

**Enhanced recovery after surgery (ERAS)  
in penetrating abdominal trauma**

**Dr Mahammed Riyaad Moydien**

**MBChB (UCT)**

**Student Number: MYDMAH001**

**A dissertation submitted in fulfilment of the requirements  
for the degree of Master of Medicine (Surgery)**

**University of Cape Town**

**Health Sciences Faculty**

**Groote Schuur Hospital**

**Department of Surgery**

**Supervisor**

**Professor Pradeep H Navsaria**

**MBChB (UCT) FCS (SA) MMED (Surg) (UCT) FACS**

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

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

## DECLARATION

I, Dr Mahammed Riyaad Moydien, hereby declare that the work on which this dissertation is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work or any part of it has been, is being, or is to be submitted for another degree in this or any other university.

I empower the university to reproduce for the purpose of research either the whole or any portion of the contents in any manner whatsoever.

Signature: M R Moydien

Date: 7 September 2015

## **ACKNOWLEDGEMENTS**

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

- My supervisor and mentor, Professor Pradeep Navsaria, for his constant guidance and support
- Dr Ravi Oodit, who was instrumental in developing the idea for this project
- Dr Juan Klopper, for his assistance with statistical analysis and interpretation of the data
- My wife, Faaïqa and son Yusuf for their unwavering support and encouragement

## **ABSTRACT**

### **Early recovery after surgery (ERAS) in trauma surgery: A prospective single-center pilot study**

#### **Introduction**

ERAS programmes employed in elective colorectal, vascular, urologic and orthopaedic surgery has provided strong evidence for decreased lengths of hospital stay without increase in postoperative complications.

#### **Aim**

The aim of this study was to explore the role and benefits, if any, of ERAS / ERP (early recovery programmes) implemented in patients undergoing emergency laparotomy for trauma at a level 1 trauma center.

#### **Methods**

Institutional UCT-HREC approved study. A prospective cohort of 38 consecutive patients with isolated penetrating abdominal trauma undergoing emergency laparotomy were included in the study. The ERP included: early feeding, early urinary catheter removal, early mobilisation/physiotherapy, early intravenous line removal and early optimal oral analgesia. This group was compared to a historical control group of 40 consecutive patients undergoing emergency laparotomy for penetrating abdominal trauma, prior to introduction of ERP. Demographics, mechanism of injury and injury severity scores (ISS and PATI) were determined for both groups. The primary end-points were the length of hospital stay and incidence of complications (Clavien-Dindo classification) in the 2 groups. The difference in means was tested using the t-test assuming unequal variances. Statistical significance was defined as  $p < 0.05$ .

#### **Results**

The two groups were comparable with regards to age, gender, mechanism of injury and ISS and PATI scores. The mean time to solid diet, urinary catheter removal and NGT removal was (non ERAS) 3.6 and (ERAS) 2.8 days [ $p < 0.035$ ], (non ERAS) 3.3 and (ERAS) 1.9 days [ $p < 0.00003$ ], (non ERAS) 2.1 and (ERAS) 1.2 days [ $p < 0.0042$ ], respectively. There was no difference in time from admission to time of laparotomy [(non ERAS) 313 vs. (ERAS) 358] min ( $p < 0.07$ ). There were 11 and 12 complications in the control and study group, respectively. When graded as per the Clavien-Dindo classification there was no significant difference in the 2 groups ( $p < 0.59$ ). Hospital stay was significantly shorter in the ERAS group: 5.5 (SD 1.8) days vs. 8.4 (SD 4.2) days [ $p < 0.00021$ ].

## **Conclusion**

This small pilot study shows that ERPs can be successfully implemented with significant shorter hospital stays without any increase in postoperative complications in trauma patients undergoing laparotomy for penetrating abdominal trauma. Furthermore, the study shows that ERP can also be applied to patients undergoing emergency surgery.

## **TABLE OF CONTENTS**

<b><u>INTRODUCTION AND LITERATURE REVIEW</u></b>	7
1. Introduction	7
1.1. What is ERAS	7
1.2. Principles of an ERP	7
1.3. Key elements of an ERP	8
1.4. The ERAS society	9
2. History of ERAS/ERP	9
2.1. Surgical stress	9
2.2. Pioneers of modern surgical modulation	9
3. The surgical stress response and postoperative organ dysfunction	10
3.1. Ways to reduce postoperative stress	11
4. Cost related factors	14
5. Patient related factors	17
6. ERAS in other specialities	19
7. Evidence base for protocols	21
8. Validation of ERAS	27
9. References	29
<b><u>PUBLICATION-READY MANUSCRIPT</u></b>	35
1. Title page	35
2. Abstract	36
3. Main paper	38
<b><u>STUDY APPROVALS</u></b>	50
1. Human Research Ethics Committee	50
2. UCT post-graduate administration approval	51

## INTRODUCTION AND LITERATURE REVIEW

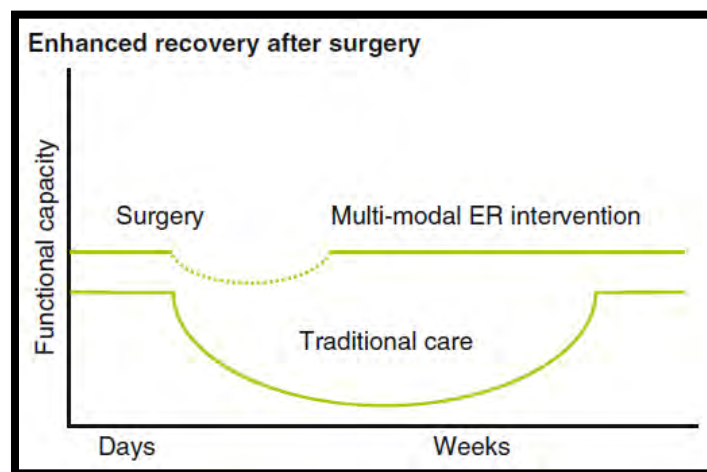
### 1. INTRODUCTION

#### 1.1 WHAT IS ERAS

ERAS or ‘enhanced recovery after surgery’ is the term coined for the perioperative protocol by which patients are treated. This perioperative treatment protocol is also referred to as an ERP or ‘early recovery program’ or ‘enhanced recovery protocol’ or FTS or ‘fast track surgery’. There are several key elements that make up any ERAS program and the principles of any such program is to modulate the surgical stress response in order enable patients to recover faster while reducing postoperative complications (1).

#### 1.2 PRINCIPLES OF AN ERP

Traditional postoperative surgical care emphasises prolonged bed rest for the patient and bowel rest for the gastrointestinal tract with acceptance of the surgical stress response. The ERAS concept aims to eliminate the surgical stress response through the application of optimal perioperative anaesthetic, analgesic and metabolic support. The focus is to maintain the patients preoperative state and promote enhanced recovery and return of function. This aims to enable patients to recover from major abdominal surgery faster, while avoiding postoperative complications and reducing healthcare costs by reducing the length of stay (1).



*Figure 1. Traditional peri-operative care results in the patient being exposed to unnecessary metabolic/nutritional debilitation resulting in a prolonged recovery interval. A multimodal ERP prevents such decline and allows the patient to recover faster. (1)*

Traditional perioperative care leads to unnecessary metabolic debilitation with a prolonged recovery period. A multimodal ERP enhances recovery with faster return to normal function.

### 1.3 KEY ELEMENTS OF AN ERP

There are several key elements that make up any ERP. These elements are diverse and varied and include a multidisciplinary team approach to patient care.

Key elements include: preadmission information and counselling, selective bowel preparation, carbohydrate loading and avoidance of preoperative fasting, avoidance of pre-anaesthetic medication, avoidance of nasogastric tubes, thoracic epidural anaesthesia, short-acting anaesthetic agents, avoidance of sodium and fluid overload, short incisions, maintenance of normothermia intraoperatively, standard early mobilization, non-opioid oral analgesia and NSAIDs, prevention of postoperative nausea and vomiting, stimulation of early gut mobility with early enteral nutrition, early removal of catheters and drains, perioperative oral nutrition and audit of compliance and outcomes (1).

