been very difficult and often not reliable. Many of them have minimal to no clinical signs at all during clinical examination. This includes patients that may have significant retroperitoneal injuries.

Many trauma surgeons use the multidetector CT scan in managing hemodynamically stable patients with suspected retroperitoneal injuries. The surgeon would then proceed with laparotomy once there is suspicion of injury on CT scan. The CT scan features of retroperitoneal hollow viscus injuries are often indirect and not definitive.

The practice of proceeding to open operation, once radiological evidence of possible injury is found, often leads to non-therapeutic laparotomy. In some cases, for example gunshot injuries, the presence of a bullet fragment may give rise to the “scatter phenomenon” which may further reduce the accuracy of the CT scan in accurately diagnosing retroperitoneal injuries. This thesis has demonstrated the benefit of laparoscopy in this cohort of patients (21). Some investigators

have advocated the concept of laparoscopic assessment in trauma (LAST). This is a similar concept to FAST, except that it uses laparoscopy to evaluate the peritoneal cavity. The accuracy is much better using LAST than FAST which has a much higher negative predictive value (29)

The traditional approach has always been to convert the laparoscopic procedures of these patients to open operation once retroperitoneal injuries are encountered. There is a lack of knowledge regarding the role of laparoscopy in the management of retroperitoneal injuries. Even in the open operation, central retroperitoneal pose the significant challenge of a possibility of an exsanguinating bleed, unless such patients are addressed carefully with inflow control at the diaphragmatic hiatus before exploring the central retroperitoneal hematoma. We propose that these patients should be managed with an open operation and not laparoscopically if they have a central hematoma. The ability to fully mobilize the retroperitoneal structures is heavily dependent on the skills level of the treating surgeon. This thesis has demonstrated the safety of laparoscopy in the cohort of hemodynamically stable patients with retroperitoneal injuries (21).

There was a higher conversion rate in this series and the main reason for this was bleeding.

Therapeutic laparoscopy

The development of laparoscopy from a diagnostic tool to a therapeutic intervention has been a long journey. Laparoscopy as a therapeutic strategy is well defined in some domains of surgery. Laparoscopy in trauma arena has been an area of fierce contestation, and understandably so, considering where we have developed from, as a surgical treatment strategy. To put this into context, we come from an era where laparoscopy in penetrating abdominal trauma had an 80% missed rate of small bowel injuries (8). There has been a radical and phenomenal treatment paradigm shift to the current position where we consider therapeutic laparoscopy feasible, accurate and safe.

We demonstrated in our initial work the safety and feasibility of laparoscopy in penetrating injuries (9). In this series, 67% of our patients were offered therapeutic laparoscopy. Many of the injuries (46%) were gunshot wounds. There were no missed injuries in this series and our conversion rate was 11%, thus demonstrating the safety and reliability of laparoscopy in this cohort of patients.

In a systematic review by O'Malley et al. (11), they looked at a number of published series involving 51 studies of which only 13 were prospective. A total of 2569 patients were subjected to laparoscopy of whom 1149 (43.95%) were positive for injury. Of these patients, 13,8% had therapeutic laparoscopy. The conversion rate was 38.9% which is considered high. In this systematic review, 1497 patients were spared open laparotomy. The criticism of the included studies in this systematic review is that the majority were retrospective, and there was a high conversion rate. Despite the poor quality of data included in this systematic review, this work by O'Malley and colleagues demonstrates the principle that therapeutic laparoscopy is possible and safe in hemodynamically stable trauma patients. The study must be understood and interpreted in the context that there is still reluctance in the use of laparoscopy as a therapeutic intervention in penetrating injuries. This thesis demonstrates a much higher rate of therapeutic feasibility than that demonstrated in the study by O'Malley (9). It is more of an institutional philosophy and approach, which some would call an institutional bias in the treatment of hemodynamically stable patients with penetrating abdominal trauma that may explain these results.

Therapeutic laparoscopy in the setting of multiple injuries

Laparoscopy has been shown to offer patients advantages in general and these include amongst others, early recovery, less postoperative pain, less bleeding, less surgical site infection and an earlier return to work, just to name a few (30). The use of laparoscopy in the setting of a gunshot wound with multiple hollow viscera injuries poses technical challenges. Even though it is feasible to repair these injuries laparoscopically, it may not be in the patient's best interests to do so, as it is time-consuming and prolongs the operation time. This thesis describes the laparoscopic-assisted technique as a solution to this problem of multiple injuries. This technique involves making a small 6-8 cm incision after identifying the injuries during the laparoscope to allow the injured segment together with its mesentery to be exteriorized and resection or repair to take place outside the peritoneal cavity. This technique still offers the patient the advantages of minimally invasive surgery. It shortens the operation time quite considerably while still maintaining the benefits of laparoscopic surgery.

This technique was subsequently tested at our own institution where we offered patients with multiple injuries the laparoscopic-assisted technique with satisfactory outcome results (31). The laparoscopic-assisted procedure was found to be safe and feasible. We advocate this as a

solution to multiple bowel injuries which may take much time to repair a generally injured patient who might rather need an expedited and quick procedure (31).

Laparoscopy in the setting of evisceration

Penetrating injuries with evisceration pose a significant management challenge on many fronts. These patients are at risk of developing an array of complications which may include, but are not limited to, the following: hypothermia, necrosis and ischemia of the eviscerated viscera; secondary trauma to the protruding viscera; loss of fluid; infection. The key questions for the treating surgeon are whether or not there is further intraperitoneal injury in the abdomen and whether or not laparoscopic management in this setting is feasible. Some investigators have proposed that laparoscopy should not be used in this context.

Matsevych et al. have shown that laparoscopy is feasible and safe in this context (32). This work further addresses the question of whether or not there are significant associated intraperitoneal injuries in the setting of penetrating injuries with evisceration (32). The findings were that the incidence of intraperitoneal injury was in the order of 58% if there was omental evisceration and that the incidence was higher (73%) if the eviscerated organ was small bowel. Based on these data, the suggested approach should be to explore all patients with evisceration laparoscopically, looking specifically at associated intraperitoneal injuries.

The type of access

The preferred method of peritoneal access has been extensively debated with many investigators averse to the Veress needle access method. The open Hasson method has been touted by many investigators as the safer option from the point of view of serious complications such as vascular injuries. The literature on the safe technique in abdominal access during laparoscopy is not conclusive. Many of the studies are of lower order of evidence and there are few randomized control trials.

Even worse there is a lack of data in the South African setting on which method of abdominal access is safer during laparoscopy. One of the confounding issues in South Africa is the high prevalence of tuberculosis (TB), both pulmonary and abdominal. Abdominal TB, in particular,

leads to adhesions in the abdomen which pose risks during laparoscopic access for any indication, including trauma.

This work looked critically at the question of the type of abdominal access when performing laparoscopy in the setting of a randomized control trial. We found no significant difference in major complications when comparing the Veress access technique and the open Hasson technique in patients undergoing laparoscopy at our institution. We noted some differences in the rate of minor complications but no major ones. This work included patients who had had previous abdominal operation(s), who are thus at high risk of developing access-related complications. The jury is still out on this and surgeons must use the methods with which they are familiar. Our preferred method of access is the open Hasson technique.

The reluctance to embrace laparoscopy in trauma

The initial concerns of missed injuries that trauma surgeons had about laparoscopy have slowly receded and an increasing number of procedures are now done laparoscopically. This has largely been due to a number of key developments in the field of laparoscopy and the fact that the safety concerns of laparoscopy in trauma have now been adequately addressed. What remains as the key issue regarding laparoscopy in trauma, is the technical proficiency of the trauma surgeon and careful selection of patients. This speaks to training issues, in order to build capacity and the requisite skills-set to safely perform a laparoscopy in trauma patients.

To approach trauma laparoscopically is not “reinventing the wheel”, nor changing the practice and principles of trauma management, but to use this minimally invasive technique to deal with the challenges of trauma and offer patients the well stated benefits of laparoscopic surgery. The principles of laparoscopic management in trauma should not differ from those well-established principles in open surgery; laparoscopic management should be adhered to similar principles except that we are using minimally invasive techniques to manage these patients. The key is that the surgeons must know their boundaries and carefully select the patients.

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* this is our work and our citation

CHAPTER 2

Laparoscopic access in general surgery: the closed (Veress needle) technique versus the open (Hasson) technique: a randomised controlled trial

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The Role of Laparoscopy in Penetrating Abdominal Trauma: Our Initial Experience

Submitted to J Laparoendosc Adv Surg Tech A. and is currently under review

The access study was the first study to be conceived. What informs this decision is that the first consideration when a laparoscopic procedure is started, is safe access into the peritoneal cavity. There are many reported complications related to abdominal access which include amongst others – hollow viscus and vascular injuries. The traditional way of achieving access into the peritoneal cavity is by Veress needle or open technique (Hasson). there are various modifications of the open technique that includes optical trocars. The available literature is based on retrospective studies and the quality of data is not high. The second concern is that the data is from outside South Africa where the population studied is different from the local population. There are confounding factors in the South African population which include amongst others, a very high prevalence of both abdominal and pulmonary tuberculosis. Abdominal tuberculosis causes increased incidence of intraabdominal adhesions which may increase the incidence of iatrogenic injury of the bowel during abdominal access. There is also a high incidence of trauma in South Africa and quite a number of our patients have a previous history of laparotomy for previous injury. This constitutes the high-risk patients for abdominal access during laparoscopic surgery. The available studies excluded this high-risk group. We designed our study to include this group who had previous abdominal surgery.

Laparoscopic access in general surgery: the closed (Veress needle) technique versus the open (Hasson) technique: a randomised controlled trial

Modise Z. Koto, Oleh Y. Matsevych, Thendo Sumbana, Soraya Patel

ABSTRACT

Background. Most laparoscopy-related complications occur during initial entry of the abdominal cavity.

The aim of this study was to compare the closed (Veress needle) with the open (Hasson) laparoscopic entry technique for general surgical operations by comparing the success rate and the early complications of these techniques.

Methods. A randomized controlled trial (RCT) comparing the closed (Veress needle) with the open (Hasson) laparoscopic entry technique in hemodynamically stable patients undergoing either emergency or elective surgical procedures was conducted over a 13-month period. The success rate and adverse events related to the technique were recorded and analyzed.

Results. Fifty (52%) patients were randomised to the closed Veress needle and 46 (48%) patients to the open Hasson technique. Six (6%) adverse events were recorded in the Veress needle arm ($p=0.03$). The Veress needle technique failed to establish pneumoperitoneum in three patients (6%), the port-site bleeding was observed in one (2%) and extraperitoneal insufflation in two (4%) patients. All patients with the adverse events had previous abdominal surgery. There were no adverse events in the open Hasson group.

Conclusion. The open Hasson technique appeared to be safer for laparoscopic entry than the closed Veress needle technique. The Veress needle technique was associated with entry failure and minor complications: extraperitoneal insufflation, port-site bleeding. The open Hasson should be preferred technique for laparoscopic entry in surgical patients, especially in patients with previous abdominal surgery.

Key words: Laparoscopy, Hasson technique, Veress needle technique, complications

Introduction

Laparoscopy has now become a standard of care for many surgical operations. It significantly reduced the complications related to open surgery. However, laparoscopy introduced some specific complications which may result in serious morbidity, mortality and medical litigations. The rate of laparoscopy-related complications remains low and most of them occur during initial entry of the abdominal cavity.^{1,2} Three techniques of peritoneal entry exist: (1) the closed (Veress needle) technique, (2) the open (Hasson) technique, and (3) the direct trocar insertion. The direct trocar insertion technique can be subdivided according to the trocar design: shielded, radially expanding, optical entry trocars and bladed ones.²⁻⁴ Each technique has advantages, disadvantages and related complications.

The aim of this study was to compare the closed (Veress needle) with the open (Hasson) laparoscopic entry technique for general surgical operations by comparing the success rate and the early complications of these techniques.

Methods

A randomized controlled trial (RCT) was conducted at a single academic tertiary institution (Dr George Mukhari Academic Hospital (DGMAH), South Africa). Patients were recruited over a 13-month period (from 1st November 2014 to 30th November 2015). All hemodynamically stable patients undergoing either emergency or elective laparoscopic procedures were requested to participate in the study. General surgical patients 18 years or older who were eligible to provide an informed written consent were included in the study. Patients younger than 18 years old, and those hemodynamically unstable were excluded from the study. The success rate and adverse events related to the technique were recorded and analyzed. Any conditions leading to complications/adverse events were also analyzed.

All included patients were randomized by a computer program into one of two arms of the study: the arm A (Veress needle) or the arm B (Hasson). Participating surgeons were fully

proficient with both techniques. The periumbilical area and the left hypochondrium (Palmer's point) were the recommended sites of entry, however, depending on the clinical situation a surgeon could opt for other sites. In arm A, a standard reusable Veress needle was used guided by tactile clicks feeling and water drop test. After pneumoperitoneum was established, a trocar was introduced in the same area. In arm B, the standard open Hasson technique was used by dissecting tissues and dividing peritoneum between two artery forceps and introducing the port (a sleeve) without a trocar under direct vision. Failed entry was defined as an inability to access the peritoneal cavity by a surgeon using the access technique initially selected.

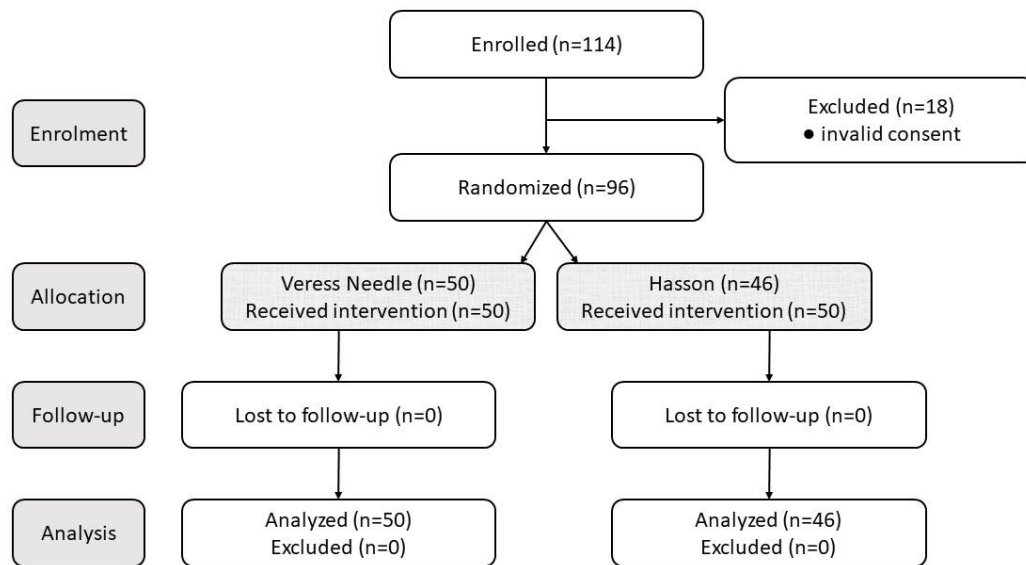
An anonymized data collection form was completed by the general surgeon responsible for the procedure. Patients' age, gender, height, weight, diagnosis, type of surgery, previous abdominal surgery, previous abdominal tuberculosis (TB), first port site placement, a surgeon, intraabdominal findings, complications and their type were recorded. Body Mass Index (BMI) was calculated and patients were categorized into weight groups: BMI above 30 and below 30. All patients were followed up in 24 hours to detect the early entry-site complications. Complication after 24 hours, like surgical site infection and port-site hernia, were not included in the design of this study.

The Fisher's exact test was used for comparisons of frequency counts/percentages. Mean values were compared using the two-sample t-test. Median values were compared by the nonparametric Wilcoxon rank-sum test. Cross-tabulations were used to show distributions of all the factors by treatment arms and chi-square test was used to compare the two treatment arms. All analyses were performed using the SPSS version 23 and STATA 14. A value of $p < 0.05$ was considered significant.

An ethics clearance was obtained from our institutional Research Ethics Committee, in accordance with the Helsinki declaration. The trial was registered on ClinicalTrials.gov.

Results

Of 114 patients recruited in the study, 18 were excluded due to invalid consent. (Figure 1)



Ninety-six patients underwent randomization to arm A (the closed Veress needle technique; n=50, 52%) and the arm B (the open Hasson technique; n= 46, 48%). (Table 1) Mean age of patients was 41 with a slight predominance of male gender in both groups. BMI of more than 30 was recorded in 20 (21%) patients.

There was no statistical difference between the two arms by age, gender, BMI, type of surgery, previous abdominal surgery, previous abdominal tuberculosis, type of surgery, primary port site, and the seniority of a surgeon performing procedure. (Table 2)

There were no statistical differences in a number of emergency cases between the groups. However, more non-trauma emergency cases were randomized to the Veress group, 23 (79%) versus 15 (62%). (Table 1) The most common procedures included diagnostic laparoscopy (n=26, 27%) followed by laparoscopic appendicectomy (n=17, 18%) and laparoscopic cholecystectomy (n=16, 16.7%). (Table 3)

Table 1 Patients characteristics

Characteristics	Total	Veress needle	Hasson	p-value
Total number	96	50 (52%)	46 (48%)	
Age				
Mean/median (min-max)	41/41 (18-73)	43/42 (20-73)	40/40 (18-65)	0.29
Gender				
male	51 (53%)	26 (52%)	25 (54%)	0.49
female	45 (47%)	24 (48%)	21 (46%)	0.49
BMI				
above 30	20 (21%)	11 (22%)	9 (20%)	0.48
below 30	76 (79%)	39 (78%)	37 (80%)	0.48
Type of surgery				
elective	43 (45%)	21 (42%)	22 (48%)	0.35
emergency	53 (55%)	29 (58%)	24 (52%)	0.35
trauma	15 (28%)	6 (21%)	9 (38%)	0.03
non-trauma	38 (72%)	23 (79%)	15 (62%)	0.01
Complications				
present	6 (6%)	6 (12%)	0 (0%)	0.03
none	90 (94%)	44 (88%)	46 (100%)	0.03

BMI, Body Mass Index

Table 2 Surgical characteristics of patients

Characteristics	Veress needle	Hasson	Total	p-value
Total number	50 (52%)	46 (48%)	96	
Previous surgery				
present	17 (34%)	12 (26%)	29 (30%)	0.50
none	33 (66%)	34 (74%)	67 (70%)	0.50
Previous abdominal tuberculosis				
present	0	1 (2%)	1 (1%)	0.48
none	50	45 (98%)	95 (99%)	0.48
Primary entry point				
Periumbilical	25 (50%)	31 (67%)	56 (58%)	0.09
Left upper quadrant	22 (44%)	11 (24%)	33 (34%)	0.09
Epigastrium	2 (4%)	4 (9%)	6 (6%)	0.09
Right lower quadrant	1 (2%)	0	1 (1%)	0.09
Surgeon				
Consultant	15 (30%)	15 (33%)	30 (31%)	0.83
Registrar	35 (70%)	31 (67%)	66 (69%)	0.83

Six (6%) adverse events were related to the laparoscopic entry, and all of them were in the Veress needle arm ($p=0.03$). The Veress needle technique failed to establish pneumoperitoneum in three patients (6%); the technique was switched to open Hasson entry. The reported minor complications were port-site bleeding in one (2%) and extraperitoneal insufflation in two (4%) patients. All patients with the adverse events had previous abdominal surgery. There were no other variables which were leading to complications. (Table 4)

Table 3 Surgical procedures

Surgical procedure	Veress needle	Hasson	Total
Total number (%)	50 (52%)	46 (48%)	96
Diagnostic laparoscopy	14 (28%)	12 (26%)	26 (27%)
Laparoscopic adhesiolysis	2 (4%)	2 (4%)	4 (4%)
Laparoscopic appendectomy	9 (18%)	8 (17%)	17 (18%)
Laparoscopic cholecystectomy	8 (16%)	8 (17%)	16 (17%)
Laparoscopic gastrectomy	1 (2%)	0	1 (1%)
Laparoscopic Graham patch	5 (10%)	1 (2%)	6 (6%)
Laparoscopic Heller myotomy	3 (6%)	2 (4%)	5 (5%)
Laparoscopic left hemicolectomy	0	1 (2%)	1 (1%)
Laparoscopic Nissen	1 (2%)	2 (4%)	3 (3%)
Laparoscopic pyloroplasty	1 (2%)	0	1 (1%)
Laparoscopic repair (trauma)	5 (10%)	6 (13%)	11 (11.5%)
Laparoscopic splenectomy	0	1 (2%)	1 (1%)
Laparoscopic wedge liver resection	1 (2%)	0	1 (1%)
Laparoscopic esophagectomy	0	2 (4%)	2 (2%)
Staging laparoscopy	0	1 (2%)	1 (1%)

The difference was not statistically significant, p-value 0.79

Table 4 Adverse events related to the Veress needle technique

Characteristics	None	Complications	Total	p-value
Total number	44 (88%)	6 (12%)	50	
Adverse events				
Failed Veress	0	3 (6%)	3	<.001
Extraperitoneal insufflation	0	2 (4%)	2	<.001
Port-site bleeding	0	1 (2%)	1	<.001
BMI				
<30	23 (75%)	6 (100%)	29	0.32
>30	11 (25%)	0	11	0.32
Type of surgery				
Elective	19 (43%)	2 (33%)	21	1.0
Emergency	25 (57%)	4 (67%)	29	1.0
Non-trauma	20 (80%)	3 (75%)	23	0.56
Trauma	5 (20%)	1 (25%)	6	0.56
Previous abdominal surgery				
present	27 (82%)	6 (100%)	33	0.08
none	17(18%)	0	17	0.08
Previous abdominal tuberculosis				
present	0	0		
none	44 (88%)	6 (12%)	50	n/a
Primary entry point				
Periumbilical	21 (48%)	4 (67%)	25	0.22
Left upper quadrant	21 (48%)	1 (16.5%)	22	0.22
Epigastrium	1 (2%)	1 (16.5%)	2	0.22
Right lower quadrant	1 (2%)	0	1	0.22
Surgeon				
Consultant	13 (30%)	2 (33%)	15	1.0
Registrar	31 (70%)	4 (67%)	35	1.0

BMI, Body Mass Index; n/a, not applicable

Discussion

The Veress needle technique is more popular among gynecologists. and, only 35% of general surgeons reported using Veress needle in their surgical practices.⁵

The complication rates for the closed technique are low. Interestingly, Vilos et al. reported lower complications by gynecologists; the visceral and vascular complication rates were 0.22% and 0.04% respectively for general surgeons and 0.10% and 0.03% for gynecologists.⁶ No gynecologists were participating in this study.