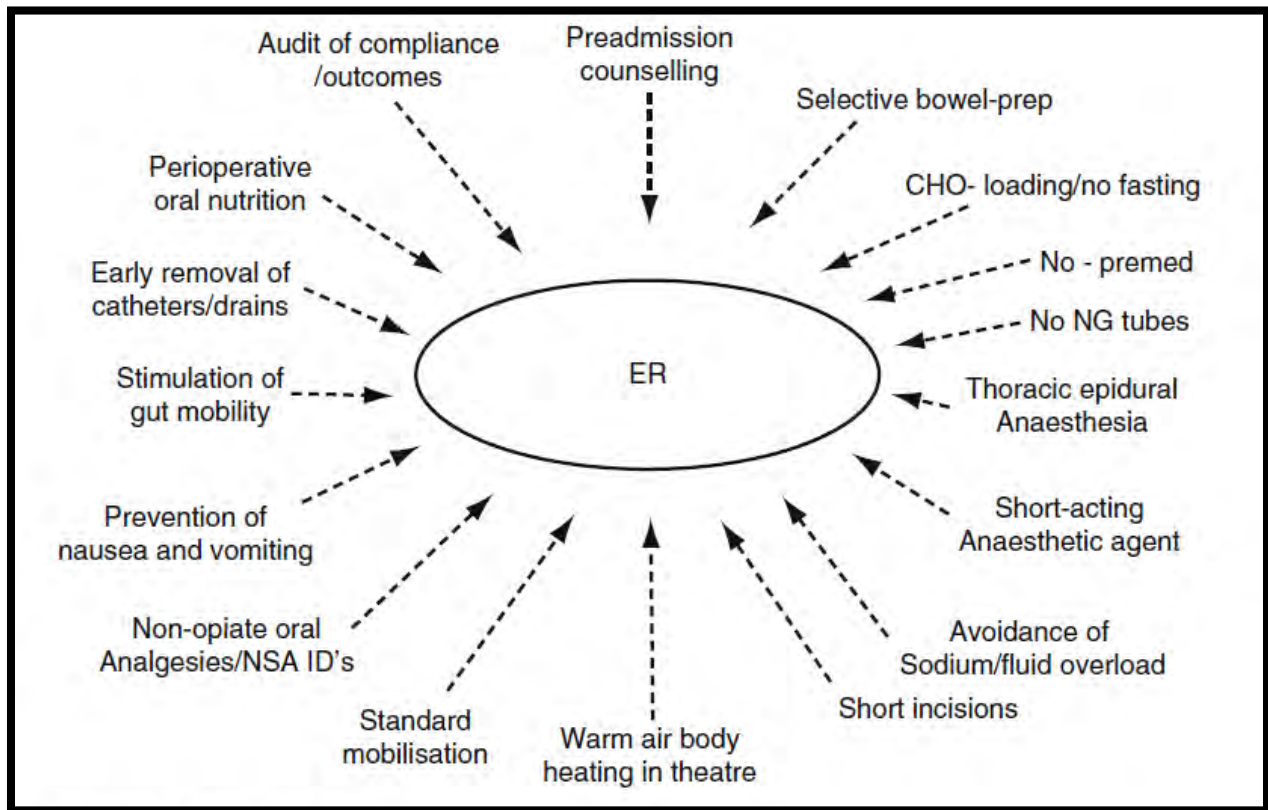


Figure 2. Elements of an enhanced recovery protocol (ERP) (1)

Not all ERPs include all of the above elements. It is the combination of elements rather than any one specific element that is important when developing and establishing any ERP. In the trauma surgery setting the ERP has to be adjusted as the preoperative period of patient preparation is absent and as such care

is focused on the immediate perioperative, intraoperative and postoperative period. Preadmission counselling, bowel preparation, carbohydrate loading, thoracic epidural anaesthesia and short incisions are not included in ‘trauma ERP’s’ as patients arrive directly from the scene. Other aspects such as avoidance of premed, nasogastric tubes, fluid overload together with intraoperative warming and early postoperative mobilization, gut stimulation, early enteral nutrition and early removal of drains are important elements in our ‘trauma ERP’ (1).

The ideal multidisciplinary team required to run a successful ERAS program include: ERAS trained nurses, dieticians, physiotherapists, occupational therapists, pain team, theatre staff, anaesthetists, surgeons, hospital management and the audit team (1).

#### **1.4 THE ERAS SOCIETY**

The ERAS group was established in 2001 as a collaborative of five university or specialised departments of surgery from five northern European countries (Scotland, Sweden, Denmark, Norway and the Netherlands). They have since produced comprehensive consensus guidelines for the perioperative management of patients undergoing colorectal resection, pancreaticoduodenectomy, gastrectomy and cystectomy (1).

### **2. HISTORY OF ERAS/ERP**

#### **2.1 SURGICAL STRESS**

Surgical stress is the result of physical injury, mechanical disruption and chemical changes that the body is exposed to during the perioperative period. The body’s response to these physiological stressors is defined by the surgical stress response. This results in stimulation of the central nervous system with activation of the hypothalamus-pituitary-adrenal axis (HPA axis) and the peripheral autonomic nervous system (PANS). These two systems elicit an integrated response, referred to as the ‘stress response’, which controls bodily functions such as cardiovascular tone, respiration, and metabolism. It also alters normal gastrointestinal activity and depresses immune/inflammatory reactions. By modifying the stress response with perioperative interventions such as early aggressive resuscitation, closure of wounds and restoring normal anatomy, draining pockets of infection and early appropriate antibiotics, providing cardiovascular, respiratory, metabolic and nutritional support we can improve outcome (2).

#### **2.2 PIONEERS OF MODERN SURGICAL MODULATION**

Modulation of the surgical stress response can improve postoperative outcomes and this can reduce postoperative morbidity and mortality. This was the impetus for change in the traditional perioperative care of patients. Early pioneers included Claude Bernard (France) and Walter Cannon (USA) who

developed the concept of the 'milieu interieur' and described the complex homeostatic responses involving the brain, nerves, heart, lungs, kidney and spleen that work to maintain body constancy respectively. Sir David Cuthbertson (UK) followed with his description of the metabolic response to injury which consisted of the ebb, flow and recovery phases and quantified the amount and likely sources of protein breakdown. Francis Moore (USA) and Douglas Wilmore (USA) were responsible for the description of the response to injury in humans and methods of optimal nutritional and metabolic support (1).

In the late nineties "the average length of hospital stay after colorectal abdominal surgery was still 10-15 days" (1). It was at this time that Henrik Kehlet (Denmark) began to investigate the reasons for prolonged hospital stay after elective abdominal surgery. He concluded that: "the key factors that keep patients in hospital after uncomplicated major abdominal surgery include the need for parenteral analgesia (because of persistent pain), intravenous fluids (because of persistent gut dysfunction), and bed rest (because of the lack of mobility)" (1).

In any patient it is often a combination of these factors that results in delayed return of normal function, not forgetting postoperative complications which may also prolong the time to full recovery and ultimately prolong the length of hospital stay.

Based on the above discoveries, Kehlet, developed a clinical pathway to accelerate recovery after major colonic resection based on "a multimodal programme with optimal pain relief, stress reduction with regional anaesthesia, early enteral nutrition and early mobilization" (1). He demonstrated improvements in physical performance, pulmonary function, body composition and a marked reduction in length of stay (1).

Since Kehlet's original published work, many different groups have published variations of his multimodal approach to perioperative care based on their own optimal 'fast-track' or enhanced recovery programmes. Other groups have achieved similar outcomes in terms of reduced length of hospital stay without increase in postoperative complications with or without epidural anaesthesia/analgesia. This would suggest that it is the combination of components rather than any single component on its own that goes to make an effective regimen (1).

### **3. THE SURGICAL STRESS RESPONSE AND POSTOPERATIVE ORGAN DYSFUNCTION:**

Surgery induces a surgical stress response proportional to the magnitude of the surgical insult. This stress response is complex and well-coordinated. It consists of an endocrine-metabolic response and an inflammatory response.

The endocrine-metabolic response can be profound, and results in changes with hypermetabolism and catabolism. The inflammatory response activates a humoral cascade that leads to malaise, hyperthermia and immunosuppression.

This surgical response, thought to be protective, is the cause of perioperative morbidity. It places undue stress on the body and puts patients at risk during the perioperative period, especially patients with pre-existing organ dysfunction (3).

In 1997, Professor H Kehlet published a paper on the multimodal approach to control postoperative pathophysiology and rehabilitation. This became a seminal paper in the field of fast track surgery and set the stage for what is now a well-established and widely practiced clinical approach to the perioperative care of patients (4).

His paper highlighted the fact that major surgery is associated with major complications. The unwanted complications of major surgery include pain, cardiovascular, pulmonary, infective, and thromboembolic complications, nausea and gastrointestinal paralysis, cerebral dysfunction, pain, fatigue and prolonged convalescence (4).

He highlighted the fact that if you were to exclude surgical and anaesthetic technical failures, the key pathogenic factor leading to postoperative morbidity was the body's natural defence mechanism, the surgical stress response; that placed an increased demand on organ function (4).

This surgical response, thought to be protective, contributes to perioperative morbidity. If amplified and prolonged, it places undue stress on the body and puts patients at risk during the perioperative period, especially patients with pre-existing organ dysfunction (4).

Studies have provided evidence for single perioperative interventions showing improved surgical morbidity. These interventions have been combined in a multimodal perioperative rehabilitation care program to optimize surgical outcome and reduce the undesirable sequelae of surgery. These programs enhance and accelerate recovery and reduce perioperative complications and overall health care costs (4).

### **3.1 WAYS TO REDUCE POSTOPERATIVE STRESS:**

Perioperative risk factors or pathophysiological responses to surgery must be recognized, avoided or treated in order to control perioperative physiology and reduce morbidity.

Various risk factors have been identified during the preoperative, intraoperative and postoperative period.

Preoperative risk factors include: concomitant disease, malnutrition, smoking and alcohol abuse.

Intraoperative risk factors include: surgical stress, blood transfusion, heat loss.

Postoperative risk factors include: pain, immunosuppression, nausea and ileus, hypoxaemia, sleep disturbances, muscle loss or catabolism, immobilization, intra-abdominal drains, urinary catheters, nasogastric tubes and surgical tradition.

#### Preoperative factors:

It is well established that patients pre-existing organ dysfunction and co-morbid disease are important predictors of increased perioperative risk and postoperative morbidity. Pre-operative optimization aims to decrease this risk and convert high risk surgical patients to moderate or low risk, thereby reducing the perioperative morbidity. Smoking, alcohol abuse and malnutrition are also well established risk factors for adverse surgical outcome and it is during this pre-operative period that these factors can be addressed (4).

#### Intraoperative factors:

The magnitude of the surgical stress response is related to the magnitude of the surgical traumatic insult. This surgical stress response leads to activation of the endocrine-metabolic and inflammatory cascade which sets off a cascade of events that lead to increased secretion of catabolic hormones, decreased secretion of anabolic hormones, hypermetabolism and increased cardiac workload, impaired pulmonary function, pain, gastrointestinal side effects with nausea and ileus, changes in coagulatory-fibrinolytic systems favouring coagulation and thrombosis, and loss of muscle tissue and immunosuppression.

Reducing the magnitude of the surgical insult can be achieved by minimally invasive surgical techniques, blocking the afferent neural stimulus by various neural block techniques such as continuous epidural analgesia, pain relief, modifying the coagulatory-thrombotic effect, pharmacologically altering the inflammatory response and limiting heat loss by using external warming devices (4).

#### Postoperative factors:

Pain attenuates organ dysfunction and delays mobilization; immunosuppression increases infective complications; nausea and ileus delays recovery and early enteral nutrition thereby enhancing catabolism; hypoxaemia increases risk for cardiac, cerebral and wound complications; sleep disturbances may increase postoperative hypoxaemia, fatigue and stress; muscle loss and catabolism increases all-over morbidity and fatigue, delaying recovery; immobilization increases the risk of thromboembolic and pulmonary complications, increases fatigue, hypoxaemia and muscle loss; and the unnecessary use of intra-abdominal drains, urinary catheters, nasogastric tubes surgical traditions all add to the delay in recovery.

The treatment modalities are thus aimed at reducing postoperative pain through effective multimodal analgesia; reducing stress by immunomodulation and avoiding unnecessary blood transfusion; avoiding postoperative nausea and vomiting by opioid sparing analgesia, use of neural blockade and pre-emptive treatment; oxygen administration; avoidance of sleep disturbances and stress reduction; early oral nutrition; active rehabilitation and avoidance of unnecessary use of drains, catheters, and tubes (4).

In 2011, almost 15 years later, Kehlet reviewed his original work on postoperative physiology and rehabilitation. By this time enhanced recovery programs had gained widespread interest and acceptance and many of the principles of fast track surgery were being employed in surgical disciplines including colorectal, orthopaedic, vascular surgery, urology and gynaecology. The combination of uni-modal evidence-based practices into a multimodal package has changed surgical practice. Aspects such as preoperative assessment, nutrition, use of tubes, drains, catheters, mechanical bowel preparation and temperature control, are all well established and evidence based principles that have shifted perioperative surgical management away from traditional surgical dogma to evidence based practice (5).

His update on physiological care principles to enhance recovery evaluated other aspects of perioperative care, such as modification of the endocrine, metabolic and inflammatory responses; haemodynamics and fluid management; pain management; nausea, vomiting and ileus prophylaxis; thromboembolic prophylaxis; and sleep disturbances and cognitive dysfunction (5).

However, the elements outlined are often practiced individually and it is Kehlet who pioneered the integration of these individual aspects of postoperative care into a multimodal package. Despite the evidence supporting these elements of postoperative care, they challenge surgical dogma and as such implementation has been slow (5).

In conclusion, Kehlet poses the following statements, ‘ ‘ The ultimate goal of fast track surgery is to achieve a pain and risk free operation, one needs to constantly ask the questions of why the patient is still in hospital and why the high risk patient is still high risk? ’ ’ (5).

Finally, he comments that fast track surgery has led to major improvements in the quality of care as well as economic benefits due to enhanced recovery with reduced need for hospitalization, medical morbidity and convalescence (5).

Despite the wealth of evidence supporting fast track principles, studies however are still needed to evaluate the role of enhanced recovery programs in emergency and trauma surgery. It is thus the aim of this study to highlight the application of enhanced recovery programs in the trauma setting.

#### **4. COST RELATED FACTORS**

Regarding the financial implications of an enhanced recovery program, several studies have addressed various aspects of the cost-related benefits of enhanced recovery programs. Factors evaluated include the influence on clinical outcome, quality of life after surgery, cost-effectiveness of implementation, optimization of resource utilization and overall costs.

Regarding the influence on clinical outcome and quality of life, it appears that enhanced recovery programs optimize and shorten overall length of stay without an increase in perioperative patient morbidity.

King, et al. (6) examined the influence of an enhanced recovery program on clinical outcomes, costs and quality of life after surgery for colorectal cancer. They compared a prospective group of patients undergoing colorectal surgery within an enhanced recovery program, with a historical cohort receiving conventional care.

Their study included 146 patients, 60 within the enhanced recovery program and 86 within the conventional care arm. Both groups were comparable in terms of baseline clinical data. They found that postoperative hospital stay was significantly shorter in the enhanced recovery program arm, with patients staying 49% as long as those in the conventional care arm. ( $P < 0.001$ ). In their study there was no differences in the number of complications, readmissions or re-operations. They also found no significant difference in health economic outcome (6). They concluded that patients that were managed according to a standard multimodal program stay in hospital half as long as those that receive conventional perioperative care, with no increased morbidity or increased cost. They were also able to show that there was no transfer of costs onto another component of the health care industry (6).

In their study, it arose that clinical practice may have changed naturally over time which may have led to a reduction in length of stay. This seems to be a problem with the use of a historical cohort. Also, it appears that there was some bias on the part of the treating surgeon regarding the decision to discharge patients. They do however comment that these factors were unlikely to account for the large reduction in length of hospital stay (6). We are able to conclude that structured, standardized multimodal perioperative care programs reduced cost not only by reducing the number of days patients stay in hospital but also because of faster recovery and thus faster return to work.

This study therefore supports the hypothesis that standardized multimodal perioperative care programs are superior to conventional care in terms of length of time patients stay in hospital, without any adverse perioperative outcomes and without increase in the cost of care.

Regarding the cost-effectiveness of implementation it seems that implementing an enhanced recovery program is associated with a significant cost saving per patient treated. Several studies showed significant savings ranging from € 263 to € 4521 (7).

Roulin et al. (7) examined the cost-effectiveness of the implementation of an enhanced recovery protocol for colorectal surgery. They provided evidence that despite enhanced recovery programs requiring time and financial investment, the cost-effectiveness was evident within the early implementation phase.

Their study included 100 patients, equally distributed between a pre and post enhanced recovery program implementation. The principles of enhanced recovery were adhered to and patients were discharged if they met the specified discharge criteria. There discharge criteria was sufficient postoperative pain control with oral analgesia, tolerance of solid food, passage of flatus or faeces and independent ambulation. <sup>7</sup>

The results of their study showed a faster postoperative recovery with shorter length of hospital stay, with a statistically significant reduction in median stay of 3 days ( $P=0.003$ ). The readmission length of stay was also reduced, 13 days in the enhanced recovery group and 36 days in the standard group.

Postoperative complications were reduced in the enhanced recovery group, but this result was not statistically significant ( $P=0.640$ ) with no difference in overall morbidity. Finally, there study provided evidence for the postulated cost-effectiveness of implementation of a structured multimodal care pathway, with a mean saving per patient in the enhanced recovery group of € 1651 and savings evident even in the initial implementation period (7).

The results of this study with regard to cost-effectiveness were similar to other studies conducted. Stephen et al. (8), Sammour et al. (9) and Ren et al. (10) all showed comparable cost benefits after implementation of an enhanced recovery program. There studies reported a decrease of € 1782, € 4521 and € 263 respectively after implementation of a standardized care pathway.

These studies provide evidence in support of the cost-effectiveness of implementation of a structured multimodal perioperative care pathway. The perceived initial costs that are incurred during the establishment phase is offset early, and the benefits such as reduced length of stay without an increase in perioperative morbidity is maintained.

Further support for the cost-effectiveness of implementing an enhanced recovery program is evident in Sammour et al. (9) study that evaluated the cost-effectiveness of implementation of an enhanced recovery program in elective colonic surgery.

Their study aimed to evaluate whether costs saved by reduced postoperative resource utilization would offset the financial burden of setting up and maintaining an enhanced recovery program (9).

Their case-control study included 100 patients, equally distributed and of similar baseline characteristics. They had previously published data outlining a significant reduction in intravenous fluid requirement, total day-stay and postoperative complications, as well as improved patient functional recovery as a direct result of instituting this program (9).

The results of this study showed that implementation an enhanced recovery program is cost-effective with the costs of implementation being offset by those recovered by reduced resource utilization in the postoperative period. They showed an approximate overall cost-saving of NZ\$ 6900 per patient. The majority of the cost was saved by halving the total postoperative day stay, and reducing postoperative complication costs (9).