There is no currently available evidence in the literature that either entry technique is superior to the other techniques.⁶ Ahmad and colleague in their recent review found no advantage for major complication rates - mortality, visceral injury or vascular injury between the closed and open techniques.⁷

This study reports the overall complication rate of 6%, all of them were minor complications and related to the Veress needle technique. In the Veress needle arm, the failure to establish pneumoperitoneum was observed in 6%, the port-site bleeding in 2% and extraperitoneal insufflation in 4% of patients. This study found no difference in complication rates based on age, sex, BMI, type of surgery, previous abdominal tuberculosis, and surgeon training. However, all patients with complications had a history of previous abdominal surgery, although, these findings did not reach statistical significance. These findings are consistent with the other reports.^{8,9} The complications did not alter patients' operation nor their recovery. However, Compeau et al. indicated that 77.5% of primary trocar complications resulted in some form of permanent injury, with an estimated 3.1% resulting in patient death.⁵ Other reported complications are the small bowel, large bowel, large vessel, omentum, solid organs and small vessel injuries, port-site bleeding, multiple access attempts, including failure, and extra-peritoneal insufflation.^{5,8} The failure to establish pneumoperitoneum accounted for 50%

of all reported complications in this study. Therefore, all surgeons should be familiar with the open entry technique as using the Veress needle is not always successful¹⁰

Multiple tricks to decrease complication rates were developed. Several needle entry sites were proposed: from more standard periumbilical and Palmer's point (which is the left subcostal area) to Jain point (is point in the left paraumbilical region at the level of the umbilicus) Latif's point (needle is placed between the xiphoid process and the right subcostal margin), the Lee–Huang point (the middle upper abdomen) 9th intercostal space, the uterine fundus, and posterior vaginal fornix.^{2,11–13} The LapCap device was introduced to facilitate uncomplicated needle entry.¹⁴ In this study, the periumbilical area (50%) and Palmer's point (44%) were commonly used for Veress needle entry, but the epigastrium (4%) and right lower quadrant (2%) were opted in three patients because of previous postoperative scars. The sixty seven percent of complications occurred at the periumbilical site of entry. Placing the patient in the surgical position before entry of trocars found to be an effective method to shorten the operation time and decrease the rate of complications.¹⁵ The caudal displacement of the umbilicus was suggested before insertion of the Veress needle.¹⁶

This study has several limitations. The study included various surgical conditions, and there was great heterogeneity present. The study did not assess the time to establish pneumoperitoneum, and only intraoperative and early postoperative complications were recorded. More studies are needed with large sample size to overcome these limitations and to confirm our findings.

Conclusion

The open Hasson technique appeared to be safer for laparoscopic entry than the closed Veress needle technique. The Veress needle technique was associated with the failure rate of 6% and minor complications: extraperitoneal insufflation, port-site bleeding. The only presence of previous abdominal surgery may envisage the possibility of the Veress needle failure.

Therefore, the open Hasson should be preferred technique for laparoscopic entry in surgical patients, especially in patients with previous abdominal surgery.

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CHAPTER 3

Diagnostic Laparoscopy for Trauma:

How Not to Miss Injuries

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Diagnostic Laparoscopy for Trauma: How Not to Miss Injuries

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The next study we embarked upon was on diagnostic laparoscopy. Diagnostic laparoscopy is at the very heart of controversy in laparoscopy in trauma. It is the concern of missed injuries associated with laparoscopy that has made many surgeons reluctant to embrace laparoscopy in trauma. Many investigators that have examined the question of missed injury like Kawahara et al, but they have not gone far enough in terms of addressing the so-called blind spots. We investigated a systematic approach to diagnostic laparoscopy with special focus on the blind spots identified by previous investigators. This study describes the diagnostic pathway to be followed during diagnostic laparoscopy and proposes an easy to remember rhyme for the surgeon doing the procedure.

Diagnostic Laparoscopy for Trauma: How Not to Miss Injuries

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Abstract

Introduction: Diagnostic laparoscopy (DL) is a well-accepted approach for penetrating abdominal trauma (PAT). However, the steps of procedure and the systematic laparoscopic examination are not clearly defined in the literature.

The aim of this study was to clarify the definition of DL in trauma surgery by auditing DL performed for PAT at our institution, and to describe the strategies on how to avoid missed injuries.

Methods: The data of patients managed with laparoscopy for PAT from January 2012 to December 2015 were retrospectively analyzed. The details of operative technique and strategies on how to avoid missed injuries were discussed.

Results: Out of 250 patients managed with laparoscopy for PAT, 113 (45%) patients underwent DL. Stab wounds sustained 94 (83%) patients. The penetration of the peritoneal cavity or retroperitoneum was documented in 67 (59%) of patients. Organ evisceration was present in 21 (19%) patients. Multiple injuries were present in 22% of cases. The chest was the most common associated injury. Two (1.8%) iatrogenic injuries were recorded. The conversion rate was 1.7% (2/115). The mean length of hospital stay was 4 days. There were no missed injuries. In the therapeutic laparoscopy (TL) group, DL was performed as the initial part and identified all injuries. There were no missed injuries in the TL group. The predetermined sequential steps of DL and the standard systematic examination of intraabdominal organs were described.

Conclusions: DL is a feasible and safe procedure. It accurately identifies intraabdominal injuries. The selected use of preoperative imaging, adherence to the predetermined steps of procedure and the standard systematic laparoscopic examination will minimize the rate of missed injuries.

Keywords: trauma, laparoscopy, diagnostic laparoscopy, missed injuries

Introduction

LAPAROSCOPIC SURGERY HAS MOVED from being an innovative technology to standard of care in many surgical disciplines. This does not apply in trauma laparoscopy with the fear of missing injuries remains an obstacle for recommending laparoscopy.¹ However, with the improvement of laparoscopic equipment and surgical technique, the missed injuries rate decreased from 13% to 0.12%.^{2,3} Indeed, some recent studies report no missed injuries.^{4,5}

Initially laparoscopy was used mainly as a screening or diagnostic tool, with a therapeutic role emerging as confidence around the safety and reliability increased.^{2,5-10} Today laparoscopy in trauma can be divided into screening, diagnostic and therapeutic applications.

The role of screening laparoscopy initially was to detect peritoneal breach which would then be followed by an exploratory laparotomy.¹⁰

Diagnostic laparoscopy (DL) goes a step beyond screening and is used to assess the peritoneal cavity in a thorough, systematic and meticulous way. This is very much in line with what would be described in the open era as diagnostic exploratory laparotomy. DL not only identifies intraabdominal injuries but also makes therapeutic intervention possible.¹¹

Therapeutic laparoscopy (TL) for trauma is reported to be feasible and safe, provided appropriate expertise is available. The rate of TL is 55% in the recent study.⁴

The definition of DL is not clear in the literature, with screening laparoscopy often being confused with DL. Some centers convert when there are any suspicious retroperitoneal

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injuries, peritoneal breach, signs of hollow viscera injuries, or organ evisceration.^{12,13} The steps of procedure and the systematic laparoscopic examination are not clearly described in the literature.

The aim of this study was to clarify the definition of DL in trauma surgery by auditing all DLs performed for penetrating abdominal trauma (PAT) at our institution. Following this we describe the strategies on how to avoid missed injuries. The study was approved by the Sefako Makgatho University Research Ethics Committee, Pretoria, South Africa.

Methods

This is a retrospective descriptive study from a prospectively collected database of patients admitted at Dr. George Mukhari Academic Hospital. This hospital is a tertiary referral institution in northwest Pretoria, South Africa. All adult patients with PAT who underwent DL from January 2012 to December 2015 were included in the study. Cases of patients under 12 years, hemodynamically unstable patients, or cases where there were missing or unclear records were excluded. All unstable patients were managed with laparotomy. Demographic data, mechanism of injury, location of injury, intraoperative findings, grading of injuries, intraoperative maneuvers, trauma scoring, length of hospital stay (LOS), and complications were interrogated. Strategies on how to avoid missed injuries were discussed.

Definitions

Penetration of the abdominal cavity was defined as a violation of the parietal peritoneum or retroperitoneal tract or hematoma signifying the possibility of injury to the intra- or retroperitoneal organs.

DL (nontherapeutic) was defined as procedure when there were no injuries or the identified injuries did not require repair. Evacuation of liquid blood or clots and mobilization of any intra- or retroperitoneal organs for diagnostic purposes were not considered therapeutic.

TL was defined as the laparoscopic management of intraabdominal injuries (more than observation or hemostatic agent application).

Laparoscopic procedures were fully laparoscopic or laparoscopic-assisted. In the *fully laparoscopic procedures* all interventions were performed intracorporeally. In *laparoscopic-assisted procedures* the injured bowel was eviscerated through 4–8-cm assisted incision for extracorporeal inspection, repair, resection, or anastomosis, usually for multiple injuries. In some patients, intracorporeal procedures were combined with extracorporeal procedures to minimize trauma to the patient.

The *locations of the injuries* were subdivided into *five areas*: the anterior abdominal area, the right and the left lower chest, the flank, and the back.⁸

Although the final decision on stability of patient was left for attending surgeon, the following criteria were commonly used to define an *unstable patient*: the systolic blood pressure below 90 mm Hg and the mean inspiratory pressure greater than 30 mm Hg.

Operative procedure

The operative procedure was performed under general anesthesia.

DL consisted of the following sequential steps of procedure:

1. Access, pneumoperitoneum, and ports placement
The camera port (11 mm) was placed by open (Hasson) technique through the periumbilical area, Palmar point, or the injury site. Carbon dioxide pneumoperitoneum of 12–15 mm Hg was established. At least two working ports (5 or 11 mm) were placed at the mid-axillary line in the right and left iliac fossae. If necessary, additional ports were placed at the hypogastrium, right and left hypochondrium (Fig. 1).
2. Quick assessment of the abdomen and bleeding control
A 30-degree telescope, suction-irrigation and one or two atraumatic forceps were used for this step. Liquid blood, clots, and gastrointestinal contents were suctioned and active bleeding was sought. Bleeding was controlled with atraumatic forceps followed by laparoscopic vascular clamp, clips, energy source, over-suturing, or ligation. If hemostatic agent application only was used to control minor bleeding, the procedure was treated as DL. If more advanced therapeutic options were used, the procedure was referred to as TL. If bleeding could not be controlled promptly, the procedure was converted to laparotomy.
3. Systematic inspection of intraperitoneal and retroperitoneal organs

The extent of mobilization was guided by clinical findings and preoperative imaging. There was liberal use of gravity retraction by changing the operating table position to retract bowel away from the area of examination to maximize visibility. Systematic inspection was performed in the following order:

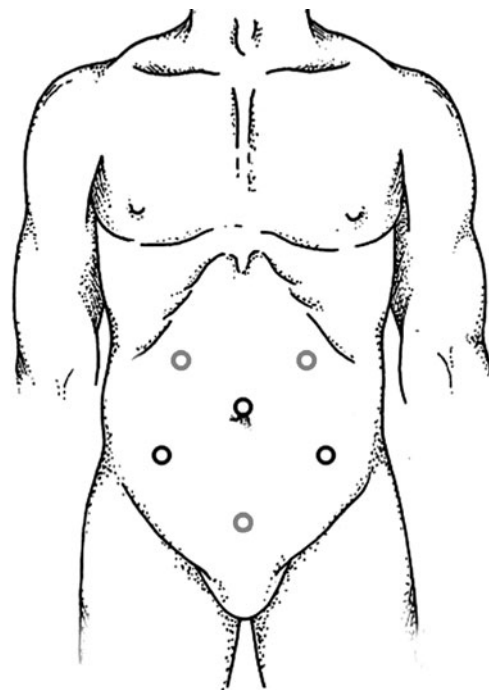


FIG. 1. Most common (open circles) and additional (gray circles) ports placement sites.

- 3.1. The diaphragm
Examined first after bleeding was controlled, because the communication with the pleural cavity can cause patient instability.
- 3.2. The liver and gallbladder
Usually examined intraperitoneally but mobilized if needed (the peritoneal attachments or ligaments were divided to examine the area of interest).
- 3.3. The spleen
Usually examined intraperitoneally but mobilized if needed (the peritoneal attachments or ligaments were divided to examine the area of interest).
- 3.4. The anterior wall of the stomach
Examined intraperitoneally but mobilized if needed.
- 3.5. The gastrocolic ligament division
The energy source was used.
- 3.6. The posterior wall of the stomach
Elevated with graspers to examine from beneath.
- 3.7. The pancreas and related retroperitoneal area
Examined intraperitoneally but mobilized if needed.
- 3.8. The duodenum above the mesocolon
Usually examined intraperitoneally but, in case of penetration of the retroperitoneal space, the duodenum was mobilized and examined.
- 3.9. The duodenum below the mesocolon
As in 3.8.
- 3.10. The small bowel run from the ligament of Treitz to the ileocaecal junction
The careful inspection of small bowel was mandatory, if a violation of peritoneum was confirmed or pathological content discovered in the abdominal cavity, it was strongly recommended to run the small bowel twice from the Treitz to the ileocecal junction and back, es-

pecially for novice surgeons. Approximately 10 cm of the bowel is spread between two atraumatic graspers and then rotated around for full examination. This maneuver was repeated until the entire bowel is examined. Clots and fibrinous exudate were carefully removed by using suction and a dry small swab so as to examine the underlying bowel, where there was contusion or suspicious area, a blunt atraumatic grasper was used to probe the bowel wall to ensure that there was no partially sealed bowel injury. Hematomas around the bowel wall were carefully inspected with liberal bowel mobilization and a dry swab was used to remove the hematomas and enable adequate bowel wall examination.

- 3.11. The right colon (the caecum, ascending colon, and the hepatic flexure) with the right kidney, hilum, and ureter
The colon was mobilized in appropriate settings and the retroperitoneal content was examined.
- 3.12. The transverse colon
The examination was done in the same way as for the small bowel.
- 3.13. The left colon (the splenic flexure, the descending and sigmoid colon) with the left kidney, hilum, and ureter
As for 3.11.
- 3.14. The pelvic cavity (the rectum and the urinary bladder)
Usually examined intraperitoneally but, in case of penetration of the retroperitoneal space, the content was mobilized and explored.
- 3.15. The additional areas of interest and other areas requiring extra attention (e.g., the IVC, aorta)
To ensure a standard systematic, complete inspection of intraperitoneal and, if required, retroperitoneal organs, we used a memory aid in the form of the following rhyme.

Memory aid (Fig. 2)

- The **right diaphragm** and the liver, ①
- The **left diaphragm** and the spleen, ②
- The **stomach** front, cut ligament and look from the back, ③
- Remember the **pancreas** is behind, ④
- The **duodenum** above and below, ⑤
- Zigzag** (jika-jika*) the bowel from Treitz ⑥ to Caecum forward and back,
- The **right colon** and behind, ⑦
- The **transverse over to the left** ⑧ **colon** and behind, ⑨
- Down to the **pelvis** and give a **second look**. ⑩

* jika-jika, means rotate or turn-turn in Zulu (local language)

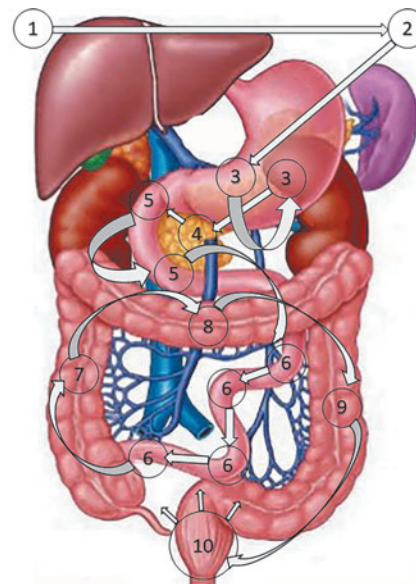


FIG. 2. Memory aid for laparoscopic systematic inspection of intraabdominal organs.

4. Decision to proceed with laparoscopy, laparoscopic-assisted approach (LAA) or conversion

Depending on the findings, further management was decided upon by the operating surgeon. Where injuries were found, these were dealt with laparoscopically either as totally laparoscopic or laparoscopic-assisted.

Patients were admitted to the general ward for hemodynamic monitoring after the operation and were discharged once they tolerated oral feed and were stable.

Data analysis

Demographic details of the patients were summarized descriptively by mean, minimum, and maximum values for continuous variables and frequency count and by percentage calculations for categorical variables. The Fisher's exact test was used for comparisons. A value of $P < .05$ was considered significant. All statistical procedures were performed with SAS software (SAS Institute, Cary, NC).

Results

A total of 318 trauma patients were approached laparoscopically (Fig. 3). Thirty-five patients with blunt abdominal trauma were excluded from the study. Out of 283 patients with PAT, 33 (11.7%) patients were converted to laparotomy. TL was performed in 137 (55%) cases. DL was performed on 113 (45%) patients and this group was analyzed.

The mean age was 32 years and 86% of patients were male (Table 1). The majority of the patients ($n=94$, 83%) sustained stab wounds. The penetration to the peritoneal cavity or retroperitoneum was documented in 67 (59%) patients and 46 (41%) patients didn't have penetration. Organ evisceration was present in 21 (19%) patients and 7 (33%) of them had small bowel evisceration. LAA was used in 2 (2%) patients with organ evisceration. No injuries were recorded. The traumatic hernia site was repaired extracorporeally in all cases. The most common location of injury was the anterior abdominal wall (45%) and in 84% of cases the peritoneum was violated. In 31% of cases the injury was located on the lower chest and penetration was recorded in 26%. However, the diaphragm was not injured in any of the cases. Flank injuries were present in 21% and the back was in 3% (Table 2). Multiple injuries were present in 22% of cases. The chest was the most common associated injury. Pneumothorax was present in 26%, and clotted hemothorax was diagnosed in 6%. One patient had penetrating cardiac injury diagnosed during diagnostic thoracoscopy and sternotomy was performed for cardiac injury repair. The mean injury severity score (ISS) was 6, abdominal new ISS (aNISS) was 5 and penetrating abdominal trauma index (PATI) was 0.9.

The colon was mobilized in 19 patients and the liver in 1 patient. The isolated retroperitoneal exploration was reported in 3 cases. However, the details of exploration were not provided in operative notes. The location and grade of injuries discovered during DL are listed in Table 3. None of the injuries required any therapeutic procedures.

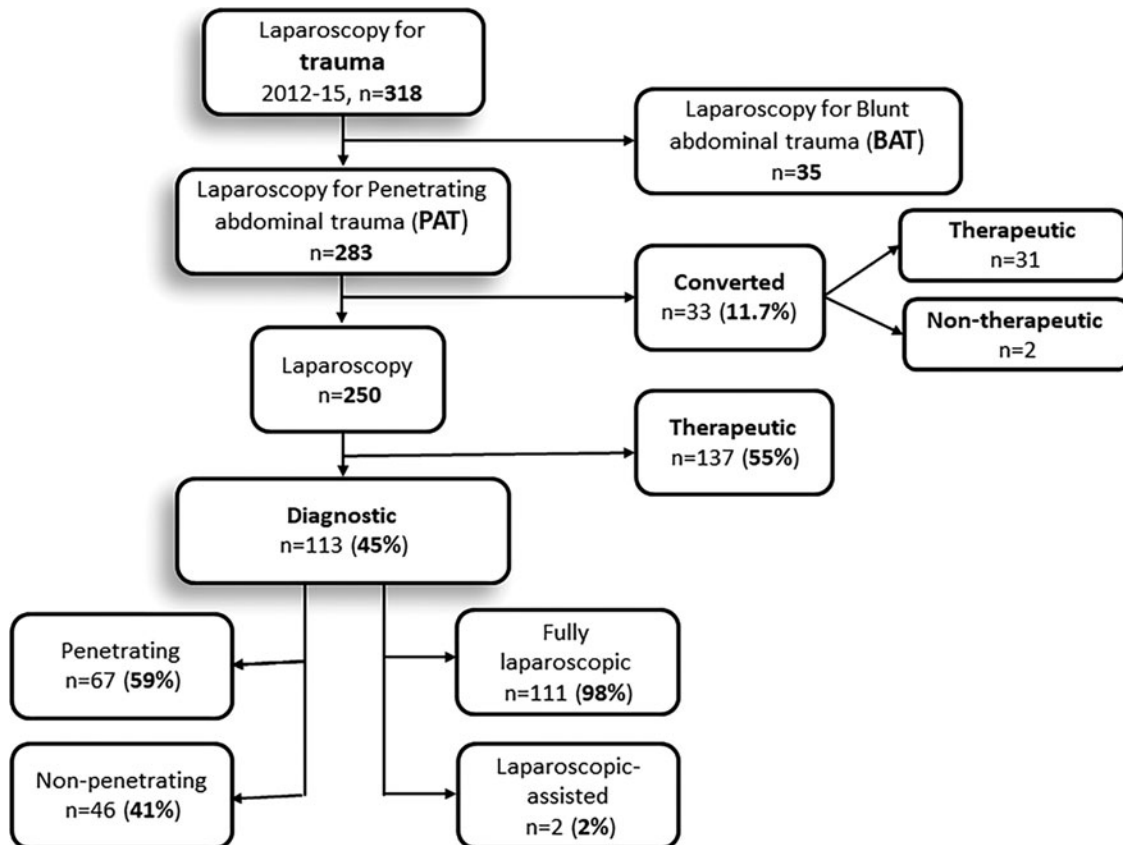


FIG. 3. Study diagram.

TABLE 1. PARAMETERS OF PATIENTS MANAGED WITH DIAGNOSTIC LAPAROSCOPY

Parameters	n	Percentage/ range
Total	113	100%
Age, mean/median, (SD)	32/30 (±9.9)	15–60
Gender		
Male	97	86%
Female	16	14%
Organ evisceration		
None	92	81%
Present	21	19%
Omentum	14	67%
Bowel	7	33%
Laparoscopy type		
Full laparoscopic	111	98%
Laparoscopic-assisted	2	2%
Trauma scoring		
ISS, mean (SD)	6 (±4)	4–27
aNISS, mean (SD)	5 (±4)	0–18
PATI, mean (SD)	0.9 (±2)	0–14
Number of injuries		
Single	88	88%
Multiple	25	22%
Associated injuries		
Long bones	2	2%
Pneumothorax	29	26%
Clotted haemothorax evacuation	7	6%
Thoracoscopy and sternotomy	1	1%
Neck exploration (pharynx)	1	1%
Extensive soft tissue injuries	1	1%
Iatrogenic intraabdominal injuries	2	1.8%
LOS, mean (SD)		
Total	4 (±2.7)	1–14
Without associated injuries (n=77)	3.4 (±2.2)	1–10
Nonpenetrating (n=25)	3.4 (±2.5)	1–10
Penetrating (n=52)	3.3 (±2)	1–10

SD, standard deviation; ISS, the Injury Severity Score; aNISS, the abdominal New Injury Severity Score; PATI, the Penetrating Abdominal Trauma Index; LOS, the length of hospital stay.

Two (1.8%) iatrogenic injuries were recorded. One patient had a serosal injury of the small bowel and pinpoint perforation that required stitch-repair, the second patient had minor bleeding from the splenic capsule injury that was controlled by diathermy. Two patients in the converted group had nontherapeutic laparotomy, which constituted the conversion rate of 1.7% (2/115) for DL (Fig. 3). Visualization problems necessitated the conversion in 1 patient and the need for exploration of a zone 1 retroperitoneal hematoma in second patient.