Several studies have addressed the various financial aspects of enhanced recovery programs. A meta-analysis of randomized controlled trials conducted by Adamina et al. (11) evaluated health outcomes and resource utilization. This study was conducted in colorectal surgery that utilised enhanced recovery pathways to optimize care.

There meta-analysis included 6 randomized controlled trials with a total of 452 patients. For patients treated according to an enhanced recovery program, the length of stay was shortened by 2.5 days (95% CI), the 30-day morbidity was halved (95% CI) and readmission was not increased (95% CI) when compared with patients undergoing traditional care (11).

From this meta-analysis it was evident that patient management as per an enhanced recovery program, standardizes the health care process and this achieves a reproducible improvement in the quality of care. Structured care can accelerate recovery and safely reduce hospital length of stay, with optimal utilization of health care resources. This supports the consensus that enhanced recovery programs should be used in all major gastrointestinal procedures (11).

Duration of hospital stay, perioperative morbidity and complication rate, and re-admission and re-operation rate are key determinants of cost. Thus, by improving patient outcome with early discharge and reduced morbidity we are able to save a significant share of our limited health budget (11).

This meta-analysis highlighted the fact that compliance with enhanced recovery programs is initially poor, but improves over time, confirming a learning curve for the individual and the institution. Anticipated reduction in length of stay and morbidity is however achieved during the first year of implementation (11).

Overall, enhanced recovery programs are evidence-based perioperative care pathways designed to improve health outcomes and reduce costs to the health care industry, and should be applied to other surgical disciplines.

Following review of these studies it appears that the role of enhanced recovery programs is vital to reducing the cost to the health care industry. These programs provided a standardization of care and this was associated with benefit.

Hospitals benefit by reducing the time the patient spends in hospital as well as reducing the utilization on resources during the index admission and re-admission period. By optimizing care this can be achieved.

Implementation of enhanced recovery programs are confidently proven to facilitate enhanced recovery by maintaining normal preoperative physiology and facilitating return to this preoperative state faster during the recovery period. This enables faster recovery and patient independence.

In the short term implementation of such programs are associated with initial setup costs, such as dedicated trained nursing staff, dieticians, physiotherapists and increased observation, but this cost is offset early by faster recovery and reduced complications without an increase in re-admission or re-operation. Thus, the benefit exceeds the initial cost of implementation.

It seems evident that implementing an enhanced recovery program can reduce the cost of care to the health care industry.

## **5. PATIENT RELATED FACTORS**

Major abdominal surgery is associated with postoperative sequelae which include pain, gastrointestinal dysfunction and paralytic ileus, reduced cardio-pulmonary function and loss of muscle mass and function, all of which may contribute to postoperative morbidity and need for prolonged hospital stay. Multimodal rehabilitation aims to reduce these postoperative complications by preserving the normal preoperative physiology (4).

Early active mobilization with more hours out of bed is associated with positive outcomes including improved pulmonary function and oxygen saturation, and less reduction of lean body mass and work performance. This early aggressive mobilization requires an optimized pain relief program, combined with appropriate patient education and dedicated nursing care programs. The benefits of early mobilization are associated with the reduced duration of postoperative ileus, less patient discomfort and pain through better pain control programs and early nutrition (12).

Improved pulmonary function leads to reduced pulmonary morbidity. Analgesia and early mobilization are further means of improving pulmonary function. The improved pulmonary function leads to improved oxygen saturation, this has important secondary implications by reducing postoperative cardiac morbidity, cerebral dysfunction and wound complications through a more favourable supply-demand balance (12).

Preservation of body composition is vital in order to reduce postoperative morbidity. Even short periods of immobilization lead to muscle atrophy and loss of lean body mass. Early oral nutrition with protein drinks and early mobilization will preserve lean body mass and maintain work performance. This is particularly important for patients undergoing major abdominal surgery (12).

The physiological response to exercise decreases after operation, but this can be maintained through a multimodal perioperative care program. Patients who undergo multimodal rehabilitation with early oral nutrition and early mobilization are home sooner with a greater degree of independence and early mobilization and therefore preserved physical performance. Another feature of multimodal rehabilitation is the reduction in postoperative ileus. Early mobilization and early oral nutrition contribute to this outcome. Early aggressive postoperative rehabilitation is superior to conventional care (12).

Basse et al (12) evaluated the impact of multimodal rehabilitation on postoperative organ dysfunction. Postoperative organ dysfunction contributes to morbidity, hospital stay and convalescence. Through a multimodal rehabilitation program that included epidural analgesia, early oral feeding, mobilization and laxative use they showed improved clinical outcomes. Their study included 14 patients managed according to conventional care and 14 patients managed with a multimodal rehabilitation program. The results of their study showed that a multimodal rehabilitation pathway prevents a reduction in lean body mass, pulmonary function, oxygenation and cardiovascular response to exercise after colonic surgery.

Delayed recovery following abdominal surgery is often the consequence of delayed initiation of oral nutrition and subsequent delayed bowel movement. Early removal of nasogastric tubes, early initiation of liquid diet and early ambulation is associated with earlier return of bowel function and earlier discharge from hospital. This can only be achieved if a standardized perioperative protocol is adhered to (12).

Bradshaw et al (13) evaluated the use of a standardized perioperative care protocol in patients undergoing colon surgery. They conducted a prospective randomized study of 72 patients, consisting of 36 control and 36 cases. What they found was that early removal of nasogastric tubes, early initiation of liquid diet and early ambulation was associated with earlier return of bowel function and earlier discharge from hospital. They concluded that a standardized perioperative care program that eliminated perioperative variation in care was associated with earlier return of bowel function and reduced length of hospital stay. This result was however not a causal effect, as it may have been affected by many other factors. They believed that the results were reproducible if a standardized perioperative care protocol was used (13).

Anderson et al (14) conducted a study comparing a program of multimodal perioperative optimization and standardized care for patients undergoing colonic resection. Their study included 25 patients, 14 patients enrolled in a 10-point optimization program and 11 patients managed as per conventional care. Groups

were similar in terms of age, male:female sex ratio and POSSUM scores. All patients were fit, healthy and fully independent preoperatively with low ASA and BMI scores (14).

Outcome measures were assessed before and after surgery. The results of this study showed that optimization was associated with maintained grip strength, earlier mobilization, significantly lower pain and fatigue scores, earlier tolerance of regular hospital diet and reduced length of stay. From this they concluded that optimization of surgical care significantly improved patients' physical and psychological function in the early postoperative period and facilitated early hospital discharge (14).

This study stressed the importance of preoperative counselling of both patients and doctors regarding the postoperative targets for mobilization, nutrition and discharge.

They designed the 10-point pathway based on evidence-based parameters shown to improve patient outcome. The parameters included: preoperative counselling, shown to reduce postoperative pain, anxiety and hospital stay; avoidance of bowel preparation, which is not shown to reduce the incidence of wound infection or anastomotic leak; preoperative oral carbohydrate loading, shown to reduce insulin resistance and not increase the risk of aspiration; epidural analgesia, shown to reduce postoperative pain, improve gastrointestinal function and reduce the incidence of serious complications; high concentration oxygen administration, which improves oxidative bacterial killing and reduces infectious complications; transverse incisions, shown to result in less pain and impairment of respiratory function than vertical incisions; avoidance of nasogastric tubes, as they are uncomfortable and hinder normal diet; avoidance of intra-abdominal drains, as they do not reduce the incidence of anastomotic leak or other morbidity; early enteral nutrition with fluids on the day of surgery followed by regular diet as tolerated, as this improves return of normal bowel function; early mobilization during the postoperative period (14).

This protocol, similar to many others used in similar studies, combines the individual elements proven to improve perioperative outcome into a clinical optimization package that can be used at any level of care.

These evidence-based parameters form the basis of modern fast track programs, and when implemented in a standardized perioperative package they benefit patient outcome.

## **6. ERAS IN OTHER SPECIALITIES**

Enhanced recovery programs are firmly established in elective colorectal surgery, and in recent years their implementation has been widespread across surgical disciplines. Enhanced recovery programs have been instituted in high-risk surgery such as radical cystectomy, lung lobectomy and infra-renal aortic surgery. The implementation of such programs in such diverse surgical domains such as urology, thoracic and vascular surgery affirms that their benefits are reproducible outside colorectal surgery. This supports

the hypothesis that these known benefits of enhanced recovery programs can be reproduced in trauma surgery.

Arumainayagam et al (15) evaluated their experience after introduction of an enhanced recovery protocol for radical cystectomy. Their study included 112 consecutive patients, 56 before implementation of an enhanced recovery program and 56 after implementation of an enhanced recovery program. They analysed their data retrospectively and found a reduced duration of hospital stay of 13 days versus 17 days ( $P<0.001$ ), and reduced duration of recovery after surgery of 12 days versus 15 days ( $P<0.001$ ). Readmission, mortality and morbidity rates showed no statistically significant difference between the groups. They concluded that the introduction of an enhanced recovery protocol was associated with reduced hospital stay, with no deleterious effect on morbidity or mortality (15).