There were no missed injuries. Two patients suffered complications. One patient with the gunshot wound required thoracoscopy for clotted hemothorax evacuation on postoperative day 8, the second patient with stab wound developed renal arteriovenous fistula and was managed endovascularly. Both patients recovered uneventfully. All patients were followed until discharge from hospital, but most failed to come for their scheduled follow-up visit in 2 weeks after discharge.

TABLE 2. MECHANISM AND LOCATION OF INJURIES, AND COMPLICATIONS IN PATIENTS MANAGED WITH DIAGNOSTIC LAPAROSCOPY

	Penetrating	Non-penetrating	Total	P
Total	67 (59%)	46 (41%)	113 (100%)	
Mechanism				
Stab	56 (60%)	38 (40%)	94 (83%)	.54
GSW	11 (58%)	8 (42%)	19 (17%)	
Location				
Anterior	43 (84%)	8 (16%)	51 (45%)	<.001
Lower chest	9 (26%)	26 (74%)	35 (31%)	
Flank	13 (54%)	11 (46%)	24 (21%)	
Back	2 (67%)	1 (33%)	3 (3%)	
Complications				
CD 3	2	0	2 (1.8%)	.35
Iatrogenic injuries	2	0	2 (1.8%)	

GSW, gunshot wound; CD, Clavien-Dindo classification.

The overall mean LOS was 4 days, and in patients without comorbidities LOS was 3.4 days. The LOS did not differ significantly between patients with penetration and without penetration.

In the TL group, DL was performed in all patients as the initial step and identified all injuries. There were no known missed injuries in the TL group.

Discussion

Currently, DL in trauma is an accepted technique.⁹ At first, laparoscopy started as a screening tool with laparotomy being

TABLE 3. GRADE OF INJURY DIAGNOSED DURING DIAGNOSTIC LAPAROSCOPY

Grade of injury	Frequency		
	Stab	Gunshot	Total
Colon			
Grade 1	2	0	2
Small bowel			
Grade 1	1	1	2
Mesentery			
Grade 1	3	1	4
Grade 2	1	0	1
Liver			
Grade 1	7	1	8
Grade 2	1	1	2
Grade 3	1	4	5
Spleen			
Grade 1	2	0	2
Kidney			
Grade 3	0	1	1
Diaphragm			
Grade 1	2	1	3
Retroperitoneum			
Zone 2	3	1	4
Zone 3	0	2	2

performed for any uncertainties. The initial attempts of laparoscopic exploration of abdominal cavity resulted in the high rate of missed injuries.² With the improvement of laparoscopic equipment and surgical techniques, and development of systematic laparoscopic examination of the abdominal cavity, the rate of missed injuries decreased and is reported to be far below 1%.^{9,14,15} Moreover, the recent studies report no missed injuries.^{4,16}

Definitions of DL in trauma vary. Many investigators use laparoscopy in trauma to identify those patients with penetrating injuries where there is a breach in peritoneum and laparotomy would follow.¹⁷ This should be referred to as screening laparoscopy. This approach has been shown to decrease the rate of nontherapeutic laparotomy quite substantially.¹⁸ The current role of screening laparoscopy is limited, however, it can be used under local anesthesia and intravenous sedation in the trauma bay as Laparoscopic Assessment in Surgical Trauma.^{18–20} The significant advantage of screening laparoscopy is an early discharge and the mean LOS of 6.4 hours was reported.²¹

In our view, DL in trauma identifies and possibly grades all intraabdominal injuries by using the standard systematic complete inspection of intraperitoneal and, if required, retroperitoneal organs, and to attend to minor injuries not requiring major therapeutic options, like clots evacuation or hemostatic agent application. DL identifies all injuries as effectively as a diagnostic laparotomy would. Hypothetically, DL should be more accurate than laparotomy, due to superior visualization with high definition magnified imaging of all inaccessible during laparotomy areas. This hypothesis is to be tested in the future.

The introduction of a systematic examination in trauma laparoscopy has reduced the rate of missed injuries from 13% to below 1%.^{2,3,9} However, the extent of laparoscopic exploration differs between centers. Kawahara et al. stopped laparoscopic exploration at the blind spots zones: the retroperitoneum, injuries to the bare area or segments VI and VII of the liver, or posterior area of the spleen.¹² Other surgeons aborted laparoscopic exploration at the sight of intestinal content in the peritoneal cavity, a visible bowel injury, or mesenteric or solid organ injury.^{20,21} In this study, complete inspection of all organs was performed, if required.

In order not to miss injuries, DL follows the predetermined steps.⁴ The standard systematic examination is the most important step in identification of injuries, however, the technique was not clearly described in the literature. Kawahara et al. suggested examining inframesocolic and then supramesocolic spaces with concentration on hollow viscera, and at the end examine the liver and spleen.¹² Uranues began systematic exploration with the right upper quadrant and proceeded clockwise.¹⁰ Our study presented the standard systematic examination, memorized as a rhyme by the surgeons, which begins from the diaphragm and follows the digestive tract and related anatomical regions. For easy recollection, the memory aid in rhyme and visual form was provided (Fig. 2). We find that this sequence of intra-abdominal examination offers economy of movement and avoids a nonstructured examination that may result in missed injuries. Initial control of encountered bleeding (Step 2) should precede any systematic examination. After bleeding is controlled, the next possible injury to cause patient instability is the diaphragm. That is

why the systematic examination (Step 3) usually starts from inspection of the diaphragm. The missed injuries of gastrointestinal tract are the most ominous. We recommend to follow the systematic examination along the gastrointestinal tract and at the same time examine organs in related anatomical regions.

Routine exploration of retroperitoneal organs cannot be justified if there is no clinical indication. The proximity of injury, presence of penetration or pathological content in the retroperitoneal space, or any other suspicion for the retroperitoneal injuries requires full laparoscopic mobilization and exploration of related organs. In this series, preoperative imaging with the CT scan was found to be beneficial to guide the extent of laparoscopic exploration of retroperitoneal organs. CT scan may also be used to select patients who will benefit from nonoperative management and will avoid laparoscopy.^{22,23} We suggest preoperative CT scan where retroperitoneal injuries are suspected, as it contributes to the laparoscopic exploration of the retroperitoneum.

DL precedes all therapeutic laparoscopies. If injuries requiring repair are identified, the procedure will progress to TL. In this study, DL identified all injuries in DL and TL groups.

LAA is mainly used for multiple bowel injuries as a part of TL.^{24,25} However, this study reported 2 cases of anterior abdominal stab wounds and organ evisceration where LAA was used for diagnostic purpose. Traumatic hernia was extended and the bowel was eviscerated through the injury site for inspection.

Organ evisceration carries a high rate (65%) of significant intra-abdominal injuries and needs exploration.^{1,26} In this study, laparoscopy ruled out intra-abdominal injuries in all 21 (19%) patients with evisceration. The patients diagnosed with significant injuries were treated with TL. There were no missed injuries in either groups. The laparoscopic management of patients with organ evisceration is reported to be feasible and safe.²⁶

Two iatrogenic (1.8%) injuries occurred in this series. Those were minor injuries and required minimal therapeutic procedures. By definition, it should have been regarded as TL, however, we decided to include those cases in the study to highlight the possibility of iatrogenic injuries. Such minor injuries usually happen during laparoscopy and laparotomy, but not always reported.¹⁷

This study reported the conversion rate 1.7% in the DL group. Prompt conversion to laparotomy is required in cases of continuous intraoperative bleeding, complexity of injuries, deterioration of the patient, poor visibility, and equipment failure.⁴

The indications for diagnostic laparotomy and DL in the trauma setting are the same, but DL is minimally invasive with all the related benefits. If there is enough expertise in laparoscopy, all stable trauma patients should be explored laparoscopically.⁴ Laparotomy is reserved for unstable trauma patients. However, Cherkasov et al. reported the safe use of laparoscopy in unstable patients.²⁷ In this study, all patients were stable. We do not recommend laparoscopy for unstable trauma patients, as besides other issues, an unstable patient forces a surgeon to rush through procedure to finish operation quickly, and that may pose the high risk of missed injuries.

In this study, we reported that the overall LOS for DL was 4 days and in patients without any associated injuries was 3.4 days. The interpretation of this LOS should be made with caution. The study was retrospective and LOS was not strictly monitored. Often patients stayed in hospital longer than needed due to logistics issues rather than requiring hospital care.

Conclusions

This study outlined the following strategies on how not to miss injuries during trauma laparoscopy:

1. selection of patient for initial laparotomy (unstable patients, limited laparoscopic expertise);
2. the use of CT scan imaging, in appropriate setting, to identify the tract and plan laparoscopy (instances of injuries to retroperitoneal space, the patient who qualifies for nonoperative management, the delay in waiting for operation is expected);
3. strict adherence to the predefined steps of DL;
4. implementation of standard systematic exploration of all intraabdominal organs;
5. surgeon's complete satisfaction with laparoscopic procedure: laparotomy would not offer more than laparoscopy.

DL is a feasible and safe procedure. The selected use of preoperative imaging, adherence to the predetermined steps of procedure and the standard systematic laparoscopic examination will minimize the rate of missed injuries.

Authors' Contributions

Study conception and design (M.K., O.M.); literature search and data collection (O.M.); data analysis, data interpretation, and article preparation (O.M., M.K.); critical review and revision of the article (C.A.); and mentoring throughout the article preparation (C.A.).

Disclosure Statement

No competing financial interests exist.

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CHAPTER 4

Laparoscopic-Assisted Approach for Penetrating Abdominal Trauma:

An Underutilized Technique

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Laparoscopic-Assisted Approach for Penetrating Abdominal Trauma:
An Underutilized Technique

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The next study we embarked upon was to describe the technique of assisted laparoscopy in the context of trauma. This technique is well described in other areas of non-trauma laparoscopy such as colorectal surgery. This technique has not been described in the setting of trauma as far as we are aware. This is meant to address the scenario of multiple intraabdominal injuries, which can unduly prolong the laparoscopic procedure. We did this study and proposed this technique as a solution to both multiple injuries and also to address the gaps in laparoscopic skills. We tested this proposal in a bigger population of patients in another study. The three preceding studies prepared us to examine the role of laparoscopy in various trauma scenarios

Laparoscopic-Assisted Approach for Penetrating Abdominal Trauma: An Underutilized Technique

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Abstract

Introduction: Diagnostic laparoscopy is well accepted in the management of penetrating abdominal trauma (PAT). Therapeutic laparoscopy, on the other hand, remains controversial. In patients with multiple hollow viscera injuries, laparoscopy is usually converted to laparotomy. We aim at describing the laparoscopic-assisted technique in the management of patients with PAT. Using our experience with laparoscopy, we tailored the technique to the setting of PAT.

Methods: The laparoscopic-assisted approach (LAA) was adapted to a trauma setting and prospectively evaluated. The technical details and indications for the technique were investigated. The distinctive steps of the technique were identified and described descriptively. The decision-making process was described as a separate step in the technique.

Technique: After having established pneumoperitoneum and ports placement, the source of bleeding is identified and controlled. Systematic inspection of intraperitoneal and retroperitoneal organs is done. In the case of multiple injuries, the hollow viscera are exteriorized via the 4–8 cm incision and extracorporeal inspection, repair, resection, and anastomosis are performed. The other part of the procedure is completed intracorporeally. Over a 2-year period, 23 patients were managed with LAA, 13 patients with stab wounds, and 10 patients with gunshot wounds. Commonly performed procedures were hollow viscera repairs, resections, and anastomoses. There were neither missed injuries nor conversion among patients managed with LAA.

Conclusion: The LAA is underutilized for PAT. This technique can be successfully used as a diagnostic and therapeutic tool in the management of stable patients. It offers the advantages of minimally invasive surgery and the speed and versatility of an open procedure.

Keywords: trauma, therapeutic laparoscopy, gastrointestinal, laparoscopic assisted, penetrating abdominal trauma

Introduction

LAPAROSCOPY IN AN ELECTIVE SETTING is ubiquitous. However, laparotomy remains the preferred surgical approach for patients with penetrating abdominal trauma (PAT). Although laparoscopy is an acceptable alternative for laparotomy in stable patients with PAT, previously reported missed injuries have resulted in reticence.¹ Missed injuries have decreased significantly with the development of the standard laparoscopic examination system of the abdominal cavity for trauma,² with the currently reported rate having fallen to below 1%.¹

Despite the evolution of equipment and improvement in the laparoscopic technique, its therapeutic role in trauma is still debated. A recent systematic review reports the rate of therapeutic laparoscopy (TL) at 13.8%.¹ However, Choi and Lim reported 83% of TL.³ TL demands adequate technical support and high performance by the trauma team. In some technically challenging cases, and where advanced laparoscopic skills are lacking, the laparoscopic-assisted approach (LAA) may be used.

The aim of this study was to describe the laparoscopic-assisted technique in the management of stable patients with PAT.

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Methods

The LAA was adapted to the trauma setting and prospectively evaluated. The perioperative setting and the standard instruments and equipment requirements were identified. The technical details of each case were discussed with the operating surgeon. The indications for the technique were established, and the distinctive steps of the technique were identified and described descriptively. The decision-making process was described as a separate step of the technique. The case illustrating the use of the technique was presented, and our experience with LAA in a trauma setting was summarized.

The study was approved by the Medunsa Research and Ethics Committee of the University of Limpopo and the authorities of Dr. George Mukhari Academic Hospital. Written consent for the laparoscopic procedure with possible laparoscopic-assisted or conversion to open procedure was obtained from all patients.

Equipment

The camera should provide good visualization with two viewing screens for a surgeon and an assistant. The 30° telescope is preferred. The instruments include two atraumatic bowel graspers, Maryland dissector, laparoscopic scissors and needle holder, liver retractor, and suction-irrigation device. Laparoscopic vascular clamps and gastrointestinal staplers should be on standby. Although diathermy is sufficient, advanced energy source devices are preferable. An adjustable operating table allows quick and safe patient position changing for gravity retraction. The laparotomy set is required for ports placement, should conversion to laparotomy be necessary.

Personnel

The trauma team consists of the following: anesthetist, anesthetic assistant, trauma surgeon, at least 1 surgical assistant, operating sister, and circulating nurse. It is crucial that the entire team be familiar with the laparoscopic procedure and equipment. The trauma surgeon assumes the leadership throughout the procedure.

During the procedure. On induction of general anesthesia, the patient's physiology is assessed. Hemodynamic, respiratory, and metabolic parameters are used to define the patient's stability. In our experience, the systolic blood pressure below 90 mmHg and the mean inspiratory pressure above 30 mmHg are the most common values used to consider laparotomy. If the patient is stable after induction of anesthesia, the team continues with laparoscopy.

Procedure

LAA follows the standard steps:

1. *Access, pneumoperitoneum, and ports placement:* Open Hasson technique is preferred for intraabdominal entry and establishment of pneumoperitoneum. We use carbon dioxide at a pressure of 12–15 mmHg. The camera port is placed preferably at the umbilicus. In some cases, the left upper quadrant or injury site is used, depending on the situation. Two working ports

(5 or 11 mm) are placed in the right and left iliac fossae. Additional trocars may be necessary, and commonly used sites are depicted in Figure 1.

2. *Quick assessment of the abdomen and bleeding control:* Blood and gastrointestinal content are suctioned out to identify injury or active bleeding.

Bleeding is controlled with atraumatic forceps followed by vascular clamp, clips, energy source, over-suturing, or ligation. In cases where bleeding cannot be controlled promptly, or attempts of definitive control have failed, the procedure is converted to laparotomy.
3. *Systematic inspection of intraperitoneal and retroperitoneal organs:* Having controlled the bleeding, the surgeon proceeds to a laparoscopic systematic examination of the intraabdominal organs.² The greatest challenge is the management of the small bowel (SB) and colon injuries. Usually, the SB is examined by spreading and rotating it with two atraumatic forceps. In this way, the SB is walked from the ligament of Treitz to the ileocaecal valve and back. The ascending and descending colon is mobilized to inspect its retroperitoneal portion, if indicated. We apply the lateral approach to mobilization, as retroperitoneal hematoma makes appreciation of the anatomy more difficult. Such an inspection is accurate and is performed within reasonable time.
4. *Decision to proceed with LAA:* Isolated injuries may be repaired intracorporeally. But laparoscopic management of multiple bowel injuries, such as those sustained from gunshot and stab wounds, may unnecessarily prolong the operation. LAA is indicated in this situation.
5. *Assisted access and extracorporeal process:* The SB or laparoscopically mobilized colon is exteriorized via the 4–8 cm incision, extracorporeal inspection, and either repair or resection and anastomosis may be

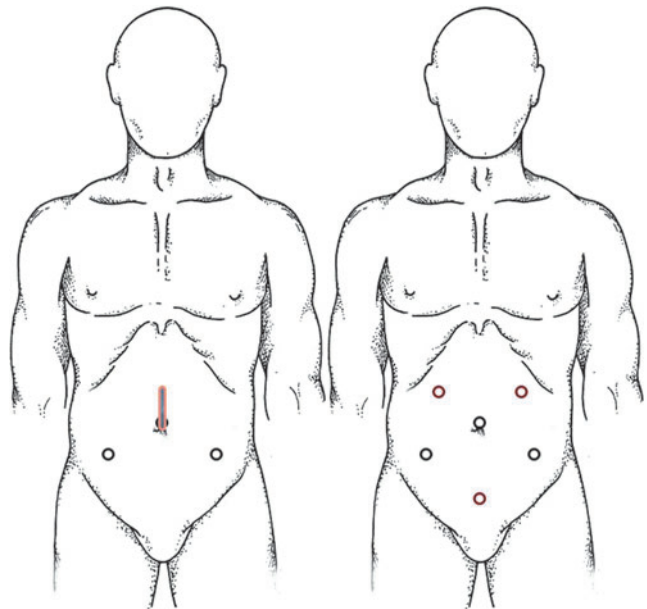


FIG. 1. Ports and assisted access placement sites. Most common ports are in black. Additional ports are in red.

performed. The laparoscopic-assisted incision is usually placed in the midline supraumbilically, incorporating the periumbilical port site (Fig. 1). This location over the root of mesentery allows maximal exposure of the SB and the colon. The surgeon may consider placing the incision suprapubically or over the injury site, depending on the clinical situation. Care is taken not to pull too hard on the mesentery to avoid iatrogenic injury. The exteriorized multiple bowel loops may cause mesenteric compression with venous congestion that results in prolonged postoperative ileus. Iatrogenic serosal injuries may also occur.

6. *Intracorporeal completion of inspection and intracorporeal therapeutic procedures:* After inspection and repair, the viscera are placed back into the peritoneal cavity. The incision is temporarily closed incorporating the 11 mm port. Pneumoperitoneum is re-established for final exploration, washout, and drain placement. The assisted incision can also be used to facilitate the intraperitoneal washout.
7. *Extracorporeal repair of port sites, site of injury, and assisted incision:* The assisted incision, port sites, and sites of injury are closed with nonabsorbable or long-term absorbable sutures.

Case example and our experience with LAA. To illustrate the practical implementation of LAA, we present a stable male patient who sustained gunshot wounds (GSWs) to the left abdomen and was approached laparoscopically.

Mesenteric injury, multiple SB, and colon injuries were discovered during systematic inspection. Due to his multiple bowel injuries, the decision to use LAA was made. The 7 cm incision incorporating the periumbilical camera port was made supraumbilically in the midline for assisted access (Figs. 2 and 3). The SB was exteriorized through the incision and inspected. The mesenteric and SB injuries were repaired, and the other severely injured part of the SB was resected and anastomosed extracorporeally. The mobilized laparoscopically left colon was exteriorized through the incision, and a segmental resection and anastomosis was performed extracorporeally (Supplementary Video S1; Supplementary Data are available online at www.liebertpub.com/lap). The patient had an uneventful recovery and was discharged on postoperative day 5.



FIG. 2. Laparoscopic-assisted approach: intraoperative view.



FIG. 3. Laparoscopic-assisted approach: postoperative view. Black arrows, assisted incision wound; red arrow, GSW. GSW, gunshot wound.

In our initial series,⁴ over a 2-year period, LAA was applied in 23 patients, 37% of all TL. Thirteen patients sustained stab wounds, and 10 patients weathered GSW. Commonly performed procedures were hollow viscera repairs, resections, and anastomoses. There were neither missed injuries nor conversions among patients managed with LAA.

Discussion

Laparoscopic inspection and therapeutic procedures for the SB and colon injuries are challenging. Many surgeons would use laparotomy as a first choice; some would attempt to repair the isolated bowel injury laparoscopically, but would switch to laparotomy for multiple bowel injuries.⁵ A recent review by El-Bendary et al. described laparotomy as a preferred approach in the case of multiple bowel injuries.⁶ We propose LAA as an alternative to full laparotomy. The LAA offers the advantages of minimally invasive surgery and at the same time it provides the benefits of laparotomy. Bowel injuries are managed extracorporeally as during laparotomy. The inspection and management of other intraabdominal organs that are not accessible via assisted incision are done laparoscopically. In our series, 23 patients were successfully managed with LAA and avoided laparotomy.⁴

The LAA for PAT is not widely applied. Choi and Lim reported the assisted approach in 20 patients.³ SB was exteriorized through the 34 cm incision, and extracorporeal resection and anastomosis was carried out. Lin et al. reported

resection and anastomosis of SB through the assisted 3–5 cm incision in 1 patient.⁵ In our experience, SB repair through the small (3–4 cm) incision is feasible; however, it does not allow complete inspection and is not suitable for colonic surgery. We also noted venous congestion of the viscera managed through the small incision. The incision of 4–8 cm allows easy exteriorization of the bowel without compressing the mesentery.

The LAA can be utilized in case of multiple bowel injuries instead of conversion to laparotomy. The lack of dexterity in intracorporeal suturing may also be considered an indication for LAA. This can be debated, as laparoscopy for trauma requires a high level of proficiency with an advanced laparoscopic technique.

In the porcine model of GSW with multiple SB injuries, the fully laparoscopic technique for isolated injuries and LAA for multiple injuries were compared with laparotomy and showed a significant reduction in the length of incision (5.27 cm versus 15.73 cm) as well as an average recovery period for bowel function. The vital appearance was improved, and patients resumed food intake earlier after laparoscopy. Although the time to diagnosis was longer in the laparoscopy group, the therapeutic time was not statistically different.⁷

In the published literature, LAA for management of PAT is rarely reported and is not compared with fully laparoscopic procedures or with laparotomy. LAA was compared with laparotomy in elective colorectal surgery. It was not inferior to laparotomy and was associated with a statistically significant smaller incision length (6 cm versus 18 cm), a shorter hospital stay, and decreased analgesics requirement.⁸

Conclusion

The LAA is a safe procedure for PAT. It can be successfully used as a diagnostic and therapeutic tool in the management of stable patients. It offers the advantages of minimally invasive surgery and the speed and versatility of an open procedure. Further studies are needed to confirm its role in the management of patients with PAT.