This study provides evidence for the utilization of a multimodal approach to perioperative care in the discipline of urology and in a surgical procedure associated with a high morbidity and prolonged inpatient stay. Bowel complications are amongst the commonest following radical cystectomy, this study however shows no statistically significant increase in complications associated with fast track surgery.

The benefits of a structured perioperative care pathway again seem to improve clinical outcome. As the combination of reduced bowel preparation, early removal of drains and epidural catheters, increased focus on nutrition and mobilization, and the use of a structured and consistent postoperative management plan are important elements of a structured perioperative care pathway.

Tovar et al (16) evaluated the clinical impact of an enhanced recovery pathway for lung lobectomy. Their study included 10 consecutive elective major lung resections. They concluded that a clinical pathway based on patient education, meticulous minimally invasive operation, analgesia, and early mobilization, was associated with rapid restoration of preoperative status which allowed for a 1-day hospital stay after major lung resection (16). This study provides evidence for the role of an enhanced recovery perioperative care pathway in major thoracic surgery.

Podore et al (17) reported on his experience with a clinical pathway for elective infra-renal aortic surgery. His clinical care pathway focused on early feeding, early mobilization, and selective intensive care unit utilization. He reviewed 50 consecutive patients that underwent infra-renal aortic surgery and concluded that the ability to ambulate independently and to tolerate a diet were related to early discharge. His study showed that a clinical pathway can facilitate safe and early discharge from hospital after major vascular surgery and also reduce the cost of hospitalization (17).

The patients in these studies were older and the surgery high-risk, however the benefits of reduced length of stay without an increase in perioperative morbidity was still evident. It would thus seem reasonable that these same benefits can be achieved in trauma surgery.

Nicholson et al (18) conducted a systematic review and meta-analysis of enhanced recovery programmes in surgical patients across different specialities. The aim of their review was to investigate whether the effect of ERP's on patient outcomes varies across surgical specialities or with the design of individual programmes. They evaluated randomized or quasi-randomized trials comparing ERP's with standard care in adult elective surgical patients. 38 trials with 5099 participants were included in the review. Their study included various specialities including upper GI, thoracic, vascular, orthopaedic, genito-urinary and pelvic surgery. They also included open versus laparoscopic surgery. The results of their review showed that ERP's reduce the length of stay and reduce the risk of all complications within 30 days. There was no evidence of a reduction in mortality, major complications or readmission rates. They concluded that the impact of ERP's in reducing length of hospital stay and overall complication rates was similar across specialities. There was no consistent evidence to identify individual components included within the ERP's that affected patient outcomes (18).

This systematic review and meta-analysis once again supports the notion that ERP's can be employed in specialities other than colorectal with the same benefits as those seen in elective colorectal surgery.

## **7. EVIDENCE BASED PROTOCOLS**

In 2009 the ERAS group published their guidelines for enhanced perioperative surgical care. This was a consensus review of perioperative care based on evidence available for each element of the multimodal pathway (19).

The ERAS group conducted a MEDLINE database search up to 31 December 2007 which included the 2005 ERAS protocol. A system developed by the Centre for Evidence Based Medicine, Oxford, England was used to evaluate the recommendations. Best quality (Grade A) recommendations were based on at least 2 good-quality randomized controlled trials or 1 meta-analysis of RCTs. Other recommendations were designated as consensus recommendations based on best available evidence.

**Table. Consensus Guidelines**

Item	Guideline
Preadmission information and counseling	Patients should receive oral and written preadmission information describing what will happen during hospitalization, what they should expect, and what their role is in the recovery process.
Preoperative bowel preparation	Patients undergoing elective colonic resection above the peritoneal reflection should not receive routine oral bowel preparation (grade A). Bowel preparation may be considered in patients scheduled for low rectal resection where a diverting stoma is planned.
Preoperative fasting and preoperative carbohydrate loading	The duration of preoperative fasting should be 2 hours for liquids and 6 hours for solids (grade A). Patients should receive carbohydrate loading preoperatively (grade A).
Preanesthetic medication	Patients should not receive medications known to cause long-term sedation, from midnight prior to surgery. Short-acting medications given to facilitate insertion of epidural catheter are acceptable (grade A).
Prophylaxis against thromboembolism	The preferred methods for prophylaxis in patients undergoing elective colorectal surgery are subcutaneous low-dose unfractionated heparin or subcutaneous low-molecular-weight heparin (grade A).
Antimicrobial prophylaxis	Patients undergoing colorectal resection should receive single-dose antibiotic prophylaxis against both anaerobes and aerobes about 1 hour before surgery (grade A).
Standard anesthetic protocol	Long-acting opioids should be avoided in patients undergoing anesthesia. Patients should receive a midthoracic epidural commenced preoperatively and containing local anesthetic in combination with a low-dose opioid (grade A).
Preventing and treating postoperative nausea and vomiting	Prevention of postoperative nausea and vomiting should be induced if $\geq 2$ risk factors are present. Treatment should be immediate, with combinations of the drugs discussed.
Laparoscopy-assisted surgery	Laparoscopic colonic resection is recommended if the surgeon or department is proficient with the technique and prospectively validated outcomes show at least equivalence to open surgery (grade A).
Surgical incisions	A midline or transverse laparotomy incision of minimal length should be used for patients undergoing elective colorectal resection.
Nasogastric intubation	Nasogastric tubes should not be used routinely in the postoperative period (grade A). They should be inserted if ileus develops.
Preventing intraoperative hypothermia	Intraoperative maintenance of normothermia with an upper-body forced-air heating cover should be used routinely (grade A).
Perioperative fluid management	Intraoperative and postoperative fluid restriction in major colonic surgery with avoidance of hypovolemia is safe (grade A). When compared with excessive fluid regimens, normovolemic regimens in major colonic surgery lead to more favorable outcomes (grade A). Intraoperative goal-directed therapy (eg, with transesophageal Doppler monitoring) is superior to a non-protocol-based standard with respect to outcome (grade A) and should be considered on an individual basis.
Drainage of peritoneal cavity following colonic anastomosis	Drains are not indicated following routine colonic resection above the peritoneal reflection (grade A). Short-term (<24-hour) use of drains after low anterior resections may be advisable.
Urinary drainage	Suprapubic urinary drainage for pelvic surgery is recommended (grade A). For colonic surgery, both suprapubic and urethral techniques are appropriate.
Prevention of postoperative ileus	Midthoracic epidural analgesia and avoidance of fluid overload are recommended to prevent postoperative ileus (grade A). A laparoscopic approach is recommended if locally validated (grade A). A low-dose postoperative laxative such as magnesium oxide may also be considered.
Postoperative analgesia	Patients should receive continuous epidural midthoracic low-dose local anesthetic and opioid combinations (grade A) for approximately 48 hours following elective colonic surgery and approximately 96 hours following pelvic surgery. Acetaminophen (paracetamol) should be used as a baseline analgesic (4 g/d) throughout the postoperative course. For breakthrough pain, epidural boluses should be given while the epidural is running. Nonsteroidal anti-inflammatory drugs should be started at removal of the epidural.
Postoperative nutritional care	Patients should be encouraged to commence an oral diet at will after surgery (grade A). Oral nutritional supplements should be prescribed (approximately 200 mL, energy dense, 2-3 times daily) from the day of surgery until normal food intake is achieved. Continuation of oral nutritional supplements at home for several weeks is recommended for nutritionally depleted patients (grade A).
Early mobilization	Patients should be nursed in an environment that encourages independence and mobilization. A care plan that facilitates patients being out of bed for 2 hours on the day of surgery and 6 hours thereafter is recommended.
Audit	A systematic audit should be performed to allow direct comparison with other institutions.

*Figure 3. Key elements of the ERAS protocol (19)*

### **Preadmission information and counselling (19):**

Evidence suggests that if patients are effectively counselled preoperatively, regarding the operative procedure and the postoperative course with clear explanation of expectations during their hospital stay, postoperative recovery is enhanced. Patients should be given clear explanations of their role during the recovery period, with specific tasks and targets for postoperative food intake, oral nutritional supplementation and mobilization.

Kiecolt-Glaser et al (20) and Egbert et al (21) showed that preoperative information can facilitate postoperative recovery and pain control, particularly in patients exhibiting denial and anxiety.

Halaszynski et al (22) and Forster et al (23) showed that a clear explanation of patient expectations during hospitalization facilitates adherence to the care pathway and allows early recovery and discharge.

Disbrow et al (24) and Blay et al (25) showed the value of imparting information to the patient at the first visit.

ERAS consensus guidelines thus recommend oral and written preadmission information describing what will happen during hospitalization, what to expect and what their role is in the recovery process.

### **Preoperative bowel preparation (19):**

Mechanical bowel preparation can cause fluid and electrolyte abnormalities and dehydration, and is not shown to reduce the risk of anastomotic leak. It is thus not recommended as part of an enhanced recovery program (26).

Jung et al (27) and Contant et al (28) showed no beneficial effect with preoperative bowel preparation. Bucher et al (29) and Ram et al (30) showed that bowel preparation may in fact increase the risk of anastomotic leak.

In colonic surgery in particular, data suggests that bowel preparation is stressful and prolongs postoperative ileus, Jung et al (31).

Regarding ultralow rectal anastomosis, Platell et al (32) reported that bowel preparation protects against anastomotic leaks.