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Study conception and design (M.K. and O.M.); literature search, data collection (O.M.); data analysis, data interpre-

tation (M.K. and O.M.); article preparation (O.M.); critical review and revision of the article (M.K. and C.A.); and mentoring throughout the article preparation (M.K.).

Disclosure Statement

No competing financial interests exist.

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CHAPTER 5

The Use of Laparoscopy

in Managing Penetrating Thoracoabdominal Injuries in Africa:

83 Cases Reviewed

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The Use of Laparoscopy in Managing Penetrating Thoracoabdominal Injuries in Africa:
83 Cases Reviewed

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The next study was to examine the role of laparoscopy in thoraco-abdominal injuries. We specifically looked at other aspects of thoraco-abdominal injuries that other investigators have excluded in their studies. Most of the published literature examined the role of laparoscopy in thoraco-abdominal injuries as a tool to picking up left sided diaphragmatic injury. There is a gap in published literature on the role of laparoscopy in both left and right-sided injuries as well as its role in thoraco-abdominal injury patients with generalized peritonitis. We recognize the challenges posed by these injuries and we viewed this study as a good test to examine the safety and efficacy of laparoscopy in this cohort of patients that are inclusive of patients excluded in other studies.

RESEARCH ARTICLE

Open Access



The use of laparoscopy in managing penetrating thoracoabdominal injuries in Africa: 83 cases reviewed

Zach M. Koto, Fusi Mosai* and Oleh Y. Matsevych

Abstract

Background: The use of laparoscopy in managing haemodynamically stable patients with penetrating thoracoabdominal injuries in developed countries is widely practiced, but in Africa, the use of laparoscopy is still in its infancy stage. We reviewed a single centre experience in using laparoscopy in Africa for management of patients with both isolated diaphragmatic injuries as well as diaphragmatic injuries associated with intra-abdominal injuries requiring intervention.

Methods: A retrospective analysis of prospectively collected data of patients presenting with penetrating thoracoabdominal injuries was done. All patients offered laparoscopic exploration and repair from January 2012 to December 2015 at Dr. George Mukhari Academic Hospital were analysed. Means (\pm SD) were presented for continuous variables, and frequencies (%) were presented for categorical variables. All analyses were performed using SAS version 9.3 (SAS Institute, Cary, NC).

Results: A total of 83 stable patients with penetrating thoracoabdominal injuries managed with laparoscopy met the inclusion criteria and were included in the study. The Injury Severity Score ranged from 8 to 24, with a median of 18. The incidence of diaphragmatic injuries was 54%. Majority (46.8%) of patients had Grade 3 (2–10 cm defect) diaphragmatic injury. Associated intra-abdominal injuries requiring intervention were encountered in 28 (62%) patients. At least 93.3% of the patients were treated exclusively with laparoscopy. The morbidity was encountered in 7 (16%) patients; the most common cause was a clotted haemothorax Clavien-Dindo III-b, but only 1 patient required a decortication. There was one non-procedure-related mortality.

Conclusions: A success rate of 93% in using laparoscopy exclusively was documented, with an overall 82% uneventful outcome. The positive outcomes found in this study when laparoscopy was used in stable patients with thoracoabdominal injuries support similar work done in other trauma centres. However, in addition, this study seem to suggest that the presence of peritonitis in stable patient is not a contra-indication to laparoscopy and thoracoscopy may be useful especially in right side diaphragmatic injury where the liver can preclude adequate visualization of the entire diaphragm and to thoroughly clean the chest cavity and prevent future complication such as residual clotted haemothorax.

Clinical relevance: The presence of peritonitis in stable patients with penetrating thoracoabdominal injury is not a contra-indication to laparoscopy provided the operating surgeon has adequate laparoscopic skills.

Keywords: Thoracoabdominal injuries, Penetrating, Laparoscopy, Treatment, Africa

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Background

Management of patients with thoracoabdominal injuries forms a crucial part of our day to day management of trauma patients for a number of reasons. Missed traumatic diaphragmatic injuries (TDI) following penetrating thoracoabdominal injuries can result in catastrophic complications both in acute and chronic setting. These complications can range from asymptomatic diaphragmatic hernia to strangulated diaphragmatic hernia with associated high mortality rate of up to 8.8% [1].

The incidence of occult diaphragmatic injuries in asymptomatic patients with penetrating thoracoabdominal injuries is as high as 43% [2]. Even with the best current available imaging technology, a missed rate of occult TDI is as high as 50% [3]. In order to avoid missing these injuries, historically, these patients would be managed with mandatory exploratory laparotomy. But this approach resulted in non-therapeutic laparotomy rate as high as 33% [4]. The morbidity and mortality associated with non-therapeutic laparotomies is too high to justify this approach [5]. However, in the era of minimal access surgery, there is no justification for non-therapeutic laparotomies.

In the recent literature, the role of diagnostic laparoscopy has been demonstrated to be efficient and effective in assessing asymptomatic patients with penetrating thoracoabdominal injuries [6]. This approach has resulted in avoidance of non-therapeutic laparotomies [7, 8] However, some investigators would convert to open surgery once laparoscopy confirms peritoneal violation [4, 9]. But more recently, Mjoli et al. suggested that there is a therapeutic role of laparoscopy in patients with diaphragmatic injuries [10]. But in their study, the therapeutic intervention was only demonstrated in patients with no suspected associated intra-abdominal injuries (no peritonitis, no evisceration, and no free air) and only in left sided diaphragmatic injuries [10]

Rivaben et al. reported in his experimental study in animals an incidence of diaphragmatic hernia as high as 39% in right sided diaphragmatic injury [11]. Various contents were found in the hernia sac including small bowel, colon and stomach [11]. From this finding, we consider management of right sided thoracoabdominal injuries equally important.

The role of laparoscopy as an all-encompassing treatment strategy in managing all haemodynamically stable patients with penetrating thoracoabdominal injuries has not been well established. This treatment strategy includes stable patients with peritonitis, evisceration and free intra-abdominal air on pre-operative assessment.

In this study, we looked at the feasibility and safety of using laparoscopy in the treatment of haemodynamically stable patients with penetrating thoracoabdominal injuries in the following settings:

1. Isolated diaphragmatic injuries both left and right sided injuries.
2. Diaphragmatic injuries with associated intra-abdominal injuries requiring intervention including hollow viscus perforation such as small bowel, colon and stomach with peritonitis.

Methods

This study is a retrospective analysis of a prospectively collected data of patients presenting with penetrating thoracoabdominal injuries and were managed with laparoscopy in a trauma unit at Dr George Mukhari academic hospital (DGMAH). DGMAH is a tertiary hospital North-West of Pretoria, South Africa. All patients who were managed with laparoscopic exploration and/or repair from January 2012 to December 2015 were reviewed. Ethics clearance was obtained from Sefako Makgatho Health Sciences University (SMU) Research Ethics Committee (SMUREC) in accordance with Helsinki declaration.

All patients were initially managed according to the Advanced Trauma Life Support (ATLS) principles.

Inclusion criteria

- Stable patients with penetrating thoracoabdominal injuries who were managed with laparoscopy
- With or without peritonitis
- Both left and right side penetrating thoracoabdominal injuries
- 12 years and above

Exclusion criteria

- Penetrating thoracoabdominal injuries managed with laparotomy
- Blunt thoracoabdominal injuries
- Pregnancy
- Associated head injury

Data collected

Demographic profile of the study population such as age and gender were documented. The mechanism of injury, number and the site of penetrating wounds, severity of the injury, cavity used to access the injury, intra-operative findings and grading, intra-operative complications and outcomes were documented.

Mechanism of injury was classified as either stab wound or gunshot wound. Numbers of penetrating wounds counted were only in the thoracoabdominal region, and the site was defined as left or right. Thoracoabdominal region was defined as the body region between upper border: from the 4th intercostal space in the mid-clavicular line anteriorly, the 6th intercostal

space laterally in the mid-axillary line and the 8th intercostal space along the mid-scapular line and lower border: sub-costal margin, with the sternum and vertebral body forming the anterior and posterior medial borders. The severity of the injury was calculated using the Injury Severity Score (ISS). Cavity used either for diagnosis or intervention was documented as thoracoscopic, laparoscopic or both. Intra-operative findings were documented as follows: no injuries found, isolated diaphragmatic injury or diaphragmatic injury with associated injuries requiring intervention, the type of injury and the grading of the injury. Type of intervention was classified as exclusively laparoscopic repair or laparoscopic-assisted repair (hybrid procedure). Intra-operative complications were divided into procedure related or non-procedure related. Procedure-related complications are defined as complication caused directly by the procedure/surgeon such as iatrogenic bowel injuries.

Outcome variables measured were morbidity and mortality based of complications. Clavien-Dindo (CD) classification of surgical complication was used Appendix. The complications were sub-classified into procedure related and non-procedure related. Procedure-related morbidity and mortality were defined as those complications caused by the procedure/surgeon such as residual-clotted haemothorax requiring re-intervention, port-site hernia and anastomotic leaks.

Patients who did not have any documented morbidity or mortality were classified as uneventful outcomes.

Operative procedure

All patients with thoracoabdominal injuries who were hemodynamically stable were offered laparoscopy under general anaesthesia. The thoracoabdominal injuries were defined as injuries that involved the body region between the nipple line or 4th intercostal space and the costal margin. The camera port was placed at the umbilicus, and the working ports were placed in the mid-clavicular line on both sides at level of the umbilicus. The entire abdominal cavity was inspected and checked for injuries, and where injuries are found, they were repaired laparoscopically. Post-operative care was done in the ward or high dependency area. Oral diet was commenced once the patient can tolerate the intake. The patient was discharged home once they can tolerate ward diet.

Statistical analysis

Means (\pm SD) were presented for continuous variables, and frequencies (%) were presented for categorical variables. All analyses were performed using SAS version 9.3 (SAS Institute, Cary, NC).

Results

A total of 83 stable patients with penetrating thoracoabdominal injuries managed with laparoscopy met the

inclusion criteria and were included in the study (Fig. 1). The median age was 26 years, with males accounting for 87% of the study population (Table 1). There were two mechanisms of injury noted, stab and gun shot. Majority (71%) were victims of stabs (Table 2).

The incidence of diaphragmatic injuries was 54% (Table 2). Majority (46.8%) of patients had Grade 3 (2–10 cm defect) diaphragmatic injury (Table 3), with 93.3% of the patients being treated exclusively with laparoscopy, 1 (2.2%) patient treated using laparoscopic-assisted approach (LAA) and 2 (4.4%) patients treated using both laparoscopy and thoracoscopy.

More than 70% of the patients sustained multiple injuries, with 20% of the site of the injury being the left sided diaphragmatic injuries. The Injury Severity Score ranges from 8 to 24, with a median of 18. Associated intra-abdominal injuries requiring intervention were encountered in 28 (62%) patients. The most common associated injury was the stomach, followed by the liver (Table 2). Six (21%) patients had more than one associated intra-abdominal injuries (Table 4). There were two intra-operative-related complications encountered, and both were due to bleeding. The most common post-operative complication was a clotted haemothorax CD III-b, and only 1 patient required a decortication (Table 5). There was one anaesthetic-related mortality.

Discussion

The incidence of diaphragmatic injuries was 54%; this is higher than the 7–48% reported in literature [10, 12–15]. The possible reason for this high incidence in our study is partly because we included stable patients with

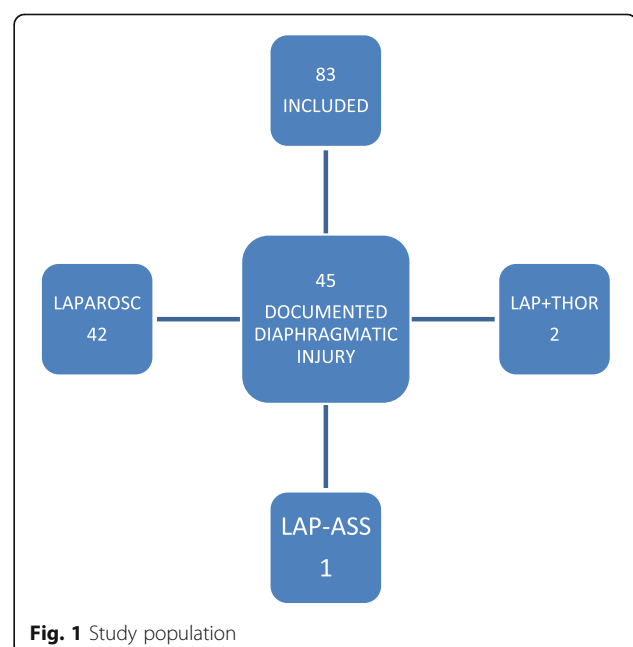


Fig. 1 Study population

Table 1 Patient’s characteristics

Gender	Frequency	Percentage		
F	6	13.3		
M	39	86.7		
Age	Minimum	Median	Maximum	
	19	26	53	

peritonitis and right side diaphragmatic injuries. All 46% of the patients who had negative laparoscopy were discharge 24 h after surgery, and there were no complications recorded at 1 and 3 weeks follow-up.

The wide spectrums of patients were represented as evidenced by wide range of ISS from 8 to 24. ISS has been identified as independent factor affecting the outcomes [16], high ISS has been widely acknowledged as a predictor of mortality [17]. Majority of these patients had Grade 3 (2–10 cm defect) diaphragmatic injury with 62% of the patients having associated intra-abdominal injuries requiring intervention. Some authors report a lower incidence of about 50% [18]; in their methodology, most of these studies derived their figures from both blunt and penetrating injuries [19]. The incidence in our study is high because we only focused on penetrating thoracoabdominal injuries, which is associated with a higher incidence of diaphragmatic injuries than blunt thoracoabdominal injury [20].

Our incidence of associated intra-abdominal injuries requiring intervention was 62%; this includes both solid and

Table 3 Grading of diaphragmatic injury

Diaphragmatic injury	Frequency	Percent
Gr 1 (contusion)	3	6.67
Gr 2 (≤2 cm)	20	44.45
Gr 3 (2–10 cm)	21	46.67
Gr 4 (>10 cm)	1	2.22
Total	45	100.00

hollow viscous organs. This figure is higher than 53.8% reported in other studies [14]. Associated injuries (abdominal and thoracic) are reported as a significant factor contributing to mortality in these patients [20]. Despite the high ISS and associated intra-abdominal injuries including the presence of peritonitis, 93% of patients were successfully treated using laparoscopy. This suggests that high ISS and having intra-abdominal-associated injuries are not a contra-indication to laparoscopy. It also demonstrates that with appropriate laparoscopic skill, these patients can still benefit from minimal access surgery.

Only 1 patient had multiple complex colonic injuries which required a laparoscopic-assisted approach. We still prefer a hybrid procedure if there are no compelling reasons to convert the patient to laparotomy. This particular patient had multiple hollow viscus injuries which included stomach and two colonic perforations in different areas, both requiring resection and anastomosis. The reason for laparoscopic-assisted approach in this particular case was to shorten the operating time.

Table 2 Results

MOI	Stab	Gunshot		
	32 (71%)	13 (29%)		
Number of wounds	Single	Multiple		
	13 (29%)	32 (71%)		
Location of injury	Lower chest	Upper chest		
	44 (98%)	1 (2%)		
Site of injury	Left	Right	Left and right	
	34 (75.6%)	9 (20%)	2 (4.4%)	
ISS	Minimum	Median	Maximum	
	8	18	24	
Mode of intervention	Laparoscopy	Laparoscopic assisted	Laparoscopy-thoracoscopy	
	42 (93.3%)	1 (2.2%)	2 (4.4%)	
TDI grade	Grade 1 (contusion)	Grade 2 (≤2 cm)	Grade 3 (2–10 cm)	Grade 4 (>10 cm)
	3 (6.7%)	20 (44.5%)	21 (46.75)	1 (2.2%)
ASS injury (28 = 62%)	Stomach	Liver	Colon	Spleen
	13	11	5	3
Morbidity	Clotted haemothorax	Bleed	Abscess	Anastomotic leak
	5 (11%)	2 (4.4%)	1 (2.2%)	1 (2.2%)
Mortality	1 (2.2%)			

MOI mechanism of injury, ISS Injury Severity Score, TDI traumatic diaphragmatic injury, ASS injury Associated injury

Table 4 Associated injury and grading

ASS INJURY	Frequency	Percent	Cum. Percent
Gr 1 liver	3	6.67	6.67
Gr 1 spleen	2	4.44	11.11
Gr 2 colon	2	4.44	15.56
Gr 2 colon	1	2.22	17.78
Gr 2 colon, Gr 4 spleen	1	2.22	20.00
Gr 2 liver	1	2.22	22.22
Gr 2 liver	2	4.44	26.67
Gr 2 stomach	7	15.56	42.22
Gr 2 stomach, Gr 2 liver	1	2.22	44.44
Gr 2 stomach, Gr 2 spleen	1	2.22	46.67
Gr 2 stomach, Gr 3 colon	1	2.22	48.89
Gr 2 stomach, Gr 3 liver	1	2.22	51.11
Gr 3 colon	1	2.22	53.33
Gr 3 colon, Gr 4 liver	1	2.22	55.56
Gr 3 liver	1	2.22	57.78
Gr 3 stomach	1	2.22	60.00
Gr 3 stomach, Gr 2 liver	1	2.22	62.22
No associated injury	17	37.78	100.00
Total	45	100.00	100.00

Intra-operative complications were encountered in 2 patients (2.2%); both were due to iatrogenic bleeding. The bleeding was controlled laparoscopically. We considered this as a complication because both patients required blood transfusion post operatively. However, this operative morbidity is not higher than 2.4% reported by other authors [21].

Post-operative complication rate was 16%. The clotted haemothorax was responsible for 5 cases (11%) of post-operative complications, which is more than half of all post-operative complications. This was despite the insertion of an under water drainage. The common factor in all these patients was associated with lung injury. The explanation for these findings could either be residual clots left behind at the index operation or patients continued to ooze from associated lung injury post operatively or both factors played a role. However, we consider these complications as purely avoidable, and since these findings were made, we have been extra-cautious and we wash the thoracic cavity thoroughly during the index operation.

Table 5 Clavien-Dindo grading

Grades	Definition	Management
I	Abscess—port-side	Opened at bedside
III-b	Anastomotic leak	Laparotomy and diverting stoma
III-b	Clotted haemothorax × 4	VATS × 4
V	Clotted haemothorax	Thoracotomy and decortication, died from anaesthetic complications

However, all but 1 patient were successfully managed with suction and under water drainage. One patient had colonic anastomotic leak that was managed by bringing out a colonic stoma. Adhesive small bowel obstruction was seen after 5 months of discharge from the hospital in 1 patient. One patient developed port-site sepsis (abscess), which was managed with local dressings and wound care. Overall, this post-operative morbidity was not higher than 48% reported in other studies [22].

Thoracoscopy is not done routinely; however, in 2 patients from the study, it was deemed necessary because in 1 case, the patient had right side diaphragmatic injury with constant oozing of blood from the chest without a clear identifiable source. Thoracoscopy revealed injury in the bare area of the liver oozing into the chest cavity. Both the liver and the diaphragm were sutured using thoracoscopic approach. The second case of thoracoscopy was done because the right side-clotted haemothorax could not be evacuated properly using laparoscopy approach due to the liver obstructing the view.

There was one (2.2%) mortality; this patient had multiple injuries in the colon as well as lung injury. The patient recovered from the index operation and was discharged from the hospital. About 2 months later, the patient presented with clotted haemothorax, which required thoracotomy for decortication. Unfortunately, the patient died from anaesthetic complications following a thoracotomy. Combined abdominal and thoracic injury in patients with TDI is notoriously associated with high mortality [20]. However, our mortality was still lower than 23% which was reported in literature [18].

Overall, 82% of the patients had uneventful outcome and there were no missed hollow viscus injuries.

The rationale for excluding patients with associated closed head injury from the study

Currently, there is no published literature as far as we are aware which demonstrates the safety of laparoscopy in patients with closed head injury. Authors have documented changes/worsening of ICP due to pneumoperitoneum when laparoscopy is used in large animal models, and they raised serious concerns about the use of laparoscopy in these patients [23, 24]. Even though there are no prospective human trials on this issue, Mobbs and Ow Yang published a case report where ICP in closed head injury patient worsened from 9 to 60 mmHg within 10 min of pneumoperitoneum [25] and Kamine et al. also raised a concern after retrospective analysis of patients who underwent VP-shunt and had abdominal insufflation with CO₂ [26, 27]. Therefore, due to uncertainty regarding the safety of laparoscopy in head injury patients, we opted to exclude these patients from the study for safety reasons. However, we do concede that further studies need to be done on this topic.

Conclusion

The positive outcomes found in this study demonstrate the feasibility of laparoscopy when used in stable patients with penetrating thoracoabdominal injuries. However, in addition, this study seems to suggest that the presence of peritonitis in a stable patient is not a contra-indication to laparoscopy. Thoracoscopy may be useful especially in right side diaphragmatic injury where the liver can precludes adequate visualization of the entire diaphragm and to thoroughly clean the chest cavity and prevent future complication.

Appendix

Clavien-Dindo Classification

‡ brain hemorrhage, ischemic stroke, subarachnoid bleeding, but excluding transient ischemic attacks (TIA); IC: Intermediate care; ICU: Intensive care unit.

Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg.* 2004;240(2):205–13.

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Availability of data and materials

A database as source of data used in the study will be made available upon request.

Authors' contributions

ZMK, initiated the study and contributed to the intellectual design of the study and contents. FM, design the methodology, data analysis. OYM collected data, design the database. All authors contributed to the write of the manuscript. All the authors listed above qualify for authorship as they met the minimum requirement based of the ICMJE guidelines. The first author made substantive intellectual contributions to the study. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Not applicable as the study was a retrospective review.

Ethics approval and consent to participate

Ethics clearance was obtained from Sefako Makgatho Health Sciences University (SMU) Research Ethics Committee (SMUREC) in accordance with Helsinki declaration.

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CHAPTER 6

Laparoscopic Management of Retroperitoneal Injuries

from Penetrating Abdominal Trauma

in

Haemodynamically Stable Patients

Modise Zacharia Koto, Oleh Y. Matsevych, Fusi Mosai, Moses Balabyeki, Colleen Aldous

Laparoscopic Management of Retroperitoneal Injuries from Penetrating Abdominal Trauma in Haemodynamically Stable Patients

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The next study examined a more challenging area of trauma which is retroperitoneal injuries. There is a paucity of literature on the role of laparoscopy in retroperitoneal injuries. Retroperitoneal injuries are surgically problematic because of a number of reasons which includes the difficulty in picking up these injuries because of subtle clinical signs. Imaging can be very challenging as the signs of hollow viscus injury are often indirect and non-specific. The presence of gas may not necessarily indicate bowel injury. These indirect signs have led to a high incidence of non-therapeutic laparotomy. We conducted this study to answer a very pertinent question of whether or not laparoscopy would help us manage retroperitoneal injuries better.