ERAS consensus guidelines thus recommend that patients undergoing elective colonic resection above the peritoneal reflection should not receive routine oral bowel preparation, however those planned for low rectal resection with a diverting stoma may be considered for bowel preparation.

### **Preoperative fasting and preoperative carbohydrate loading (19):**

Preoperative fasting from midnight prior to surgery has been standard practice to avoid pulmonary aspiration in elective surgery. Ljungqvist et al (33) found no evidence to support this and a 2003 Cochrane review (34) of 22 RCTs showed that reducing the preoperative fasting period to 2 hours for clear fluids does not increase complications.

The national anaesthesia society now recommends the intake of clear fluids until 2 hours before induction and solid food up to 6 hours prior to induction. Common misconceptions exist for obese and morbidly obese patients, and it appears that gastric emptying characteristics are similar to lean patients. Diabetic patients are the exception, as patients with neuropathy may have delayed gastric emptying.

Feeding patients preoperatively reduces preoperative thirst and hunger, reduces anxiety and reduces postoperative insulin resistance. This can be achieved by providing patients with a clear carbohydrate drink before midnight and 2 to 3 hours before surgery.

By providing preoperative nutrition the patients' preoperative anabolic state is maintained and this reduces postoperative protein loss and maintains lean body mass and muscle strength. Evidence suggest that avoidance of preoperative starvation and promoting preoperative carbohydrate loading facilitate accelerated recovery and a shorter length of hospital stay (35,36).

### **Pre anaesthetic medication (19):**

A 2000 and 2003 Cochrane review showed that long-acting premedication such as opioids, long-acting sedatives and hypnotics negatively impact recovery by hindering the patient's ability to drink and mobilize after surgery. This ultimately prolongs length of hospital stay (37).

ERAS guidelines therefore avoid such agents, but do allow for the use of short-acting medications given to facilitate the insertion of epidural catheters (38).

### **Prophylaxis against thromboembolism (19):**

Subcutaneous low-dose unfractionated heparin has been shown to be effective in reducing deep vein thrombosis, pulmonary embolism and mortality (39,40,41,42). Meta-analyses comparing unfractionated heparin with low-molecular weight heparin showed no difference in efficacy or associated bleeding risk (41,42,43,44). The current recommendation therefore supports the use of low-molecular weight heparin because of its once-daily regimen and lower risk of heparin-induced thrombocytopenia.

Regarding the continuous use of low-molecular weight heparin and epidural analgesia is still under debate. The recommendation is for prophylactic doses of LMWH not to be given within 12 hours of insertion or removal of the epidural catheter.

### **Antimicrobial prophylaxis (19):**

The use of prophylactic antibiotics effective against both aerobes and anaerobes can minimize infectious complications. A second-generation cephalosporin and metronidazole is recommended and the first dose should be given at induction about 1 hour prior to the skin incision with further doses given in prolonged cases more than 3 hours (45,46).

### **Standardized anaesthetic protocol (19):**

There is currently no evidence to direct the choice of the optimal anaesthetic method. However, long-acting opioids should be avoided, and patients should receive a mid-thoracic epidural preoperatively containing a combination of local anaesthetic and low-dose opioid.

### **Preventing and treating postoperative nausea and vomiting (19):**

In studies conducted by Van Den Bosch et al (47), Gan et al (48), Eberhart et al (49) and Macario et al (50), patient experience suggests that postoperative nausea and vomiting can be more stressful than pain.

Risk factors for postoperative nausea and vomiting include being female, being a non-smoker, having a history of motion sickness and postoperative administration of opioids (51,52).

Individuals deemed at moderate to high risk, having 2 or more risk factors, should receive prophylaxis (53). The agents used depend on availability, but should be administered at the beginning and prior to the end of surgery.

### **Surgical incisions (19):**

Some RCTs suggest that transverse or curved incisions cause less pain and pulmonary dysfunction than vertical incisions following abdominal procedures, while others have found no advantage of transverse incisions.

A Cochrane review of RCTs comparing midline with transverse incisions for abdominal surgery confirms that although analgesic use and pulmonary compromise may be reduced with transverse or oblique incisions, complication rates and recovery times are the same as with midline incisions (54). However, the length of the incision affects patient recovery (55). Overall, choice of incision remains the preference of the surgeon.

### **Nasogastric intubation (19):**

A meta-analysis has shown that avoidance of nasogastric tubes in colorectal surgery is associated with improved outcomes as they reduce the risk of postoperative complications such as fever, atelectasis and pneumonia and enhance the return of normal bowel function (56). This was supported by a Cochrane

review of more than 33 trials (57). Nasogastric tubes should thus be avoided and if placed should be removed before reversal of anaesthesia.

### **Preventing intraoperative hypothermia (19):**

RCTs have shown that by preserving and maintaining normothermia, postoperative complications such as wound infections, cardiac complications, bleeding and blood transfusion requirements can be reduced. This can be achieved with the use of upper-body forced-air heating covers.

### **Perioperative fluid management (19):**

Traditional perioperative fluid regimens can lead to significant positive fluid balance in excess of 5 litres, leading to a 3- to 6-kg weight gain. This leads to delay in return of normal gastrointestinal function, impaired wound and anastomotic healing, and affect tissue oxygenation, leading to prolonged hospitalization. Evidence suggests that limiting postoperative intravenous fluid administration and maintaining a neutral fluid balance, guided by body weight may significantly reduce postoperative complications and reduce hospital length of stay. The best way to achieve this is to stop intravenous fluid administration, and initiate early oral fluid intake, which should be feasible from day 1 postoperatively.

### **Drainage of peritoneal cavity following colonic anastomosis (19):**

Meta-analysis have demonstrated that the use of drains after colonic surgery does not reduce the incidence or severity of anastomotic leaks or other complications (58,59).

### **Urinary drainage (19):**

Meta-analysis suggests that supra-pubic catheters are better tolerated by patients with reduced morbidity compared to trans-urethral catheters (60). The overall advantage of prolonged catheterization seems to benefit patients undergoing pelvic surgery with prolonged catheterization times.

### **Prevention of postoperative ileus (19):**

Preventing postoperative ileus is a key objective of all ERP's since it delays initiation of full ward diet and thus prolongs overall length of hospital stay. Analgesic protocols such as epidural analgesia as opposed to intravenous opioid analgesia has been advocated as highly efficient in reducing postoperative ileus. Intravenous fluid restriction is also important in this regard.

### **Postoperative analgesia (19):**

Evidence suggests that epidural analgesia provides better postoperative analgesia with beneficial effects on the surgical stress response compared with intravenous opioid analgesia. After removal of the epidural

catheter, postoperative analgesia is best achieved with a combination multi-modal approach, using oral or intravenous paracetamol, non-steroidal anti-inflammatory drugs, and limiting intravenous opioids.

### **Postoperative nutritional care (19):**

RCTs of early enteral or oral feeding versus 'nil by mouth' have shown that there is no advantage of prolonged fasting of patients after gastrointestinal resection (61,62,63). Early feeding reduced both the risk of infection and the length of hospital stay and was not associated with an increased risk of anastomotic dehiscence. In ERP's, oral nutritional supplementation have been used successfully during the perioperative period to achieve the recommended intake of energy and protein.

### **Early mobilization (19):**

Evidence suggests that bed rest not only increases insulin resistance and muscle loss, but also decreases muscle strength, pulmonary function, and tissue oxygenation (64). There is also an increased risk of thromboembolism. Effective pain relief which is a key objective in ERP's aims to facilitate and encourage early mobilization. Early removal of abdominal drains and urinary catheters also facilitate and encourage early mobilization. A prescheduled care plan should be provided which states the daily goals for mobilization. The aim is to get the patient out of bed for 2 hours in the day of surgery and for 6 hours per day until discharge.

### **Audit (19):**

Systematic audit is mandatory to determine clinical outcome and to establish the successful implementation of the care protocol.

## **8. VALIDATION OF ERAS**

Major abdominal surgery results in significant physiological surgical stress, which is followed by an often prolonged period of recovery. ERP's aim to shorten this period of disability and enhance recovery.

Since the introduction of ERP's many studies have provided evidence of the benefits associated with ERP's, most importantly the decreased length of hospital stay without an increase in postoperative complications.

Length of hospital stay has thus been used as a surrogate for recovery. However, postoperative recovery is more than just a shortened length of hospital stay and it begins at the time of surgery and is only complete when the patients returns/recovers to their baseline. Recovery is a complex process that depends on objective physiological variables and patient-related variables such as symptoms, emotions, social and economic function, health perception and overall quality of life (65).

Currently, most studies evaluating the benefits of ERP's have focused on hospital length of stay. But it seems that LOS alone is not a true reflection of postoperative recovery. The challenge is thus how best to assess the benefit of ERP's.

Neville et al (65) conducted a systematic review of outcomes used to evaluate ERAS. His group highlighted the fact that validated outcome measures are lacking and that the process of recovery is complex. Their systematic review evaluated prospective studies evaluating ERP's compared with traditional care in abdominal surgery published between 2000 and 2013. 38 studies were included. They classified outcomes into categories: biological and physiological variables, symptom status, functional status, general health perceptions and quality of life. The phases of recovery measured were defined as baseline, intermediate (in hospital) and late (following discharge) (65).