Laparoscopic management of retroperitoneal injuries from penetrating abdominal trauma in haemodynamically stable patients

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Abstract

Background: Laparoscopy is increasingly utilised in the trauma setting. However, its safety and reliability in evaluating and managing retroperitoneal injuries are not known.

Aim: The aim of this study was to analyse our experience with laparoscopic management of retroperitoneal injuries due to penetrating abdominal trauma (PAT) and to investigate its feasibility, safety and accuracy in haemodynamically stable patients.

Methods: Over a 4-year period, patients approached laparoscopically with retroperitoneal injuries were analysed. Mechanism, location and severity of injuries were recorded. Surgical procedures, conversion rate and reasons for conversion and outcomes were described.

Results: Of the 284 patients with PAT, 56 patients had involvement of retroperitoneum. Stab wounds accounted 62.5% of patients. The mean Injury Severity Score was 7.4 (4–20). Among retroperitoneal injuries, the colon (27%) was the most commonly involved hollow viscera followed by duodenum (5%). The kidney (5%) and the pancreas (4%) were the injured solid organs. The conversion rate was 19.6% and was mainly due to active bleeding (73%). Significantly more patients with gunshot wound were converted to laparotomy (38% vs. 9%). Therapeutic laparoscopy was performed in 36% of patients. There were no recorded missed injuries or mortality. Five (9%) patients developed the Clavien-Dindo Grade 3 complications, three were managed with reoperation, one with drainage/debridement and one with endovascular technique.

Conclusion: Laparoscopic management of retroperitoneal injuries is safe and feasible in haemodynamically stable patients with PAT. However, a high conversion rate indicates difficulties in managing these injuries. The requirements are the dexterity in laparoscopy and readiness to convert in the event of bleeding.

Keywords: Diagnostic laparoscopy, penetrating abdominal trauma, retroperitoneal traumatic injuries, therapeutic laparoscopy, trauma

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INTRODUCTION

The role of laparoscopy in penetrating abdominal trauma (PAT) is increasing.^[1-3] The safety and the efficacy of laparoscopy in detecting injuries in haemodynamically stable patients with PAT were the main point of concerns. This was due to the earlier publication which had demonstrated a high missed rate.^[4] However, subsequent studies have shown a much lower rate of missed injuries.^[3,5] This difference has been suggested to be due to the current improvement of laparoscopic skills and better-operating equipment as compared with previous experience.

Currently, many studies are emerging demonstrating the safety and efficacy of laparoscopy in haemodynamically stable patients with PAT.^[6,7] However, there is a major concern about the possibility of missed retroperitoneal injuries. Patients with retroperitoneal injuries may show minimal or no clinical signs at all. The current approach of using triple-contrast multi-detector computed tomography (CT) scan to detect retroperitoneal injuries has certainly improved the diagnostic yield. However, the scatter of metal fragments, the reliance on indirect findings, inability to distinguish injuries that can be managed nonoperatively, and administration of oral contrast in patients who needs general anaesthesia impose significant limitations on CT scan.

Kawahara demonstrated the reliability of systemic examination of the abdominal cavity, thereby reducing the rate of missed injuries.^[3] The role of laparoscopy in PAT has been well established.^[1,2,5,8] However, the concern was raised, that the laparoscopic exploration of the retroperitoneum is technically very challenging.^[9] At present, the safety and reliability of laparoscopic surgery in evaluating and managing retroperitoneal injuries are not known.

The aim of this study was to analyse our experience with laparoscopic management of retroperitoneal injuries in haemodynamically stable patients due to PAT and to investigate its feasibility, safety and accuracy.

METHODS

This was a retrospective study of prospectively collected data from a trauma unit at Dr. George Mukhari Academic Hospital (DGMHAH). DGMHAH is a tertiary hospital in Northwest of Pretoria, South Africa. All haemodynamically stable patients with penetrating abdominal injuries offered laparoscopy from January 2012 to December 2015 were reviewed. We defined retroperitoneal injuries as those

involving the retroperitoneum, retroperitoneal structures and the root of the mesentery of the bowel. The injuries with the potential to enter the retroperitoneal space and required exploration of retroperitoneal organs were considered as retroperitoneal injuries.

The following patients were included in the study: penetrating injuries to the back, flank, anterior abdominal wall and lower chest with the involvement of the retroperitoneum. The retroperitoneal injuries to the colon, kidneys and ureters, pancreas, duodenum and root of the mesentery were also included in the study.

The anterior abdominal area extended from the lower costal margin superiorly to the iliac crest, the ilioinguinal ligament and the pubic bone inferiorly, between the anterior axillary lines anteriorly. The right and left lower chest areas were defined as the areas above the lower costal margin anteriorly and posteriorly and below the nipple line circumferentially on each side of the midline. The flank was defined as the area extending from the lower costal margin to the iliac crest, between the anterior and posterior axillary lines. The back was defined as the area extending from the lower costal margin to the iliac crests and medial to the posterior axillary line.

Injuries to intraperitoneal organs without any suspicious of violation of the retroperitoneum were excluded. Haemodynamically unstable patients were also excluded from the study.

Data regarding patient's demographics such as age and gender were collected. The Injury Severity Score (ISS), intraoperative findings as well as their management were documented. Outcomes such as conversions, complications, missed injuries and mortality were recorded. The complications were recorded according to the Clavien-Dindo classifications and the grades of three and more were considered as statistically significant.^[10]

The operative technique and standard steps of procedure were followed, as described by Koto *et al.*^[11] The peritoneal cavity would be meticulously inspected and where necessary, the retroperitoneal viscera would be extensively mobilised to ensure adequate exposure. When injuries are encountered, the surgeon would proceed with therapeutic laparoscopy or laparoscopic-assisted repair of the injuries. Decision to convert would be made in cases of continuous intraoperative bleeding, the patient becomes haemodynamically or metabolically unstable, the complexity of injuries, visibility is compromised or equipment failure. Complex injuries were defined as multiple injuries not amenable for the laparoscopic repair

or requiring prolong laparoscopic procedure. Diagnostic laparoscopy was defined as an absence of significant injuries or identified injuries that did not require repair. Evacuation of liquid blood or clots and mobilisation of any intra-peritoneal or retroperitoneal organs for diagnostic purposes were not considered therapeutic.

All operating surgeons were proficient in advanced laparoscopic skills.

Statistical analysis

Means (\pm standard deviation) were presented for continuous variables and frequencies (%) were presented for categorical variables. All analyses were performed using SAS version 9.3 (SAS Institute, Cary, NC, USA).

The ethics clearance for the study was obtained from the Sefako Makgatho Health Sciences University Ethics Committee. Reciprocal approval was obtained by the Biomedical Research Ethics Committee of the University of KwaZulu-Natal.

RESULTS

A total of 284 patients with PAT were reviewed, and of these, 56 (20%) patients met the inclusion criteria and were included in the study. The mean age was 31 years (15–60 years) and males constituted 87.5% of the study population. The mean ISS was 7.4 (4–20) with the most common mechanism of injury been penetrating stab wounds in 35 (62.5%) patients. Significantly, more patients with gunshot wound (GSW) were converted to laparotomy (38% vs. 9%) [Table 1].

The grades of injuries and performed procedures are listed in Table 2. In many cases, injuries were multiple. The most encountered retroperitoneal hollow viscus was the colon in 15 (27%) followed by the duodenum in 3 (5%) patients. The most commonly injured solid organs were the kidney in 3 (5%) and the pancreas in 2 (4%) patients [Table 2].

The most common location of injury was the flank (63%) followed by back, anterior abdominal wall and lower chest [Table 1]. Nine patients with the anterior abdominal wall injuries had retroperitoneal and multiple intra-abdominal organ injuries at the same time. Three patients were managed laparoscopically, including one patient with inferior vena cava injury. Other six were converted. In three patients, the injury was located posteriorly on the lower chest. All patients had retroperitoneal haematoma and two of them had pneumothorax. One patient had kidney injury and consequently developed arteriovenous fistula which was managed endovascularly. Other patient had haematoma in zone 1 which started to bleed during laparoscopic exploration and patient was converted.

The conversion rate was 19.6% ($n = 11$) with the most common indication for conversion been active bleeding in eight (73%) patients. The intraoperative bleeding did not cause any haemodynamic instability. Other reasons for conversion in this study are listed in Table 3.

Forty-five patients (80.3%) were managed laparoscopically. Of these, 16 (36%) patients had injuries that required therapeutic interventions and in three patients, the

Table 1: Patients characteristics

	Laparoscopic	Converted	Total	P
Number of patients (%)	45 (80.4)	11 (19.6)	56	
Age	31/26 (15-60)	29/28 (17-42)	31/27 (15-60)	NS
Gender (%)				
Female	6 (86)	1 (14)	7 (12.5)	NS
Male	39 (80)	10 (20)	49 (87.5)	
Mechanism of injuries (%)				
GSW	13 (62)	8 (38)	21 (37.5)	0.01
Stab wounds	32 (91)	3 (9)	35 (62.5)	
LOS, mean/median (range)	4.6/4 (1-15)	13.6/9 (5-47)	6.3/4 (1-47)	0.03
ISS, mean/median (range)	6/4 (4-13)	12.5/13 (4-20)	7.4/6 (4-20)	0.005
Location of injury (%)				
Anterior	3 (33)	6 (67)	9	0.001
Back	7 (78)	2 (22)	9	
Flank	33 (94)	2 (6)	35	
Lower chest	2 (67)	1 (33)	3	
Type of laparoscopy (%)				
Diagnostic	29 (64)	-	-	
Therapeutic	16 (36)	-	-	
Complications (Clavien–Dindo) (%)				
Grade 3	2 (40)	3 (60)	5 (9)	0.047
No complications	43 (84)	8 (16)	51 (91)	

GSW: Gunshot wound, ISS: Injury Severity Score, NS: Not significant, LOS: Length of hospital stay

Table 2: Injuries and procedures

Injuries and procedures	Laparoscopic	Converted	Total	P
Colon injuries (%)				
Grade 1, 2, 3	11 (73)	4 (27)	15	NS
Colonic procedures (%)				
Mobilised	15 (94)	1 (6.3)	16	NS
Repair	5 (62.5)	3 (37.5)	8	
Stoma	5 (83)	1 (17)	6	
Small bowel injuries (%)				
Grade 1, 2, 3	7 (64)	4 (36)	11	0.03
Small bowel procedures (%)				
Repair	7 (70)	3 (30)	10	NS
Resection and anastomosis	0	1	1	
Mesentery injuries (%)				
Grade 1, 2	3 (50)	4 (50)	7	NS
Mesenteric procedures				
Diathermy	0	1	1	<0.001
Repair	0	3	3	
Duodenum injuries				
Grade 1, 2	0	3	3	0.002
Duodenum procedures				
Repair	0	3	3	0.006
Stomach injuries				
Grade 3	0	1	1	NS
Stomach procedures				
Repair	0	1	1	NS
Liver injuries				
Grade 1, 2, 3	3	1	4	NS
Gall bladder injuries				
Grade 2	1	0	1	NS
Gall bladder procedures				
Cholecystectomy	1	0	1	NS
Spleen injuries				
Grade 3	0	1	1	NS
Spleen procedures				
Repair	0	1	1	NS
Kidney injuries				
Grade 2, 3, 4	0	3	3	0.015
Kidney procedures				
Repair	0	1	1	NS
Pancreas injuries (%)				
Grade 1	1 (50)	1 (50)	2	NS
Pancreas procedures (%)				
Drain	1 (50)	1 (50)	2	NS
Retroperitoneum (%)				
Zone 1	1 (17)	5 (83)	6	<0.001
Zone 2	5 (63)	3 (38)	8	
Zone 3	2	0	2	
Retroperitoneal procedures (%)				
Mobilised/explored	4 (50)	4 (50)	8	0.001
Repair/sutures/ligation	1 (25)	3 (75)	4	
Vascular injuries (abdominal)				
Grade 3, 4	1	1	2	NS
Vascular procedures (%)				
Repair	1 (50)	1 (50)	2	NS

NS: Not significant

laparoscopic-assisted approach was utilised. All converted cases were recorded as therapeutic [Table 1]. There were no recorded missed injuries and mortality in this group. Five (9%) patients developed the Clavien-Dindo Grade 3 complications. One patient had debridement, two had relaparotomy, one relaparoscopy and another patient was managed endovascular techniques. All patients successfully recovered [Table 4].

Table 3: Reasons for conversion

Reasons for conversion	Frequency (%)
Bleeding from the retroperitoneal vessels	3 (28)
Large retroperitoneal haematoma	2 (18)
Mesenteric bleeding	2 (18)
Retroperitoneal bleeding	2 (18)
Bleeding spleen	1 (9)
Large mesenteric haematoma	1 (9)
Total	11 (100)

DISCUSSION

Challenges in managing patients with penetrating retroperitoneal injuries principally revolve around the lack of clinical signs even in the setting of significant injuries to the retroperitoneum. Trauma surgeons have relied on various imaging modalities to detect these injuries. Although Focused Assessment with Sonography in Trauma is widely used for quick imaging of intraperitoneal bleeding, its diagnostic value in the assessment of retroperitoneal injuries is poor.^[12] CT scan has been the cornerstone of the management decision-making process of these injuries. In the study by Pham *et al.*, CT scan showed the sensitivity of 100% and a specificity of 96% in detecting injuries requiring laparotomy.^[13] The concern with CT scan is that the findings are often non-specific and this would lead to an exploratory laparotomy which in many cases turns out to be non-therapeutic. However, we found pre-operative CT scan to be very helpful in selecting patients for non-operative management or laparoscopy. In case of surgery, CT scan imaging was useful in planning the extent of laparoscopic exploration of the retroperitoneum.

Our report represents a significant number of patients with retroperitoneal injuries managed laparoscopically. The majority of patients were males and the mean age was 30 years. The mechanism of injury was mainly due to stab wounds in 62.5% and GSWs accounting for 37.5% of the patients.

Retroperitoneal injuries carry the high potential for occult injuries of which the most commonly encountered is colonic injury, followed by injuries to the spleen and kidney.^[14] In this study, fifteen patients had colonic injury either isolated or combined with injury to the kidney, spleen or mesentery. The location of injury can raise suspicion for possible retroperitoneal involvement. Injuries to the flank, back and the posterior aspect of lower chest carry the highest potential for retroperitoneal penetration. However, this study demonstrated that anterior abdominal wall injuries can also penetrate the retroperitoneum and usually associated with multiple intraperitoneal and retroperitoneal injuries.

Table 4: Significant complications

Type of procedure	LOS (days)	Description of complication and management
Converted	20	Relook laparotomy for leak of duodenal repair
Converted	20	Relook laparotomy for leak of duodenal repair
Converted	47	Wound sepsis, managed with drainage, debridement and wound care
Diagnostic laparoscopy	5	Haematoma of the left kidney was not explored, diagnosed with renal AV fistula on CT scan, managed endovascular techniques
Therapeutic laparoscopy	20	Relook laparoscopy and colostomy for leak (colon repair, Grade 3)

LOS: Length of hospital stay, AV: Arteriovenous, CT: Computed tomography

The attempt of non-operative management over 48 h was reported by Kong *et al.*, but resulted in 100% of failure rate.^[14]

There is no doubt that violation of retroperitoneum carries a high risk for life-threatening injuries and all unstable patients should undergo immediate laparotomy. Concerning haemodynamically stable patients, the laparoscopy is not reported in the literature as an option for management of retroperitoneal injuries.^[15-18] On the contrary, in this study, 80.4% of stable patients with retroperitoneal injuries were successfully managed with laparoscopy. The retroperitoneal organs were mobilised and haematoma explored to inspect for injuries. There were no missed injuries in this series.

Diagnostic laparoscopy was performed in 29 (64%) patients. Therefore, 64% of patients avoided non-therapeutic laparotomy with its associated morbidity. Therapeutic laparoscopy was performed in 16 (28.6%) cases. Three of these patients were offered a laparoscopic-assisted approach due to complex bowel injuries. The laparoscopic-assisted approach seems to be effective for complex bowel injuries and retroperitoneal injuries to the colon.^[19] There is a paucity of data about the role of therapeutic laparoscopy for retroperitoneal injuries. This report shows that therapeutic laparoscopy was feasible and successful in 36% of the patients with retroperitoneal injuries. The length of hospital stay was shortened significantly in the laparoscopy group (4.6 vs. 13.6 days in the converted to laparotomy group).

The surgeon involved in retroperitoneal exploration for trauma has to be proficient in advanced laparoscopic skills. Even simple diagnostic laparoscopy requires an extensive mobilisation of retroperitoneal organs and an ability to control possible bleeding.

The laparoscopic exploration of retroperitoneum remains technically challenging resulting in the higher conversion rate. In this study, the conversion rate was 19.6%. The

conversion rate was higher compared to our reported 7% conversion of overall laparoscopy for penetrating abdominal injuries.^[2] Due to potential danger of massive bleeding, the threshold to convert was very low. There is no available data to compare this conversion rate with. Conventionally, the retroperitoneal injuries are managed with laparotomy. Moreover, the presence of retroperitoneal haematoma is considered by many surgeons as an absolute indication for laparotomy or conversion to laparotomy.^[15-17] This study indicates that a significant number of patients with retroperitoneal injuries can be safely managed laparoscopically. As expected, the major cause of conversion in this study was bleeding. All eleven patients were converted due to active bleeding or high potential for bleeding; five patients had bleeding from the retroperitoneal vessels, one patient bled from the spleen, and two patients had bleeding from the mesentery, two patients had large retroperitoneal haematoma and one patient had large mesenteric haematoma. Besides the potential for bleeding, the penetration of retroperitoneum carries a high rate of complex injuries. All injuries were identified and if needed corrected. No missed injuries were reported in this study. Laparoscopic exploration was feasible, however, with a high conversion rate.

Although the numbers in our study were small to draw a firm conclusion, a very important trend emerged that laparoscopic intervention is a safe strategy in retroperitoneal injuries.

CONCLUSION

The laparoscopic management of retroperitoneal injuries is safe and feasible in haemodynamically stable patients with PAT. There is a high conversion rate indicating the difficulties in a managing these injuries. The requirements are the dexterity in laparoscopy and readiness to convert in the event of bleeding or complex injuries extending beyond laparoscopic capabilities of operating surgeon.

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Conflicts of interest

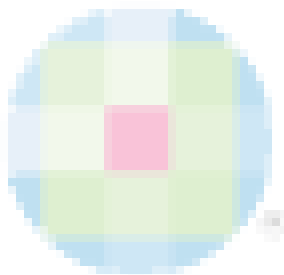
There are no conflicts of interest.

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CHAPTER 7

Laparoscopy for Blunt Abdominal Trauma:

A Challenging Endeavour

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Laparoscopy for Blunt Abdominal Trauma: A Challenging Endeavour

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The next study was to determine the role of laparoscopy in blunt abdominal trauma. Unlike penetrating abdominal trauma, blunt abdominal trauma is associated with significant impact and energy transfer. These patients are more than likely to present with significant injuries. Laparoscopy is not well established in this cohort of patients. Our study was to look at the role of laparoscopy in this cohort of patients with significant injuries compared to penetrating injures.

Laparoscopy for blunt abdominal trauma: a challenging endeavour

Modise Z Koto, Oleh Y Matsevych, Fusi Mosai, Soraya Patel, Colleen Aldous, Moses Balabyeki

ABSTRACT

Introduction: Laparoscopy in blunt abdominal trauma (BAT) is challenging because of multiple associated injuries, higher trauma score values and higher morbidity and mortality, as compared with patient with penetrating abdominal trauma (PAT).

The aim of this study was to investigate the role of laparoscopy in management of BAT patients and to highlight related challenges.

Methods: Patients managed laparoscopically for BAT over a four-year period were retrospectively analyzed. Perioperative details, indications for laparoscopy and conversion, complications and length of hospital stay were discussed.

Results: Thirty-five stable patients underwent laparoscopy. The mean Injury Severity score was 12 (4-38). Therapeutic laparoscopy was performed in 15 (56%) and diagnostic in 12 (44%) patients. Eight (23%) patients were converted to therapeutic laparotomy. Intraoperative bleeding, complex injuries, visualization problem and equipment failure necessitated conversion.

Three (30%) patients with negative CT scan had therapeutic laparoscopy for mesenteric injuries. There were no missed injuries. The mean length of hospital stay was 11 days in both groups.

Conclusion: Laparoscopy for stable patients is feasible and safe. Multiple injuries make laparoscopy more difficult and advanced laparoscopic skills are required. The conversion rate is high; however, the non-therapeutic laparotomies were completely eliminated in this study.

Keywords: blunt abdominal trauma; trauma; laparoscopy; therapeutic; diagnostic.

Introduction

Laparoscopy for penetrating abdominal trauma (PAT) is increasingly practiced all over the world with the reported sensitivity, specificity, and accuracy of nearly 100%.¹⁻³ The current rate of missed injuries is reported to be below 0.4% and the conversion rate is ranging from 7% to 47%.⁴⁻⁸

The role of laparoscopy in blunt abdominal trauma (BAT) is not clearly defined.⁹ Patients with BAT have higher trauma score values and higher morbidity and mortality, compared with patient with PAT.¹⁰ BAT is usually associated with other injuries and clinical examination is not always reliable, due to distracting associated injuries.¹¹ CT scan examination is the gold standard but it is unreliable for detecting hollow viscus injuries. In cases of diagnostic uncertainty, exploratory laparotomy is seen as an innocuous intervention by many investigators. However, laparotomy is associated with the morbidity rate as high as 41%.¹² Moreover, the rate of negative unnecessary laparotomies is 27%.¹²

Laparoscopy is widely applied in patients with PAT and proven to be accurate, associated with low morbidity, faster recovery and lower length of hospital stay (LOS).^{5,13,14} On the contrary, laparoscopy for BAT encounters many challenges and is rarely reported in the literature.

The aim of this study was to investigate the role of laparoscopy in the management of patients with BAT and to highlight the challenges encountered with laparoscopic management of these patients.

Methods

This study analyzed the prospectively collected data of hemodynamically stable patients with BAT who were managed laparoscopically at a single academic hospital, from January 2012 to December 2015. Our institution is a tertiary academic hospital providing trauma services for a

population of 7.3 million people. Ethics clearance was obtained from our Research Ethics Committee.

Exclusion criteria: patients managed with initial laparotomy or successful nonoperative management, patients with penetrating abdominal injury, cases with incomplete records and patients under 12 years of age.

Patients' age and gender, mechanism of injury, location of injury, the Injury Severity Score (ISS) and the Penetrating Abdominal Trauma Index (PATI), CT scan findings (64 multislice system), indications for surgery, intraoperative findings and procedures performed and reasons for conversion were recorded and analyzed. The complications of Clavien–Dindo (CD) grades 3–5 were considered significant and were analyzed.¹⁵

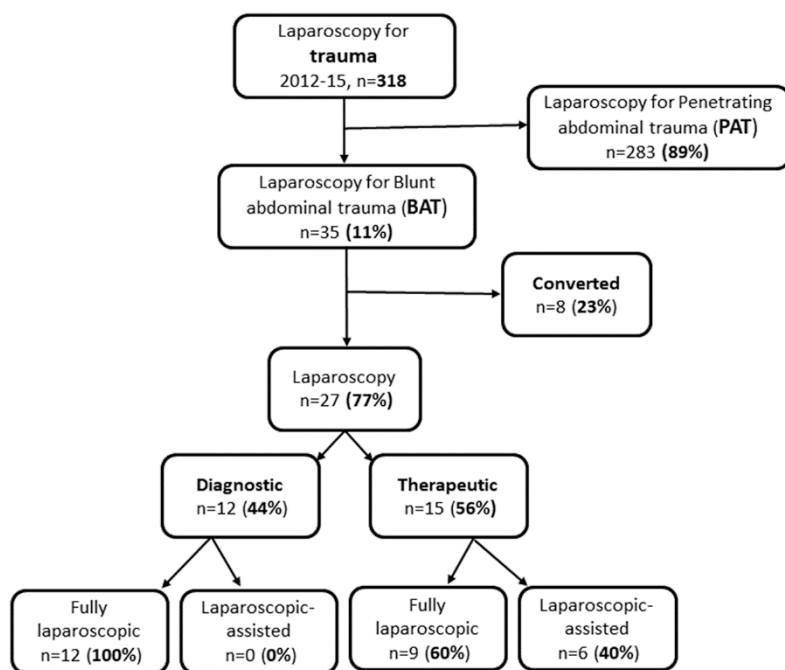
This study included converted-to-laparotomy patients in a control group, based on the point that at the time of laparoscopy all patients were considered stable and similar in the intent to complete operation laparoscopically.

The patients with the systolic blood pressure below 90 mm Hg and the mean inspiratory pressure greater than 30 mm Hg were considered unstable and offered laparotomy.

Details of the patients were summarized descriptively by mean, median, minimum, and maximum values for continuous variables, and by frequency count and percentage calculations for categorical variables. The Fisher's exact test was used for comparisons of frequency counts/percentages. Median values were compared by the nonparametric Wilcoxon rank-sum test. All statistical procedures were performed with SAS software (SAS Institute, Cary, NC). A value of $p < 0.05$ was considered significant.

Results

Three hundred and eighteen trauma patients were managed with laparoscopy over the study period, (Figure 1)



All the patients were resuscitated along the Advanced Trauma Life Support (ATLS) principles and were stable at the beginning of laparoscopy. PAT were recorded in 283 (89%) patients. Thirty-five (11%) patients had BAT and were analyzed. Eight (23%) patients were converted to therapeutic laparotomy. Twenty-seven (77%) patients were managed with laparoscopy, 15 (56%) of them underwent therapeutic intervention, while 12 (44%) patients had diagnostic laparoscopy. Laparoscopic-assisted approach was utilized for therapeutic procedures in six patients with hollow viscera injuries. (Table 1)

The most common mechanism of blunt trauma was assault in the laparoscopic group and traffic accident in the converted group. Two or more anatomical regions were involved in 15 (43%) of the patients. The ISS did not differ between the groups, however, the PATI was significantly higher in the converted group.

Only one patient did not have preoperative abdominal CT scan. Ten (37%) patients in the laparoscopy group had negative findings on abdominal CT scan, however, three (30%) of them had therapeutic laparoscopy for grade 2 mesenteric injuries requiring repair. The indications for laparoscopic exploration were the following: peritoneal irritation, abdominal tenderness,

suspicious of hollow viscera injuries on abdominal CT and unequivocal signs on physical examination.

Table 1 Characteristics of patients

	Laparoscopic	Converted	Total	p-value
Total	27 (77%)	8 (23%)	35	
Age (years)	30/26 (15-56)	47/45 (27-66)	34/30 (15-66)	<0.001
Gender				
Male	2	1	3	0.55
Female	25	7	32	
Mechanism				
Assault	16 (59%)	1 (12.5%)	17 (48.5%)	0.13
Traffic accident	11 (41%)	6 (75%)	17 (48.5%)	
Fall from height	0	1 (12.5%)	1 (3%)	
Regions involved				
Abdomen only	15 (56%)	5 (62.5%)	20 (57%)	0.53
Two or more	12 (44%)	3 (37.5%)	15 (43%)	
Associated injuries				
Head injury	3	0	3	0.62
Chest	2	0	2	0.73
Long bones	4	2	6	0.60
Abdominal CT				
Positive	17 (63%)	7 (87.5%)	24 (69%)	
Negative	10 (37%)	0	10 (29%)	0.03
Not done	0	1 (12.5%)	1 (2%)	
Injury severity				
ISS	11/9 (4-38)	12/13 (4-18)	12/9 (4-38)	0.73
PATI	4/4 (0-12)	10/9 (2-28)	6/6 (0-28)	0.006
Type of laparoscopy				
Diagnostic	12 (44%)	0		
Therapeutic	15 (56%)	8 (100%)		
LOS	11/8 (1-49)	11/10 (7-20)	11/9 (4-38)	0.99
Outcomes				
CD 3	2 (7%)	1 (12.5%)	3 (9%)	0.32
CD 5	2 (7%)	2 (25%)	4 (11%)	
No complications	23 (86%)	5 (62.5%)	28 (80%)	

CT, computed tomography; ISS, the Injury Severity Score; PATI, the Penetrating Abdominal Trauma Index; LOS, length of hospital stay; CD, Clavien-Dindo grade

Repair of the small bowel and mesentery were commonly performed procedures. Intraoperative findings and procedures performed are listed in Table 2. The conversion to open laparotomy was necessary in four patients with intraoperative bleeding which could not be quickly controlled, one patient was converted because of complex injuries, two due to poor visualization, and one due to equipment failure.

Table 2 Intraoperative findings and therapeutic procedures

Injuries and therapeutic procedures	Laparoscopic group	Converted group	Total
Small Bowel (Grade 1, 2, 3)	8	3	11
Duodenum (Grade 1, 3)	0	2	2
Colon (Grade 1, 2)	1	1	2
Resection and anastomosis	-	1	1
Repair	7	3	10
Stoma	2	1	3
Mesentery (Grade 1, 2, 3)	7	5	12
Repair	3	4	7
Liver (Grade 1, 2, 3)	6	0	6
Spleen (Grade 3, 4)	0	2	2
Splenorrhaphy	-	1	1
Splenectomy	-	1	1
Kidney (Grade 2)	2	-	2
Urine bladder (Grade 2, 3)	3	-	3
Bladder repair	3	-	3

Evacuation of clots and application of haemostatic agent were not considered as therapeutic procedures

There were no missed injuries in this study. The mean length of hospital stay was 11 days in both groups. Two patients died in each group. These patients were severely injured polytrauma patients (ISS, 16-38). Three patients suffered Clavien-Dindo grade 3 complications. In the laparoscopy group, one had percutaneous drainage of intraabdominal abscess and second had drainage/debridement of assisted access site for wound sepsis. One patient in the converted group had re-look laparotomy for intraabdominal abscess. (Table 3)

Table 3 Patients with significant complications

Clavien -Dindo grade, Age years	Mechanism and associated injuries	Type of laparoscopy	ISS/ PATI	LOS, days	Grade of abdominal injuries, therapeutic procedures	Complications
CD 5, 49	Traffic accident, Severe head injury, Craniotomy	Therapeutic	25/7	49	Mesentery Gr 2, repair; Liver Gr 2	Re-look, Severe head injury
CD 5, 35	Traffic accident, Severe head injury, Pneumothorax, Chest drain	Diagnostic	38/0	1	No injuries	Severe head injury
CD 5, 39	Traffic accident, Long bones	Converted	18/9	9	Colon Gr 2, stoma; Mesentery Gr 2, repair;	Pulmonary embolism
CD 5, 39	Traffic accident. Long bones	Converted	16/28	20	Small bowel Gr 3, repair; Duodenum Gr 3, repair; Mesentery Gr 3, repair	ECF, pneumonia, ARDS
CD 3, 25	Assault	Therapeutic	9/6	12	Small bowel gr 2, repair	Percutaneous abscess drainage
CD 3, 36	Assault	Therapeutic	9/6	19	Small bowel gr 2, repair	Assisted access wound sepsis
CD 3, 66	Assault	Converted	18/2	7	Small bowel gr 2, repair	Re-look for intraabdominal abscess

ISS, the Injury Severity Score; PATI, the Penetrating Abdominal Trauma Index; LOS, length of hospital stay; CD, Clavien-Dindo grade; Gr, grade; ECF, enterocutaneous fistula; ARDS, acute respiratory distress syndrome

Discussion

The management of patients with BAT poses significant challenges to the treating physicians. Only 5 to 10% of blunt trauma patients will have significant intraabdominal injuries requiring surgical intervention and 10% of them will present with negative clinical examination.¹⁶ Severe “occult” intraabdominal injuries requiring specific treatment were described in BAT patients even without distracting injuries and abdominal pain.¹⁷ In this scenario, abdominal imaging improves diagnostic yield, however, it is still not a completely accurate approach.

The Focused Assessment with Sonography in Trauma (FAST) is non-invasive bedside imaging modality to identify free fluid in the abdominal cavity, however, it is highly operator-dependent. It is commonly used as an adjunct to the primary survey according to the ATLS guidelines. However, Dolich et al. reported that 1.7% of patients with negative FAST had organ injuries and 23% of them required exploratory laparotomy.¹⁸ In the recent study from United States, the authors discovered the sensitivity of FAST in stable patients with BAT was 22%, and they proposed, where possible, to bypass FAST exam and go directly to CT scan.¹⁹ CT scan is the imaging of choice in BAT, however, it also has limitations. Hollow viscus injuries are not easily demonstrated on abdominal CT scan. In most patients only indirect signs of injuries can be identified, this can lead to missed injuries and delayed surgical treatment.²⁰ A delay in surgical treatment of hollow viscus injuries in as little as 5 hours may result in an increase in morbidity and mortality.^{21,22} Despite its limitations, CT remains standard imaging of hemodynamically stable patients with BAT.^{8,23-26} In this study, abdominal CT scan was performed preoperatively in 98% of patients, only one patient did not have a scan for an unknown reason. All patients in the converted group had positive findings on CT scan, however, in the laparoscopic group 37% of patients had negative CT scan. Three (30%) patients with negative CT scan had therapeutic laparoscopy for mesenteric injuries. Although most injuries will be identified by physical examination and CT scan findings, there are still sizable groups of patients who will have false negative findings and necessary treatment will be delayed. Laparoscopy in these cases will accurately identify and offer therapeutic options for occult intraabdominal injuries. The question on when to offer laparoscopy and whether to engage in a trial of nonoperative management still remains unanswered.

Diagnostic peritoneal lavage (DPL) in BAT was discouraged due to over-sensitivity and relatively low specificity.²⁷ However, the concept of DPL can be modified to the laparoscopic

assessment in surgical trauma (LAST) under local anesthesia in the trauma resuscitation area.²⁸

LAST appears a promising screening tool but needs validation.

In our institution, all stable trauma patients requiring surgical exploration will undergo laparoscopy and be converted to laparotomy when conversion criteria are met. There are no doubts that BAT patients with signs of peritonitis, positive findings on imaging, or with high suspicions for injuries (like seatbelt sign) require surgical exploration and our choice for stable patients is laparoscopy. Equivocal or worsening abdominal examination in most cases warrants surgical exploration. Our indications for surgical exploration are in agreement with other studies.^{25,27,29-31} High index of suspicious for hollow viscus injuries is reasonable, as in this study, the most common injuries were small bowel and mesenteric injuries; the same is reported in the literature.³² More studies are needed to draw the line between indications for diagnostic laparoscopy and nonoperative management.

Most patients with BAT suffer from road traffic accidents and have multiple associated injuries. The prompt diagnosis of all injuries is difficult and a delay in management may result in higher complication rate of 25 to 65%.³³ In this study, the most common mechanism of injury was assault (59%) in the laparoscopic group and traffic accident (75%) in the converted group. The mechanism of injury did not affect the laparoscopic management. Associated injuries were present in both groups and accounted for 43%.

The ISS score was higher in converted group but the difference was not statistically significant. However, the PATI score was significantly higher in the converted group. These findings suggest that more complex intraabdominal injuries were eventually managed with open approach.

Patients with BAT frequently have major physiologic derangements or associated severe injuries, often making them unstable and not suitable for laparoscopy. The recovery of patients depends mostly on associated injuries convalescence and that seems to mitigate the potential

benefits of laparoscopy, such as LOS and ventilator-free days.³⁴ In this study, associated injuries were the main reason why LOS was similar in both groups. The similar LOS stay for BAT patients was reported by Johnson et al.⁹ The complications were higher in the converted group but it may be related to more complex intraabdominal injuries. All four patients who died were severely injured polytrauma patients. In the laparoscopy group, two patients died from severe head injury. In one patient, laparoscopy was negative, and, in second patient, the mesentery was repaired. The mortalities in the laparoscopic group was expected and were unrelated to laparoscopy. Although it is controversial, we believe that laparoscopy benefits of less operative trauma and faster recovery outweigh the potential increase in intracranial pressure during laparoscopy. However, some investigators suggest head injury as a relative contraindication to laparoscopy.²⁵ Further studies are needed to investigate this issue.

The rate of septic complications was higher in the converted group.

Our policy is to offer initial laparoscopy to all stable patients who need surgical exploration. The algorithm was recently reported by Matsevych et al.¹³ Our conversion rate (23%) for BAT was higher than the reported rate for PAT (11.7%).¹³ The higher conversion rate for blunt trauma reflects the severity and multiplicity of intraabdominal injuries. In the literature, the conversion rate varies from 8.5 to 37% depending on the selection criteria.^{27,32,35,36} The reasons for conversion in this study were bleeding, multiple complex injuries, visualization problem and equipment failure. Although it was not observed in this study, the respiratory and hemodynamic deterioration of patient should lead to conversion.¹³

Benefits of laparoscopy over laparotomy in patients with abdominal trauma are well documented. The decrease or even elimination of non-therapeutic laparotomies, reduction in the incidence of postoperative morbidity and mortality, decrease of postoperative pain, enhance recovery and shorter LOS were reported.^{2,9,37,38}

Our study has some limitations. The study was a retrospective, had small sample size, and follow-up was not accurately documented. The result of this study strongly depends on the possession of advanced laparoscopic skills by operating surgeons and, therefore, can be reproduced only in centers with a similar expertise. The groups comparison should be taken with caution because of a heterogeneity and small numbers. The overall LOS was calculated and it does not accurately represent LOS after laparoscopy. Nonetheless, the study gives an insight of how laparoscopy could be used for blunt trauma, and it highlights the challenges encountered during laparoscopy.

Conclusion

In conclusion, laparoscopy for stable patients with BAT is feasible, accurate and safe, however, it faces multiple challenges. Pre-operative abdominal CT scan can help to select patients for nonoperative management, although, the low accuracy of CT scan in detecting hollow viscus injuries should be taken into consideration. Laparoscopy cannot replace CT scan or non-operative management, but it can accurately identify and manage hollow viscus injuries in cases of uncertain findings on physical examination and imaging. Multiple intraabdominal injuries make laparoscopic exploration more difficult, and advanced laparoscopic skills are required. Associated extraabdominal injuries contribute to the severity of patients and prolong the convalescence by masking the benefits of laparoscopy. The conversion rate is high; however, the non-therapeutic laparotomies were completely eliminated in this study. More studies are needed to confirm our findings with the laparoscopy for blunt trauma patients.

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M.K. participated in study conception and design, literature search, data collection, analysis, and interpretation of data, preparation and revision of the manuscript.

O.M. participated in the study conception and design, literature search, data collection, analysis and interpretation of data, critical review, preparation and revision of the manuscript.

F.M. participated in data interpretation, critical review and revision of the manuscript.

S.P. participated in data collection, interpretation, and revision of the manuscript.

C.A. participated in the data interpretation, critical review and revision of the manuscript, and mentoring throughout the manuscript preparation.

M.B. participated in the data interpretation, critical review and revision of the manuscript.

Disclosure Statement

No competing financial interests exist.

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CHAPTER 8

SYNTHESIS AND DISCUSSION

Overview

This work has demonstrated that laparoscopy, as an intervention strategy in the context of hemodynamically stable trauma patients, is safe and accurate, provided that the surgeon has the necessary technical skill and proficiency (1-4). The thesis further demonstrated that laparoscopy is safe and feasible in the setting of trauma that was previously presumed to be unsafe (5).

There has been knowledge contribution in the area of thoraco-abdominal injuries with associated generalized peritonitis and right sided injuries (6).

To our knowledge, this is the first attempt to address the question of the role of laparoscopy in this setting. The work has contributed to the body of knowledge in this area by providing a roadmap to the management of these challenging injuries using laparoscopy (7).

Peritoneal access during laparoscopy is fraught with complications, some of which can be life-threatening (8). The type of peritoneal access in the setting where there is high prevalence of abdominal tuberculosis can be challenging. The study on laparoscopic access has demonstrated that there is little difference between the open access technique and the Veress needle technique (9).

The management of trauma patients with both penetrating and blunt trauma has traditionally been done by laparotomy (10). This includes both stable and unstable trauma patients (11). Laparoscopy has been shown to decrease the rate of negative laparotomy (12). Although laparotomy is a very potent intervention strategy for trauma patients, it is associated with significant morbidity and mortality (13). Laparoscopic surgery is associated with shorter hospital stay, less postoperative pain, better cosmesis, and generally more acceptable outcomes for patients (14).

In many areas of surgery, minimal access surgery is now well-established (15,16). In laparoscopic cholecystectomy, Phillip Mouret is credited as the very first surgeons to

show the benefits of laparoscopy as being feasible and safe. The first surgeon to successfully perform the first laparoscopic cholecystectomy was Eric Muhë. The role of laparoscopy in trauma, however, has not been well defined. Earlier publications indicated a high incidence of missed small bowel injuries. In the work on the role of laparoscopy in trauma, Ivatury et al. showed that at least 80% of small bowel injuries were missed by laparoscopic surgery (17). These results had a long-lasting effect of general reluctance by trauma surgeons in embracing laparoscopy in the management of trauma patients.

Laparoscopy as an interventional surgical procedure is still not widely practised by trauma surgeons and continues to be viewed with scepticism. The prevailing view of many trauma surgeons is that laparoscopy as a management of trauma patients is unreliable (17). This view, however, is slowly changing (18).

Looking at possible reasons for the reported high incidence of missed injuries, two main possible explanations emerge. Laparoscopic equipment that were used two decades ago were entry level technology and therefore not able to provide the clear images available today. The skills level of the surgeons was not yet adequately advanced in laparoscopy. Laparoscopy is a skill-intensive specialty and results are dependent on the skills of the individual surgeon concerned. The more skilled the surgeon is, the better the surgical outcome. This may partly explain the unfavourable results reported by earlier investigators (17).

In the last 20 years, there has been a steady increase in laparoscopic skills. There are formal structured laparoscopic training programmes in many centres that have helped elevate the skills-set of surgeons. New surgical trainees and surgeons are therefore more familiar with laparoscopic surgery now than previously, and the technology used in laparoscopic surgery has improved significantly (19).

The key question is whether the benefits of minimal access surgery seen in other areas of surgery such as laparoscopic cholecystectomy can be extended to trauma laparoscopy without compromising patients' outcomes (3). The work in this thesis has demonstrated the effectiveness and safety of laparoscopy in various areas of trauma (18-20).

The comparison of abdominal access between Veress needle and the open Hasson Technique

Safe access to the peritoneal cavity is key to successful laparoscopic surgery. The suggestion is that the Hasson technique is safer and results in fewer major vascular complications compared to the Veress technique (8). This area of research is bedevilled by poor quality data. Many of the studies addressing this question are low evidence type studies, such as retrospective chart reviews and case series. The unique challenge in South Africa is the high prevalence of tuberculosis in general and abdominal tuberculosis in particular. Unlike other studies that excluded patients with previous laparotomy, the study on laparoscopic access in this thesis included this cohort of patients. The concern is how safe the Veress needle access is, in this group of patients.

We have asked the question: “Should we be offering the Hasson technique access to all our patients in South Africa because of the confounding problem of possible adhesions from previous laparotomy or abdominal TB?” The randomized control trial in this cohort of patients did not show a major difference in terms of the primary endpoint of major complications such as hollow viscus and vascular injuries. The secondary endpoints were haematomas, minor bleeds and surgical site infection. We found no difference between the two methods of access as far as major complications were concerned. However, some minor complications were reported, including failed Veress needle access and port site bleeding in the Veress needle group. Although the study was underpowered, very important trends emerged, namely that the two approaches were not significantly different, as far as major complications are concerned. The only noticeable difference was on minor complications.

Laparoscopy in addressing the question of diagnosis and minimizing the rate of missed injuries.

Missed injuries are a major concern in laparoscopic surgery for trauma. This is one area where initial publications raised concerns regarding the safety of laparoscopy in trauma (17). Part of this thesis suggests that a structured and systematic approach that should be used every time diagnostic laparoscopy is performed, as a solution in minimizing the chance of missed injuries (23). The work by Kawahara also suggested a systematic

approach to laparoscopic examination of the intraperitoneal organs (24). However, the work of Kawahara and colleagues raised some questions concerning the blind spots, which are the splenic flexure, retro-peritoneum and the bare area of the liver (24).

This thesis addresses these specific questions of blind spots by suggesting mobilization of the abdominal structures at risk so as to see them clearly (23). The splenic flexure should be adequately mobilized in order to be able to detect any injuries. The liver should be mobilized to access the bare area. The duodenum and the hepatic flexure should be adequately mobilised to see the retroperitoneum adequately. The prerequisite for successful laparoscopic exploration is good proficiency and dexterity in laparoscopy. We conclude in this work that diagnostic laparoscopy for trauma can be performed safely (23). We are of the view that diagnostic laparoscopy should be used in a similar context as FAST for purposes of diagnosis of abdominal trauma. This approach has potential to minimize the chances of missed injuries in equivocal clinical cases (23).

Laparoscopic-assisted technique in trauma: an underutilized technique

The management of multiple injuries, especially from penetrating injuries, can pose significant challenges that can significantly prolong the laparoscopic procedure. The laparoscopic-assisted technique is widely used in other areas of laparoscopic surgery such as colorectal surgery. The rationale is that by using a small access port, the surgeon is able to exteriorize and extracorporeally examine hollow viscera to complement the laparoscopic exploration. It gives the surgeon the best of both worlds, namely the laparoscopic option and the tactile feel of open surgery. In the end, the patient still gets the benefits of minimal access surgery. The above technique is not widely used in the setting of trauma. The thesis describes this technique in the setting of trauma and demonstrates its feasibility and safety in a pilot study. Furthermore, the technique was validated in another study with greater numbers. It is feasible and safe to use a laparoscopic-assisted technique as a solution to multiple injuries (21).