Of the 38 studies included, 30 studies highlighted biological or physiological variables such as return of gastrointestinal function, pulmonary function and physical strength which were reported most frequently. Patient-reported symptoms, such as pain and fatigue were reported less commonly. Functional status outcomes, such as mobilization and the ability to perform activities of daily living, and health aspects of quality of life were also reported less commonly. All studies documented in-hospital outcomes but only 17 reported late outcomes (post hospital discharge). They concluded that patient-related outcomes, in particular post discharge functional status were not commonly reported (65).

This study highlights the fact that when evaluating the benefits of ERP's we should look at more than just the hospital length of stay. It is important to understand the individual patients' baseline, and an ERP should aim to return the patient to baseline as soon as possible after surgery.

In hospital it seems reasonable to evaluate length of stay and postoperative complications as they reflect what is desired by the health care industry. Reduced hospital length of stay without an increase in postoperative complications reflect technical success and reduce overall cost of care. But does this really lead to patient benefits?

All studies evaluating length of stay in an ERP measure time from admission/surgery to discharge. Length of stay is thus based on time to discharge. Protocols rely on certain criteria for discharge, such as ability to tolerate oral intake, pain controlled with oral analgesia, return of bowel function and ability to mobilize independently. Once patients reach these postoperative goals they are deemed recovered and fit for discharge. However recover, return to baseline, may take months. It is thus important that future studies evaluate patient outcomes such as resolution of pain and fatigue, and late post-discharge outcomes reflecting return to baseline.

## 9. REFERENCES

1. Manual of Fast Track Recovery for Colorectal Surgery. 2012:1-15.
2. Wilmore DW. From Cuthbertson to fast-track surgery: 70 years of progress in reducing stress in surgical patients. *Ann Surg.* 2002;236(5):643-648.
3. Kehlet H; Dahl J. Prevention of surgical stress and postoperative organ dysfunction. *Lancet.* 2003;362:1921-1928.
4. Kehlet H. Multimodal approach to control postoperative pathophysiology and rehabilitation. *Br J Anaesth.* 1997;78:606-617.
5. Kehlet H. Fast-track surgery - An update on physiological care principles to enhance recovery. *Langenbeck's Arch Surg.* 2011:585-590.
6. King PM, Blazeby JM, Ewings P, et al. The influence of an enhanced recovery programme on clinical outcomes, costs and quality of life after surgery for colorectal cancer. *Color Dis.* 2006;(8):506-513.
7. Roulin D, Donadini A, Gander S, et al. Cost-effectiveness of the implementation of an enhanced recovery protocol for colorectal surgery. *Br J Surg.* Vol ; 2013:1108-1114.
8. Stephen AE, Berger DL. Shortened length of stay and hospital cost reduction with implementation of an accelerated clinical care pathway after elective colon resection. *Surgery* 2003; 133: 277–282.
9. Tarik Sammour, Kamran Zargar-Shoshtari, Abhijith Bhat, Arman Kahokehr AGH. A programme of Enhanced Recovery After Surgery (ERAS) is a cost-effective intervention in elective colonic surgery. *J New Zeal Med Assoc.* 2010;123(1319).
10. Ren L, Zhu D, Wei Y, Pan X, Liang L, Xu J et al. Enhanced Recovery After Surgery (ERAS) program attenuates stress and accelerates recovery in patients after radical resection for colorectal cancer: a prospective randomized controlled trial. *World J Surg* 2012; 36: 407–414.
11. Adamina M, Kehlet H, Tomlinson GA, Senagore AJ, Delaney CP. Enhanced recovery pathways optimize health outcomes and resource utilization: A meta-analysis of randomized controlled trials in colorectal surgery. *Surgery.* 2011:830-840.
12. Basse L, Raskov HH, Hjort Jakobsen D, et al. Accelerated postoperative recovery programme after colonic resection improves physical performance, pulmonary function and body composition. *Br J Surg.* 2002;(89):446-453.

13. Bradshaw BGG, Liu SS, Thirlby RC. Standardized perioperative care protocols and reduced length of stay after colon surgery. *J Am Coll Surg.* 1998;(186):501-506.
14. Anderson ADG, McNaught CE, MacFie J, Tring I, Barker P, Mitchell CJ. Randomized clinical trial of multimodal optimization and standard perioperative surgical care. *Br J Surg.* 2003;(90):1497-1504.
15. Arumainayagam N, McGrath J, Jefferson KP, Gillatt DA. Introduction of an enhanced recovery protocol for radical cystectomy. *BJU Int.* 2008;(101):698-701.
16. Tovar EA, Roethe RA, Weissig MD, Lloyd RE, Patel GR. One-day admission for lung lobectomy: An incidental result of a clinical pathway. *Ann Thorac Surg.* 1998;(65):803-806.
17. Podore T. Infrarenal aortic surgery with a 3-day hospital stay: a report of success with a clinical pathway. *J Vasc Surg.* 1999;(29):787-792.
18. Nicholson a., Lowe MC, Parker J, Lewis SR, Alderson P, Smith a. F. Systematic review and meta-analysis of enhanced recovery programmes in surgical patients. *Br J Surg.* 2014;101(3):172-188.
19. Lassen K, Soop M, Nygren J, et al. Consensus review of optimal perioperative care in colorectal surgery: Enhanced Recovery After Surgery (ERAS) Group recommendations. *Arch Surg.* 2009;144(10):961-969.
20. Kiecolt-Glaser JK, Page GG, Marucha PT, MacCallum RC, Glaser R. Psychological influences on surgical recovery: perspectives from psychoneuroimmunology. *Am Psychol.* 1998;53(11):1209-1218.
21. Egbert LD, Battit G, Welch C, Bartlett M. Reduction of postoperative pain by encouragement and instruction of patients: a study of doctor-patient rapport. *N Engl J Med.* 1964;270:825-827.
22. Halaszynski TM, Juda R, Silverman DG. Optimizing postoperative outcomes with efficient preoperative assessment and management. *Crit Care Med.* 2004; 32(4)(suppl):S76-S86.
23. Forster AJ, Clark HD, Menard A, et al. Effect of a nurse team coordinator on outcomes for hospitalized medicine patients. *Am J Med.* 2005;118(10):1148-1153.
24. Disbrow EA, Bennett HL, Owings JT. Effect of preoperative suggestion on postoperative gastrointestinal motility. *West J Med.* 1993;158(5):488-492.
25. Blay N, Donoghue J. The effect of pre-admission education on domiciliary recovery following laparoscopic cholecystectomy. *Aust J Adv Nurs.* 2005; 22(4):14-19.

26. Holte K, Nielsen KG, Madsen JL, Kehlet H. Physiologic effects of bowel preparation. *Dis Colon Rectum*. 2004;47(8):1397-1402.
27. Jung B, Paahlman L, Nyström P-O, Nilsson E; Mechanical Bowel Preparation Study Group. Multicentre randomized clinical trial of mechanical bowel preparation in elective colonic resection. *Br J Surg*. 2007;94(6):689-695.
28. Contant CM, Hop WC, van't Sant HP, et al. Mechanical bowel preparation for elective colorectal surgery: a multicentre randomised trial. *Lancet*. 2007; 370(9605):2112-2117.
29. Bucher P, Gervaz P, Soravia C, Mermillod B, Erne M, Morel P. Randomized clinical trial of mechanical bowel preparation vs no preparation before elective leftsided colorectal surgery. *Br J Surg*. 2005;92(4):409-414.
30. Ram E, Sherman Y, Weil R, Vishne T, Kravarusic D, Dreznik Z. Is mechanical bowel preparation mandatory for elective colon surgery? a prospective randomized study. *Arch Surg*. 2005;140(3):285-288.
31. Jung B, Lannerstad O, Paahlman L, Arodell M, Unosson M, Nilsson E. Preoperative mechanical preparation of the colon: the patient's experience. *BMC Surg*. 2007;7:5.
32. Platell C, Barwood N, Makin G. Randomized clinical trial of bowel preparation with a single phosphate enema or polyethylene glycol before elective colorectal surgery. *Br J Surg*. 2006;93(4):427-433.
33. Ljungqvist O, Søreide E. Preoperative fasting. *Br J Surg*. 2003;90(4):400-406.
34. Brady M, Kinn S, Stuart P. Preoperative fasting for adults to prevent perioperative complications. *Cochrane Database Syst Rev*. 2003;(4):CD004423.
35. Nygren J, Thorell A, Ljungqvist O. Preoperative oral carbohydrate nutrition: an update. *Curr Opin Clin Nutr Metab Care*. 2001;4(4):255-259.
36. Noblett SE, Watson DS, Huong H, Davison B, Hainsworth PJ, Horgan AF. Pre-operative oral carbohydrate loading in colorectal surgery: a randomized controlled trial. *Colorectal Dis*. 2006;8(7):563-569.
37. Smith AF, Pittaway AJ. Premedication for anxiety in adult day surgery [update of: *Cochrane Database Syst Rev*. 2000;(3):CD002192]. *Cochrane Database Syst Rev*. 2003;(1):CD002192.
38. Smith AF, Pittaway AJ. Premedication for anxiety in adult day surgery. *Cochrane Database Syst Rev*. 2000;(3):CD002192.