This work concludes that in multiple injuries, the laparoscopic assisted technique should be the preferred technique. It is safe, effective and it shortens the operative time whilst transferring the benefit of minimal access surgery to the patient.

The role of laparoscopy in penetrating thoraco-abdominal injuries

The management of thoraco-abdominal injuries has always posed a significant challenge to the trauma surgeon in that these injuries involve two cavities and the diaphragm. Many publications, including the South African work by Mjoli and colleagues, addressed the role of laparoscopy in detecting left diaphragmatic injuries in hemodynamically stable patients. The study by Mjoli et al. excluded patients with peritonitis and those with right-sided diaphragmatic injuries (25). The work in this thesis included patients with both left and right potential diaphragmatic injuries as well as patients with peritonitis. This work showed that laparoscopy is feasible and safe even in this cohort of patients (6). The critical prerequisite is laparoscopic dexterity. The study in this thesis concludes that the management of penetrating thoraco-abdominal injuries on both sides is safe and feasible in hemodynamically stable patients, even in the setting of peritonitis (6).

Laparoscopy in retroperitoneal injuries

Retroperitoneal injuries are, by their nature, challenging in many ways. Firstly, they are often difficult to diagnose and can present with subtle clinical signs. Secondly, the patient's abdomen can be clinically benign even in the presence of significant retroperitoneal injuries. Thirdly, repairing these injuries can be difficult, because of access and the presence of large vessels with the ever-present threat of exsanguination. There is a lack of publications in this area because there is very little work that looks at the role of laparoscopic management of these injuries. The retroperitoneal injury study in this thesis showed that it is possible to manage these injuries laparoscopically (7). The study showed that a number of patients with retroperitoneal injuries were successfully managed laparoscopically. The conversion rate to open operation was 19.6% in retroperitoneal trauma in comparison to our conversion rate of 11.7% with other penetrating injuries. The main reason for conversion was bleeding.

This work showed that, whilst it is technically demanding to manage retroperitoneal injuries laparoscopically, it is feasible provided that the attending surgeon has the requisite laparoscopic skills and a low threshold to convert to open surgery when the need arises. The tried and tested principles of trauma care still apply in this cohort of

patients. The CT scan is still critical in the evaluation of the stable patients and central hematomas should still be managed by the open approach with prior inflow control of the major vessels to prevent catastrophic haemorrhage.

There are challenges in the management of duodenal and pancreatic injuries. With regard to pancreatic injuries we still apply the traditional principle that injuries to the head of the pancreas should be managed with drainage alone unless there is destructive injury that may necessitate a pancreaticoduodenectomy procedure and we would consider resection of the tail if it is involved. Prior imaging is critical in the evaluation of the integrity of the pancreatic duct. Simple injuries of the tail that do not involve the main pancreatic duct would be managed with simple drainage, and where the need arises we would consider laparoscopic distal pancreatectomy. Duodenal injuries pose another significant challenge; it is critical that good exposure is achieved and thorough mobilization of the duodenum and pancreas is accomplished. The repair must be done in a meticulous manner to avoid catastrophic leaks. This study shows the management of retroperitoneal injuries with laparoscopy is feasible and can be achieved with satisfactory results.

Despite the inherent difficulties of laparoscopic management of retroperitoneal injuries, the results of this study showed that therapeutic laparoscopy could be achieved in 36% of these patients and there were no missed injuries or mortality in the series. We concluded that laparoscopy is feasible and safe in managing penetrating retroperitoneal injuries in hemodynamically stable patients provided the surgeon has the necessary dexterity and skills.

Laparoscopy in blunt trauma

Blunt abdominal trauma poses different challenges to that of penetrating injuries. Firstly, a number of these patients can be managed non-operatively. The CT scan is the cornerstone in the initial management of these patients as it assists in selecting patients that can be managed non-operatively. It also helps to plan the surgical approach (26). The management of the central hematoma is a special challenge. Once this is detected on CT imaging, the necessary resources and expertise should be mobilised and these patients should be managed by open operation and not laparoscopy. The appropriate approach would be to get inflow control of the abdominal aorta at the hiatus before

exploring the central hematoma. These are potentially lethal injuries and laparoscopy is contraindicated.

The second challenge is that the magnitude of the energy that causes these injuries may be much higher than in penetrating injuries and therefore the management of these injuries is much more involved and complex. While most investigators agree that the CT scan is critical in the evaluation and management of these injuries, the detection of hollow visceral injuries becomes the Achilles heel of a CT scan. The advent of multidetector CT scan has gone a long way towards resolving the concern of the detection of hollow viscus injury. It has considerably increased the accuracy of the diagnostic yield for hollow viscus injury.

The traditional use of Focused Assessment of Sonography in Trauma (FAST) has been widely used because it is non-invasive and is widely available. Apart from the fact that it is operator dependent, it cannot distinguish between blood and intestinal contents. For this reason, laparoscopy may be valuable in this situation. The study on laparoscopy in blunt abdominal trauma shows that laparoscopy is feasible and accurate in the setting of blunt abdominal trauma (27).

This thesis has demonstrated that therapeutic laparoscopy can be achieved in 56% of the patients and diagnostic laparoscopy was feasible in 44% of the patients. The conversion rate was 23% which was almost double that reported earlier in our series on penetrating trauma (28). The reason for this is the severity of the injuries encountered in this group of patients is certainly higher than that in penetrating injury patients. This work further demonstrates that laparoscopy in blunt trauma is feasible and safe; it also demonstrates a considerably high conversion rate. This work concluded that laparoscopy is feasible and safe in the setting of blunt abdominal trauma provided that the surgeon is proficient in laparoscopic surgery.

In Conclusion

This work demonstrates the utility, safety and role of laparoscopic surgery in various scenarios of trauma. It demonstrates that laparoscopy can be applied safely and effectively, provided that the attending surgeon has enough dexterity and skills to tackle various complexities of laparoscopy in trauma. Very importantly, the established principles of trauma management still apply and no shortcuts should be taken when managing trauma patients.

Patient selection is key and hemodynamically unstable patients should be excluded from the laparoscopic approach. The impact of this work has changed our own institutional practice and our suggestion is that all hemodynamically stable patients with abdominal stab wounds should be offered laparoscopy from the beginning. The practice of trauma laparoscopy at least for hemodynamically stable patients with stab abdomen wounds is now slowly gaining traction in South Africa (18). Indeed, in many parts of the world laparoscopy in trauma is becoming more accepted. The overriding consideration is the patient's hemodynamic stability. The team, which includes the surgeon, the anaesthetist and the nursing sister, plays a key role in the successful outcomes.

The approach and views of other surgeons that initially opposed laparoscopy has changed over the years, including Ivatury et al. who published a high incidence of missed small bowel injuries during laparoscopy. It is noteworthy that these investigators are now suggesting that laparoscopy is an option in carefully selected trauma patients (29). In their publication involving 510 patients (316 stabs and 194 gunshot wounds), these authors demonstrated that laparotomy was avoided in 277 of the 510 patients (54.3%). The authors concluded that laparoscopy has an important diagnostic role in stable patients with penetrating trauma.

The novelty and contribution of this work to the general body of knowledge

Laparoscopy is the new surgical revolution that has transformed the surgical landscape of many areas of surgery. This ranges from a number of elective as well as emergency surgical procedures. The benefits of laparoscopic surgery include less post op pain, faster post-operative recovery, early return to work and better cosmesis. However, the role of laparoscopy in trauma has been frowned upon world-wide and indeed in South Africa. This was after initial studies in the early 1990s had showed high rate of missed small bowel injuries. The novelty of this work is that it shows that laparoscopy is safe in a variety of trauma setting. This thesis proposes a laparoscopic management pathway of trauma patients. This work is topical and uses leading edge technology.

The success of laparoscopy in the management of thoraco-abdominal injuries challenges existing dogma. The accepted approach was to offer laparoscopy in this cohort of patients as a diagnostic tool to pick up diaphragmatic injures. This thesis suggests a more comprehensive strategy which considers the left and right sided injuries as well as patients with generalized peritonitis. This work demonstrated that in the context of right sided thoracic-abdominal injuries, and those patients with peritonitis, management by laparoscopy is safe. This is different management pathway as it suggests a reappraisal of the existing management strategies of thoraco-abdominal injuries.

The role of laparoscopy in the management of retroperitoneal injuries in hemodynamically stable patients has always been difficult. This thesis has demonstrated that this cohort of patients, with complex retroperitoneal injuries, can be managed successfully with the laparoscope. This work demonstrates a slightly higher conversion rate compared to that with penetrating abdominal trauma. This work, as far as we know, is the first attempt to define the role and safety of laparoscopy in the setting of retroperitoneal injuries. This approach is a departure from what many investigators have stated in various publications, namely that laparoscopy is contraindicated in retroperitoneal injuries. What is evident is that retroperitoneal injuries constitute a spectrum of different injuries from simple to the most complex injuries that may be life

threatening. The key is to identify those that pose a potential threat to life and promptly convert them to open operation and only deal with those that are less complex. The threshold to convert must be very low to avoid mortality.

The role of laparoscopy is relevant in the diagnosis and reduction in the rate of missed injuries in this cohort of patients. The trauma surgeon community comes from the era where there was an 80% missed small bowel injury rate when using laparoscopy. Kawahara and colleagues suggested a systematic examination of the abdomen during laparoscopy to minimize the risk of missed injuries. This was a significant contribution as it resulted in fewer missed injuries. However, Kawahara and colleagues pointed out that there were the so-called blind spots which necessitated a conversion during diagnostic laparoscopy, such as the splenic flexure and the posterior segment of the liver. This question has been addressed by our suggestion that it is safe to approach these patients totally laparoscopically, including attention being paid to the blind spots as identified by Kawahara.

Laparoscopy in blunt trauma is another challenging endeavour. It is largely due to the fact that these injuries result in a far more severe hemodynamic and physiological derangement. The reason for this is that these injuries result from much more severe trauma compared to penetrating ones.

The thesis addressed the issue of access to the abdominal cavity and demonstrated that when using the major complications as the endpoint, there was no difference at all between the use of the Veress needle and the Hasson approach. There was, however, a trend towards a higher rate of minor complications after the Veress needle approach.

Laparoscopy in multiple abdominal organ injuries poses challenges in terms of how fast these injuries can be managed in a reasonable operating time. This work showed the feasibility and utility of using the laparoscopic-assisted technique as a solution to management of multiple injuries. The patient can still benefit from the advantages of laparoscopy by a small assisted incision and a much reduced operation time. The reluctance by trauma surgeons to fully embrace laparoscopy as an interventional strategy in trauma can be addressed by improving the technical dexterity and proficiency to adequately manage these patients. We suggested the laparoscopic-

assisted technique can compensate the lack of advanced laparoscopic skills and provide benefits of minimally invasive surgery in the trauma setting.

The strength of the study

The study looks at several aspects of the laparoscopic management of trauma patients (n=389) over a four-year period, at a dedicated tertiary trauma centre in an academic hospital in South Africa. The patient sample reflects the population that can be found in a tertiary setting in South Africa. Patients were managed by surgeons with varying levels of laparoscopic experience which reflects what truly happens in a South African environment. The questions asked concerning access technique were addressed in a randomized control trial. There is broad coverage of different aspects of trauma in this thesis.

Weakness of the study

This is a single-institution study where there is a bias in favour of laparoscopy for a variety of indications including non-trauma. The majority of procedures at this institution are done laparoscopically. In some of the papers, the sample number may be considered too small to draw firm conclusions from, but they provide a definite trend in the utilization of laparoscopy in trauma.

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APPENDICES

Appendix 1. Concept sheet

Appendix 2. Postgraduate and ethics approval

Appendix 3. Protocol

APPENDIX 1

CONCEPT SHEET



UNIVERSITY OF KWAZULU NATAL

COLLEGE OF HEALTH SCIENCES

NELSON R MANDELA SCHOOL OF MEDICINE

CONCEPT SHEET

FOR MMEDSC & PHD APPLICANTS

Surname	Koto
First Name	Modise Zacharia
Student number	
Department	Surgery
Supervisor	Prof Colleen Aldous and Prof T Madiba
Title of study	
Novel contributions anticipated from this research	Laparoscopy has become entrenched in elective surgery for both diagnostic and therapeutic purposes. However, it is not well-established in trauma surgery. This research is expected to bring to light this new application of laparoscopy in diagnosing and treating trauma patients, and also in training surgeons in the technique. This research has the potential to change practice in trauma surgery.
Statement of purpose	The purpose of this series of descriptive studies is to evaluate the utility and role of laparoscopy as a diagnostic, therapeutic and teaching tool in trauma patients . The central focus of the study will be on the outcomes of patients with trauma treated laparoscopically. For the diagnostic and therapeutic studies this will include all patients with both penetrating and blunt trauma who are hemodynamically stable presenting at Dr George Mukhari Academic hospital from November 2011 to December 2017. In this study we will evaluate the utility of laparoscopy both as a therapeutic and a

	teaching tool
Aim of study (What you are going to do)	The aim of the study is to look at the role laparoscopy as a diagnostic and therapeutic tool in trauma patients. In addition it will investigate the usefulness of laparoscopic surgery in trauma as a teaching tool in improving skills and dexterity in minimal access surgery amongst surgeons.
Objectives (How you are going to do it)	<p>The study will take a format of peer reviewed publications in various areas of laparoscopy.</p> <ol style="list-style-type: none"> 1. In order to report on the diagnostic and therapeutic potential of laparoscopy in trauma surgery, study objectives will be undertaken to describe: <ol style="list-style-type: none"> 1.1 the role of laparoscopy in Thoraco-abdominal injuries 1.2 the role of laparoscopy in blunt trauma 1.3 the role of laparoscopy in retroperitoneal injuries 1.4 the role of laparoscopy as a diagnostic tool and how to reduce the incidence of missed injuries 1.5 the role of laparoscopic assisted technique as a tool in managing complex in multiple bowel injuries. 1.6 The comparison of Veres needle and open Hasson as a randomised control trial 2. The study will also evaluate the utility of laparoscopy-assisted surgery in penetrating trauma
Summary of Research Proposal (Max 500 words)	<p>There are few major revolutions that have impacted on the medical fraternity with more forcefully than minimal access surgery. To say that minimal access surgery has changed the way surgery is performed across the world is an understatement. The benefits to patients include reduced hospital stay, quicker recovery, less operative pain, early return to normal activity, and cosmesis amongst others. There are several well-established procedures where it is now considered standard of care to operate on these patients laparoscopically, with an increasing number of procedures being added to the list.</p> <p>The role of laparoscopy in trauma management is still clouded in controversy, especially when it comes to its therapeutic role. Our unit has pioneered laparoscopy in trauma as a therapeutic tool over and above its well-established role in elective surgery. This is potentially a practice-changing and innovative strategy. The well-established benefits of minimal access surgery will though this study be extended trauma patients and such a strategy will be innovative.</p> <p>The Achilles heel of embracing the minimal accesses technique is the long learning curve and difficulty in overcoming it for training surgeons. There has not yet been an adequate definition of what a learning curve is and what constitutes an adequate learning curve in laparoscopic surgery. The question of whether looking at numbers alone will suffice in addressing the learning curve has not been adequately addressed in the literature and the role of laparoscopy in trauma as a training tool has not been evaluated.</p> <p>This study aims to evaluate the role of laparoscopy as both a diagnostic and therapeutic tool as well as a training tool in trauma patients. It will take a</p>

	series of publications that will look at the role of laparoscopy in various scenarios. The endpoints of each publication will be outcomes (morbidity, mortality, hospital stay, conversion rate, re-intervention rate, readmission rate). The study will also look at the impact of trauma laparoscopy in dexterity training in laparoscopy in general (will look at how exposure to laparoscopy in trauma impacts on performance on other types of elective procedures)
Key References (max 5)	<p>References</p> <ol style="list-style-type: none"> 1. Mada AK, Frantzides CT, Prospective randomized controlled trial of laparoscopic trainers for basic laparoscopic skills acquisition. Surg Endosc 2007 21:2 pg 209-13 2. Leon Morgenstern , Warning ! Dangerous curve head: the Learning Curve; Surgical Innovation, 2005; 101-103 3. Cushieri A. Whither minimal access surgery: Tribulations and Expectations Am J.Surg 1995: 169:9-19. 4. Schlachta CM, Mamazza J, Seshadri PA Cadeddu M, Gregoire R, Poulin EC. Defining a learning curve for laparoscopic colorectal resection. Dis Colon Rectum 2001 44(2):217- 22 5. Perino A, Cucinella G, Venezia R, Castelli A, Cittadini E. Total Laparoscopic hysterectomy versus total abdominal hysterectomy: an assessment of the learning curve in a prospective randomized study. Human Rep 1999 14:12 2996-2999

Signed by applicant: MZ Koto

Date:

20/02/2016

Signed by proposed supervisor: _____

Date: _____

Signed by proposed co-supervisor: _____

Date: _____

APPENDIX 2

ETHICS APPROVAL



Office of the Director Clinical Services
Directories: Dr. PMT Mabusela
tel: (011) 579 3360
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email: philip.mabusela@eastcape.gov.za
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To : Dr OY Matsewych
Department of General Surgery
Setako Makgatho Health Sciences University
Private Bag x 63
MEDUNSA
0204

Date : 04 September 2015

PERMISSION TO CONDUCT RESEARCH

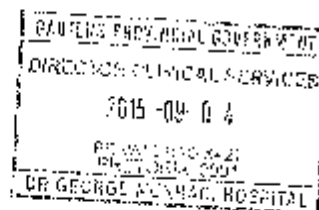
The Dr. George Mukhari Hospital hereby grants you permission to conduct research on " A retrospective audit of diagnostics and therapeutic laparoscopy in patient with abdominal trauma" at the Dr. George Mukhari Hospital."

This permission is granted subject to the following conditions:

- That you obtain Ethical Clearance from the Human Research Ethics Committee of the relevant University
- That the Hospital incurs no cost in the course of your research
- That access to the staff and patients at the Dr George Mukhari Hospital will not interrupt the daily provision of services.
- That prior to conducting the research you will liaise with the supervisors of the relevant sections to introduce yourself (with this letter) and to make arrangements with them in a manner that is convenient to the sections.

Yours sincerely


DR PMT MABUSELA
DIRECTOR: CLINICAL SERVICES



Dr George Mukhari Academic Hospital
Medunsa Drive
PRETORIA
0001

Private Bag X422
PRETORIA
0001



UNIVERSITY OF
KWAZULU-NATAL

INYUVESI
YAKWAZULU-NATALI

RESEARCH OFFICE
BIOMEDICAL RESEARCH ETHICS ADMINISTRATION
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4000

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Tel : 27 31 2604769 - Fax: 27 31 260-4609
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Website: <http://research.ukzn.ac.za/ResearchEthics/BiomedicalResearchEthics.aspx>

06 March 2017

Prof MZ Koto (922409972)
Department of Surgery
Sefako Makgatho Sciences University
MEDUNSA
0204
Mathilda.Howard@smu.ac.za

Dear Prof Koto

Re: Request for Reciprocity
Study Title: "Revisiting the critical role of minimal invasive surgery (laparoscopy) in the management of trauma patients at a dedicated trauma unit at the George Mukhari Academic Hospital Pretoria, South Africa".
Degree: PhD
BREC REF NO: RECIPO93/17

I wish to advise that your letter dated 06 February 2017 to the Chair of the Biomedical Research Ethics Committee (BREC) requesting reciprocity for the above study refers.

The chair has granted reciprocity to the Sefako Makgatho Health Sciences University ethics approval (SMUREC/M/32/2016).

This approval will be noted at the next Biomedical Research Ethics Committee meeting to be held on 14 March 2017.

Yours sincerely

Professor J Tsoka-Gwegweni
Chair: Biomedical Research Ethics Committee



**Sefako Makgatho Health Sciences University
Research & Postgraduate Studies Directorate
Sefako Makgatho University Research Ethics Committee
(SMUREC)**

Molotlegi Street, Ga-Rankuwa 0208
Tel: (012) 521 5617/3698 | fax: (012) 521 3749
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P.O. Box 163 Medunsa 0204

APPROVAL NOTICE - NEW APPLICATION

04 February 2016

Dr OY Matsevych
Department of General Surgery
P.O Box 231
Medunsa, 0204

MEETING: 01/2016
SMUREC Ethics Reference Number: SMUREC/M/32/2016: IR

The New Application received on 06 November 2015, was reviewed by members of Sefako Makgatho University Research Ethics Committee 04 February 2016 and was approved on 04 February 2016.

Title: An audit of the outcome of diagnostic and therapeutic laparoscopy in patients with abdominal trauma at Dr George Mukhari Academic Hospital, Pretoria, South Africa

Researcher: Dr OY Matsevych
Co-worker: Prof MZ Koto
Hospital Superintendent: Dr S Mogotsi (DGMAH)
Department: General Surgery
School: Medicine
Research Type: Independent Research

Please note the following information about your approved research protocol:

Protocol Approval Period: 04 February 2016 – 04 February 2017

Please remember to use your protocol number (SMUREC/M/32/2016: IR) on any documents or correspondence with the REC concerning your research protocol.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modification, or monitor the conduct of your research and the consent process.

After Ethical Review: Please note a template of the progress report is obtainable in the Research Office and should be submitted to the Committee before the year has expired. The Committee will then consider the continuation of the project for a further year (if necessary). Annually a number of projects may be selected randomly for an external audit. Translation of the consent document in the language applicable to the study participants should be submitted.

International Organisation (IORG0004319), Institutional Review Board (IRB00005122), Federal Wide Assurance (FWA00009419)
Expiry date: 11 October 2016 and NHREC No: REC 210408-003

Sincerely

DR C BAKER
DEPUTY CHAIRPERSON SMUREC



**Sefako Makgatho Health Sciences University
Research & Postgraduate Studies Directorate
Sefako Makgatho University Research Ethics Committee
(SMUREC)**

Molotlegi Street, Ga-Rankuwa 0208
Tel: (012) 521 5617/3698 fax: (012) 521 3749
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P.O. Box 163 Medunsa 0204

AMENDMENTS APPROVAL NOTICE

03 November 2016

Dr CY Malsewych
Department of General Surgery
P.O Box 231
Medunsa, 0204

MEETING: 01/2016
09/2016

SMUREC Ethics Reference Number: SMUREC/M/32/2016: IR

The New Application received on 06 November 2015 was reviewed by members of Sefako Makgatho University Research Ethics Committee 04 February 2016 and was approved on 04 February 2016.

On the 03 November 2016 SMUREC approved an extension of database period to 2012-2017 on the following protocol:

Title: An audit of the outcome of diagnostic and therapeutic laparoscopy in patients with abdominal trauma at Dr George Mukhari Academic Hospital, Pretoria, South Africa
Researcher: Dr CY Malsewych
Co-worker: Prof MZ Koto
Hospital Superintendent: Dr S Mogotsi (DSMAH)
Department: General Surgery
School: Medicine
Research Type: Independent Research

Please note the following information about your approved research protocol:


Protocol Approval Period: 04 February 2017 – 04 February 2018

Please remember to use your protocol number (SMUREC/M/32/2016: IR) on any documents or correspondence with the REC concerning your research protocol. Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modification, or monitor the conduct of your research and the consent process.

After Ethical Review: Please note a template of the progress report is obtainable in the Research Office and should be submitted to the Committee before the year has expired. The Committee will then consider the continuation of the project for a further year (if necessary). Annually a number of projects may be selected randomly for an external audit. Translation of the consent document in the language applicable to the study participants should be submitted.

International Organisation (IORG0008891), Institutional Review Board (IRB00010398) Expiry date: 09 December 2016, Federal Wide Assurance (FWA000023043) Expiry date: 31 August 2017 and NHREC No: REC 210408-003

Sincerely


PROF GA UGURBANJO
CHAIRPERSON-SMUREC



**SEFAKO MAKGATHO
HEALTH SCIENCES UNIVERSITY**
SMU Research Ethics Committee
Chairperson
Date: 03/11/2016

APPENDIX 3

STUDY PROTOCOL

University of KwaZulu-Natal
College of Health Sciences
School of Clinical Medicine

Title “Revisiting the critical role of minimal invasive surgery (laparoscopy) in the management of trauma patients at a dedicated trauma unit at the George Mukhari Academic Hospital Pretoria, South Africa.”

Degree: Doctor of Philosophy in Surgery (PhD)

Principal Investigator: Modise Zacharia Koto

Contact details:

Address: 12 Piet Myburgh Street, Meyersdal, Alberton, South Africa

Tel:±2712 5214150

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E-mail:zachkoto@gmail.com

Supervisor : Prof Colleen Aldous

E-mail address:Aldousc@ukzn.ac.za 1

Co-supervisor: Prof Thandinkosi Madiba

E-mail address :madiba@ukzn.ac.za

Executive summary

Laparoscopic surgery has had a very profound impact on the way surgical patients are managed. There has been phenomenal growth of laparoscopy in various facets of surgery and indeed many procedures are now managed using laparoscopy as a standard of care, including complex operations such as pancreatoduodenectomy. The sea- change that has taken place I other areas of surgery have not been matched by equal advancement I the arena of trauma

The reluctance of trauma surgeons to embrace laparoscopy in trauma was largely influenced by early publications that decried the very high incidence of missed injuries, particularly the small bowel. Significant strides have been made since that fateful pare that demonstrated a very high incidence of missed injuries.

The reluctance of trauma surgeons to embrace laparoscopy as an intervention has been largely due to high demand in psychomotor skills.

The purpose of this study is to look at the role and safety of laparoscopy in various setting s of trauma.

The study will look at the role of laparoscopy in thoraco-abdominal injuries.

The study will also look at the role and safety of laparoscopy in retroperitoneal injuries

The study will also look at the role of laparoscope in blunt abdomen injuries.

We will look at the role of laparoscopy as a diagnostic tool and how it can be used to reduce the rate of missed injuries

The study will also look at the safe methods of abdominal access during laparoscopy given the high incidence of tuberculosis in South Africa

The various aspect as outline will be investigated as separate objectives and each aspect will form a basis for a publication

The work will be done by publications into the various aspects trauma

Statement of purpose

This purpose of this cross sectional study was to describe the utility of laparoscopic surgery in the management of hemodynamically stable trauma patients admitted a dedicated trauma centre of the Dr. George Mukhari Academic hospital.

laparoscopic surgery has now become the standard of care in an increasing number of surgical procedures. Its role however in trauma has always been shrouded in controversy since the initial publications that demonstrated an alarming rate of missed small bowel injuries.

Defining the research problem

Laparoscopic surgery has had a profound impact the way surgery is practiced around the world. Many procedures are today done laparoscopically as a standard of care. The catalyst procedure around which many laparoscopic procedures unfolded was the laparoscopic cholecystectomy. There has been accelerated development in the areas of laparoscopy except in trauma. Fundamentally there has been slow uptake of laparoscopic intervention in trauma due to a number of reasons chief amongst which was skill acquisition. The benefits of laparoscopic surgery are well articulated in various publications and just to mention a few, shorter hospital stay, less post-operative pain, early return to work, better cosmesis and overall better economic outlook at a national scale.

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The early publication by Ivatury and colleagues looking at the role of laparoscopy on penetrating trauma did not help matters as these investigators demonstrated a very high rate of missed small bowel injuries when utilizing laparoscopy. This was a serious setback for laparoscopy as an intervention in a trauma setting. The trauma community issued a very strong caution against the use of laparoscopy in the trauma cohort of patients. In some units, the use of laparoscopy was barred because of the real fear of misused injuries. It is important to state that the publication by Ivatury and colleagues was more than two decades ago and lot has improved since that work was published.

The skill set in laparoscopy has improved significantly over time and much more complex surgical procedures are done laparoscopically. There are now well-established programs for skill training in laparoscopy whose efficacy is well established. The improvement in optics has been phenomenal and we have moved from single chip camera to double chip camera to high definition camera systems and now we have 4k which is ultra-high definition camera system.

The visuals have improved several folds, in fact you see several times better out a laparoscopy than you would with a naked eye. That said, with all the stated benefits of laparoscopy in general, it would be prudent to revisit this notion that laparoscopy is dangerous in a trauma setting. The key question is whether or not it can be done safely in the trauma setting.

There have been several publications looking at laparoscopy in a trauma setting since the work by Ivatury demonstrated and colleagues. These early papers demonstrated the safety and accuracy of laparoscopy in trauma patients and demonstrated that it reduces the incidence of negative laparotomy in these patients. However, their published data has excluded a number of trauma scenarios where it would not be prudent to use laparoscopy. There is a dearth of published knowledge in those scenarios.

The purpose of this work was to critical review the role of laparoscopy in managing hemodynamically stable trauma patients in a variety of settings and establish a new paradigm in the usage of laparoscopy in trauma.

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AIM

The purpose of this work was to critical review the role of laparoscopy in managing hemodynamically stable trauma patients in a variety of settings and establish a new paradigm in the usage of laparoscopy in trauma

The impact of this project in the community is huge in the sense the it will influence management decision in trauma patients. This will enable the decision to offer trauma patients laparoscopy with its attended huge potential benefits. Of minimal access surgery. This will have huge potential benefit to patients

THE PROTOCOL

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1. DEFINING THE RESEARCH PROBLEM

Laparoscopic surgery has had a profound impact the way surgery is practiced around the world. Many procedures are today done laparoscopically as a standard of care. The catalyst procedure around which many laparoscopic procedures unfolded was the laparoscopic cholecystectomy. There has been accelerated development in the areas of laparoscopy except in trauma. Fundamentally there has been slow uptake of laparoscopic intervention in trauma due to a number of reasons chief amongst which was skill acquisition. The benefits of laparoscopic surgery are well articulated in various publications and just to mention a few, shorter hospital stay, less post-operative pain, early return to work, better cosmesis and overall better economic outlook at a national scale.

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The purpose of this work was to critical review the role laparoscopy in managing hemodynamically stable trauma patients in a variety of settings and establish a new paradigm in the usage of laparoscopy in trauma

LITERATURE OVERVIEW AND MOTIVATION

Laparoscopy dates as far back as 400BC. The first laparoscopy account was narrated by in the 1900. To say that laparoscopy has changed the way we manage patients is an understatement. It has completely revolutionized the way we manage patients. there has been phenomenal growth in the number of procedures that are done laparoscopically. Many procedures that were traditionally done by open surgery are now done laparoscopically as standard of care. The benefit of laparoscopy is well known and include short hospital stay, less post-operative pain, early recovery, better cosmesis, and early return to work.(Mahajna, Mitkal, Bahuth, & Krausz, 2004)(Uranues, Popa, Diaconescu, & Schrittwieser, 2015)(Uranüs & Dorr, 2010)

The progress in the field of laparoscopy has continued unabated and more complex procedure are now done safely laparoscopically. The reason to this relentless progress has been attributed to the development in skill set and the advancement of technology(Lim, Chung, Kim, & Kim, 2015). Not-withstanding this tide of progress in laparoscopic surgery, one cannot help it but notice that there has been a serious lack of progress in the arena of trauma. There is a distinct lack of progress in the manner in which trauma has lacked behind in the arena of trauma.

It is important to note what triggered this lethargic approach to laparoscopic in trauma. One of the early publications that showed a very high missed injury rate particularly small bowel injury (Ivatury, Simon, & Stahl, 1993). This early work by Ivatury and colleagues demonstrated an 80% missed small bowel injury rate from penetrating abdominal injuries (Ivatury et al., 1993). This paper cause serious consternation in the surgical trauma world. Laparoscopy as a

minimalist intervention was banished in many trauma units around the world. A lot has happened since the water hit the shore. It is important to reflect on some of the key changes that took place since this happened a while back (Lim et al., 2015). It is key to note that this paper was published in the early 1990s. laparoscopy as a new interventional strategy was still at its infancy at the time. There were developed training programs and many laparoscopists were self-taught at the time.

Many surgeons were doing laparoscopic cholecystectomy and other elective procedures such as Nissan fundoplication and colon resection. The skill set of no-trauma surgeons were kept abreast (Gould & Philip, 2014). There was minimal laparoscopic surgery performed by trauma surgeons and it is not surprising that many trauma surgeons find the field of laparoscopy an uncharted territory and a very daunting experience. It is not surprising therefore that the results of laparoscopy performed by trauma surgeon has been less than satisfactory (Lim et al., 2015). It would be remiss of us to blame the laparoscopic intervention without delving on the cause of this less than ideal outcome. The issue is really about skills than anything else and nor on the laparoscopic procedure itself.

Laparoscopy and its tools of the trade has fundamentally improved in the last few decades. We have now moved from a single chip camera to a double chip camera and high definition camera system and now we are talking about the ultra-high definition system. All these developments have translated into an incredibly high-quality visual. It is very difficult to imagine how one would miss injuries where the visuals are more than ten times the visuals one would get with a naked eye.

Many subsequent publications have challenged this notion that laparoscopy has a high missed injury (Koto, Matsevych, & Motilall, 2015). O'Malley and colleagues in a systematic review demonstrated that laparoscopy was feasible as a diagnostic tool as well as a therapy (O'Malley, Boyle, O'Callaghan, Coffey, & Walsh, 2013). To address the fundamental concern of missed injuries raised by Ivantury et al (Ivatury et al., 1993), Kawahara et al suggested a systematic and carefully considered approach in examination technique of the abdomen (Zantut et al., 1997a). This examination technique by Kawahara and colleagues led to a significant improvement in the accuracy of diagnostic laparoscopy in trauma.

That said, Kawahara et al pointed out in their work some of the blind spots such as the splenic flexure, the bare area of segment vi and vii of the liver and the retro-peritoneum should be carefully evaluated and in some cases actually avoided in order not to miss any injuries (Zantut et al., 1997b) (Kawahara, Alster, Fujimura, Poggetti, & Birolini, 2009). We have proposed and equally a systematic examination, unlike the suggestion by Kawahara et al, we have included

these blind spot area, with the proviso of laparoscopically mobilizing these areas in order to accurately identify these injuries (in Press). It is our considered view that the surgeon should see better with laparoscopy than in open surgery due to the superior optics (high definition) obtained in laparoscopic surgery. We have suggested mobilization of the liver (falciform and triangular ligament) to see posteriorly, the full mobilization of the splenic flexure and the retro peritoneum.

In the evaluation of solid organs, laparoscopy has been shown to be very reliable (Morrison, Clasper, Gibb, & Midwinter, 2011; Parra & Reddy, 2004) (Mahajna et al., 2004). This applies to therapy as well (Stephen Smith, Fry, Morabito, Koehler, & Organ, 1995). Our data shows that liver suture is feasible and safe laparoscopically, the spleen can equally be handled very well laparoscopically, this includes laparoscopic splenectomy (Koto et al., 2015). The retroperitoneal organs can also be handled well laparoscopically this include renal trauma and pancreas injuries (in press). There was initial concern about the role and safety of laparoscopy in retroperitoneal injuries. Initial publications were not looking at retroperitoneal injuries specifically, but as a general part of the management of penetrating abdominal injuries. Our publication is one of the first to specifically address the role of laparoscopy in managing retroperitoneal injuries (in press). We demonstrated in this publication that laparoscopy is feasible, safe and accurate in addressing retroperitoneal injuries in hemodynamically stable patients (in press).

Thoracoabdominal injuries are by their very nature very challenging and difficult to treat. These injuries involve more than one cavity and the diaphragm. The diagnosis of occult diaphragmatic injuries can be very challenging even with the modern imaging modalities. Laparoscopy has been shown to be very reliable for diagnosis. Mjoli et al in their publication from Kwazulu-Natal demonstrated the safety and accuracy of laparoscopy in demonstrating left sided diaphragmatic injurie (Mjoli, Oosthuizen, Clarke, & Madiba, 2015). These authors did not look at injuries on the right-hand side and very importantly they excluded all those patients that had signs of peritonitis. We demonstrated in our publication that laparoscopy is feasible and safe in thoracoabdominal injuries even in patients with generalized peritonitis including those with right-sided thoracoabdominal injuries. In our review of 83 cases of thoraco-abdominal injuries we included all patients with thoracoabdominal injuries who were hemodynamically stable including those with peritonitis. We addressed the diaphragmatic injuries on the right as well as intra-abdominal injuries that were encountered. Our view is that diaphragmatic injuries on

the right should be repaired as these do complicate over time and patients may come with major complications and mortality in some cases.

Laparoscopy in children with trauma is also not well defined and there is emerging evidence it is safe and feasible. Our work has not focused on this cohort of patients, suffice to say that laparoscopy does have both a diagnostic and therapeutic role in hemodynamically stable paediatric patients.

Pregnant patients pose a very unique problem. The gravid uterus poses significant challenges during access with potential injury to the uterus and consequently the foetus. The pneumoperitoneum exerts pressure on the gravid uterus with the potential consequence of pre-term labour or miscarriage. The few patients that we saw in our cohorts we used very low pressures and the patient did very well with no reported foetal loss.

The practice of trauma surgery has always been viewed as the kindergarten of surgical training. This is where novice surgeons practice the art of surgery and dexterity training during the open era. The same principle holds in laparoscopic training. This is where the up and coming surgeons can learn how to operate laparoscopically. We demonstrated in our publication the utility of trauma laparoscopy in dexterity training

Laparoscopy in blunt abdominal trauma

The role of laparoscopy in blunt abdominal trauma is still evolving. Focused assessment with sonography in trauma (FAST) is a simple bedside examination of the abdomen to detect the presence of fluid. This investigation even though it is readily available, it requires skills and its operator dependent. Branney et al found that a volume of 619ml is required in order to be detected by FAST. even fluid more than this has been missed by FAST. Dolich et al found that 1,7% of patients with significant intraabdominal injuries had negative FAST. In a recent American study, the sensitivity of FAST was found to be a paltry 22% and the authors suggested that based on their results, FAST should be bypassed and the trauma surgeon should go straight to CT scan of the abdomen This tool has its role and clearly its limitations. CT scan of the abdomen is considered the corner stone of management of blunt abdominal trauma patients who are hemodynamically stable. The challenge with CT scan is its unreliability in missing hollow viscus injuries. Laparoscopy in this subgroup of patients can be very useful and help delay treatment in these patients. A delay of a very few hours in trauma can result in significant morbidity. The benefits of laparoscopy are well documented. In our series of laparoscopy in BAT 23% of the patients were converted. this is high when compared at 11,7% conversion rate for penetrating abdominal trauma. The reported conversion rate in the literature range from

8,5% to 35% depending on the selection criteria used and the expertise of the surgeon. Our conversion rate seems higher in comparison to penetrating injuries. this is a reflection of the severity of the injuries

The traditional way of managing these blunt trauma(BAT) has been around using abdominal CT Scan. The role of laparoscopy in this cohort of patients remains undefined. Heng- Fu Lai et al in their study comparing laparoscopy and open laparotomy. A total of 62 patients underwent exploratory laparotomy and 59 underwent laparoscopy. These investigators found that there was significantly shorter hospital stay (mean 11.0 days' vs 17,6 days; $p<0,001$). They also found significantly lower wound infection rate; mean 5,1% vs 16.1%; $p=.049$)

The conversion rate in the laparoscopic group to laparotomy was 8,5% and the entire cohort of patients in the laparotomy had open operation. The laparoscopic group clearly had significant advantages over their open operation counterparts. These results compare very well with our own institution. We looked at laparoscopy I blunt trauma at our own institution. Out of 318 patients that were managed laparoscopically at our institution, 35(11%) were blunt trauma patients that were hemodynamically stable and were offered laparoscopy. Eight (23%) patients were converted to therapeutic laparotomy. Twenty-seven (77%) patients were managed with laparoscopy, 15 (56%) of them underwent therapeutic intervention, while 12 (44%) patients had diagnostic laparoscopy. Laparoscopic-assisted approach was utilized for therapeutic procedures in six patients with hollow visceral injuries.

Laparoscopy in retroperitoneal injuries

Laparoscopy in retroperitoneal injuries pose a very significant challenge and hazards. The traditional way of investigating these patients that are hemodynamically stable has been to use triple contrast multi-detector CT scan. This approach allows one to detect the tract and trajectory of the injury. The findings on CT scan are often not very definitive but circumstantial and indirect. Some of the features that suggests hollow viscus are by no means specific to bowel injuries. the decision to proceed to laparotomy must always be balanced against the ever-present thread of missed hollow viscus injury including colon. Missed colon injury in the retro peritoneum potentially may results in severe necrotizing infection which in some instances can be fatal. The aggressive approach is justified in this setting. That said, laparotomy is not a necessarily benign intervention. () There is a considerable array of complications that are associated with laparotomy. Clinical assessment of these patients has always been very challenging. Many of them have minimal to no clinical signs at all during clinical examination. The practice of proceeding to open operation, once radiologic evidence of possible injury is found often leads to non-therapeutic laparotomy. In some cases, gunshot injuries, presence of

a bullet fragment may lead to the scatter phenomenon which may further reduce the reliability of CT scan to pick up retroperitoneal injuries. our work in this field has demonstrated the utility of laparoscopy in this cohort of patient (Koto et al)

The traditional approach has always been to covert these patients to open operation once retroperitoneal injuries are encountered. There is a real dearth of knowledge on the role of laparoscopy on the setting of laparoscopy I retroperitoneal injury

Even in the open operation, hematomas that are central I location poses a significant challenge of potential to exsanguinating bleed unless these are addressed carefully with inflow control at the hiatus. We entirely agree that this should be the safe approach even in laparoscopy. The ability to fully mobilize the retro-peritoneal structures is heavily dependent on the skill level of the surgeon

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3. AIM AND OBJECTIVES

Aims

The aim of this study is to show the safety and efficacy of laparoscopy surgery in the management of hemodynamically stable trauma patients admitted at the Dr George Mukhari Academic Hospital.

Objectives

To look at the optimal and safety of access during laparoscopic procedure

To look at the role of laparoscopy in the management of thoraco-abdominal injuries

To look at the role of laparoscopy in the management of blunt abdominal injuries

To look at the role of laparoscopy in the management of retroperitoneal injuries

To look at the role laparoscopic assisted procedure as a solution for multiple bowel injuries

To look at the role of laparoscopy as a diagnostic tool in trauma and how this impacts in the reduction of missed injuries

METHODS

The methods will entail a number of publications that will look specifically at the following areas using prospectively collected data

A randomized controlled one to one trial will be conducted to evaluate the which is the safest method of abdominal access during trauma laparoscopy especially in the context of a high prevalence of abdominal tuberculosis in South Africa. The results of this will be published. The work will also involve the evaluation of laparoscopy in the setting of retroperitoneal injuries. The work will include evaluation of this subset of patient with retroperitoneal injuries and specifically looking at the outcomes of these patients. This will also be published. The work will also include the role of laparoscopy in in the management of patients with blunt abdominal injuries. In this cohort of patient we will be looking at the outcomes and safety of laparoscopy in this cohort of patients. We will also look at the role of laparoscopy in the management go laparoscopy in thoraco-abdominal injuries. We will be looking at the outcomes of laparoscopy in this cohort of patients. Finally, the work will be looking at the role of laparoscopy as a diagnostic tool and how this can result in a reduction of missed injuries. All these will by form

of publications from a prospectively collected data of trauma patients admitted at the Dr George Mukhari Academic Hospital over a three -year period.

STUDY DESIGN

This will be a cross sectional study from a prospectively collected data base of trauma patients admitted at the Dr George Mukhari Academic Hospital academic hospital. There will also be a randomized controlled trial looking at the outcomes of open Hasson technique and the VERES needle as method of access

4.2. SETTING

This will be in a tertiary care centre which is a dedicated trauma care centre at the Dr. George Mukhari Academic Hospital . These will be hemodynamically stable patients

4.3. PARTICIPANT SELECTION

This will include all the hemodynamically stable trauma patients who are 18 years or older admitted at the Dr George Mukhari Academic Hospital between January 2014 and December 2016 . This will include both penetrating and blunt abdominal trauma patients admitted during the time period.

4.4. MEASUREMENTS

The primary outcome that will be measured will be mortality and the secondary outcome measure will be major complications and hospital stay

4.5. DATA ANALYSIS

Descriptive statistics will be use to describe the sample. The categorical values will be described using percentages and standard deviation and continuous values will be described using means and standard deviations

4.5.1. SAMPLE SIZE

The sample size will determined by the statistician to make the result generalizable as the work will entail different publications of different aspect of trauma defined in the study objectives . The sample size will differ on different publications that arise out of this work

5. ETHICAL CONSIDERATIONS

Ethical clearance will be obtained from the Sefako Makgatho University Ethics Committee and the University of Kwazulu-Natal Ethics committee

6. BUDGET (including Funding obtained)

Item Description	Cost
Collection of data	R10000
ANALYSIS OF DATA	15000
Stationery	5000
Statistical services	15000
Manuscripts edits	20000
Total Project Cost	R65000

7. TIME LINES AND PROJECT MANAGEMENT

Writing of protocol- 3 months

Collection of data 1 years

Analysis of data 6 months

Writing up of different articles 12 months

8. CONTRIBUTORS AND AUTHORSHIP

Name	Department	Contribution	Author acknowledgement
Colleen Aldous	Genetics	Critical review	Co-author
Oleh Matsevych	Surgery	Data analysis and write-ups	Co-author
Fusi Mosai	Surgery	Data collection and review	Co-author
Moses Balabyeki	Surgery	Data collection	Co-author
David Mashego	Surgery	Data Collection	Co-author
Zach Koto	Surgery	Study conceptualization, analysis, manuscript write-up	Author
T Sumbana	Surgery	Data collection and analysis	Author