39. Clagett GP, Anderson FA Jr, Geerts W, et al. Prevention of venous thromboembolism. *Chest*. 1998;114(5)(suppl):531S-560S.
40. Wille-Jørgensen P, Rasmussen MS, Andersen BR, Borly L. Heparins and mechanical methods for thromboprophylaxis in colorectal surgery [update of: *Cochrane Database Syst Rev*. 2001;(3):CD001217]. *Cochrane Database Syst Rev*. 2003;(4):CD001217.
41. Collins R, Scrimgeour A, Yusuf S, Peto R. Reduction in fatal pulmonary embolism and venous thrombosis by perioperative administration of subcutaneous heparin: overview of results of randomized trials in general, orthopedic, and urologic surgery. *N Engl J Med*. 1988;318(18):1162-1173.
42. Clagett GP, Reisch JS. Prevention of venous thromboembolism in general surgical patients: results of meta-analysis. *Ann Surg*. 1988;208(2):227-240.
43. Koch A, Ziegler S, Breitschwerdt H, Victor N. Low molecular weight heparin and unfractionated heparin in thrombosis prophylaxis: meta-analysis based on original patient data. *Thromb Res*. 2001;102(4):295-309.
44. Koch A, Bouges S, Ziegler S, Dinkel H, Daures JP, Victor N. Low molecular weight heparin and unfractionated heparin in thrombosis prophylaxis after major surgical intervention: update of previous meta-analyses. *Br J Surg*. 1997;84(6):750-759.
45. Song F, Glenny AM. Antimicrobial prophylaxis in colorectal surgery: a systematic review of randomized controlled trials. *Br J Surg*. 1998;85(9):1232-1241.
46. Bratzler DW, Houck PM; Surgical Infection Prevention Guidelines Writers Workgroup; Antimicrobial prophylaxis for surgery: an advisory statement from the National Surgical Infection Prevention Project. *Clin Infect Dis*. 2004;38(12):1706-1715.
47. van den Bosch JE, Bonsel GJ, Moons KG, Kalkman CJ. Effect of postoperative experiences on willingness to pay to avoid postoperative pain, nausea, and vomiting. *Anesthesiology*. 2006;104(5):1033-1039.
48. Gan T, Sloan F, Dear GL, El Moalem HE, Lubarsky DA. How much are patients willing to pay to avoid postoperative nausea and vomiting? *Anesth Analg*. 2001; 92(2):393-400.
49. Eberhart LH, Morin AM, Wulf H, Geldner G. Patient preferences for immediate postoperative recovery. *Br J Anaesth*. 2002;89(5):760-761.
50. Macario A, Weinger M, Carney S, Kim A. Which clinical anesthesia outcomes are important to avoid? the perspective of patients. *Anesth Analg*. 1999; 89(3):652-658.

51. Apfel CC, Kranke P, Eberhart LH, Roos A, Roewer N. Comparison of predictive models for postoperative nausea and vomiting. *Br J Anaesth*. 2002;88(2): 234-240.
52. Rüsç D, Eberhart L, Biedler A, Dethling J, Apfel CC. Prospective application of a simplified risk score to prevent postoperative nausea and vomiting. *Can J Anaesth*. 2005;52(5):478-484.
53. Carlisle JB, Stevenson CA. Drugs for preventing postoperative nausea and vomiting. *Cochrane Database Syst Rev*. 2006;3:CD004125.
54. Brown SR, Goodfellow PB. Transverse vs midline incisions for abdominal surgery. *Cochrane Database Syst Rev*. 2005;(4):CD005199.
55. O'Dwyer PJ, McGregor JR, McDermott EW, Murphy JJ, O'Higgins NJ. Patient recovery following cholecystectomy through a 6 cm or 15 cm transverse subcostal incision: a prospective randomized clinical trial. *Postgrad Med J*. 1992; 68(804):817-819.
56. Cheatham ML, Chapman WC, Key SP, Sawyers JL. A meta-analysis of selective vs routine nasogastric decompression after elective laparotomy. *Ann Surg*. 1995;221(5):469-476, discussion 476-478.
57. Nelson R, Edwards S, Tse B. Prophylactic nasogastric decompression after abdominal surgery [update of: *Cochrane Database Syst Rev*. 2005;(1):CD004929]. *Cochrane Database Syst Rev*. 2007;(3):CD004929.
58. Karliczek A, Jesus EC, Matos D, Castro AA, Atallah AN, Wiggers T. Drainage or nondrainage in elective colorectal anastomosis: a systematic review and meta-analysis. *Colorectal Dis*. 2006;8(4):259-265.
59. Jesus EC, Karliczek A, Matos D, Castro AA, Atallah AN. Prophylactic anastomotic drainage for colorectal surgery. *Cochrane Database Syst Rev*. 2004; (4):CD002100.
60. McPhail MJ, Abu-Hilal M, Johnson CD. A meta-analysis comparing suprapubic and transurethral catheterization for bladder drainage after abdominal surgery. *Br J Surg*. 2006;93(9):1038-1044.
61. Andersen HK, Lewis SJ, Thomas S. Early enteral nutrition within 24h of colorectal surgery vs later commencement of feeding for postoperative complications. *Cochrane Database Syst Rev*. 2006;(4):CD004080.
62. Lewis SJ, Egger M, Sylvester PA, Thomas S. Early enteral feeding vs "nil by mouth" after gastrointestinal surgery: systematic review and meta-analysis of controlled trials. *BMJ*. 2001;323(7316):773-776.

63. Han-Geurts IJ, Hop WC, Kok NF, Lim A, Brouwer KJ, Jeekel J. Randomized clinical trial of the impact of early enteral feeding on postoperative ileus and recovery. *Br J Surg*. 2007;94(5):555-561.
64. Kehlet H, Wilmore DW. Multimodal strategies to improve surgical outcome. *Am J Surg*. 2002;183(6):630-641.
65. Neville a., Lee L, Antonescu I, et al. Systematic review of outcomes used to evaluate enhanced recovery after surgery. *Br J Surg*. 2014;101(3):159

## **PUBLICATION-READY MANUSCRIPT**

### **TITLE PAGE**

#### Title of paper:

Early recovery after surgery (ERAS) in penetrating abdominal trauma: A prospective single-center pilot study

#### Authors:

- Mahammed Riyaad Moydien, MBChB, FCS
- Pradeep H Navsaria, MBChB, MMed, FCS, FACS
- Andrew J Nicol, MBChB, FCS, PhD
- Ravi Oodit, MBChB, FCS
- Sorin Edu, MBChB, FCS

#### Corresponding author:

- Pradeep H Navsaria

Trauma Centre  
Groote Schuur Hospital  
University of Cape Town  
Anzio Road  
Cape Town  
7925  
South Africa  
E-mail: pradeep.navsaria@uct.ac.za

## **ABSTRACT**

### **Early recovery after surgery (ERAS) in penetrating abdominal trauma: A prospective single-center pilot study**

#### **Introduction**

ERAS programmes conducted in elective colorectal, vascular, urologic and orthopaedic surgery has provided strong evidence for decreased lengths of hospital stay without increase in postoperative complications.

#### **Aim**

The aim of this study was to explore the role and benefits, if any, of ERAS / ERP (early recovery programmes) implemented in patients undergoing emergency laparotomy for trauma at a level 1 trauma center.

#### **Methods**

Institutional UCT-HREC approved study. A prospective cohort of 38 consecutive patients with isolated penetrating abdominal trauma undergoing emergency laparotomy were included in the study. The ERP included: early feeding, early urinary catheter removal, early mobilisation/physiotherapy, early intravenous line removal and early optimal oral analgesia. This group was compared to a historical control group of 40 consecutive patients undergoing emergency laparotomy for penetrating abdominal trauma, prior to introduction of ERP. Demographics, mechanism of injury and injury severity scores (ISS and PATI) were determined for both groups. The primary end-points were the length of hospital stay and incidence of complications (Clavien-Dindo classification) in the 2 groups. The difference in means was tested using the t-test assuming unequal variances. Statistical significance was defined as  $p < 0.05$ .

#### **Results**

The two groups were comparable with regards to age, gender, mechanism of injury and ISS and PATI scores. The mean time to solid diet, urinary catheter removal and NGT removal was (non ERAS) 3.6 and (ERAS) 2.8 days [ $p < 0.035$ ], (non ERAS) 3.3 and (ERAS) 1.9 days [ $p < 0.00003$ ], (non ERAS) 2.1 and (ERAS) 1.2 days [ $p < 0.0042$ ], respectively. There was no difference in time from admission to time of laparotomy [(non ERAS) 313 vs. (ERAS) 358] min ( $p < 0.07$ ). There were 11 and 12 complications in the control and study group, respectively. When graded as per the Clavien-Dindo classification there was no significant difference in the 2 groups ( $p < 0.59$ ). Hospital stay was significantly shorter in the ERAS group: 5.5 (SD 1.8) days vs. 8.4 (SD 4.2) days [ $p < 0.00021$ ].

## **Conclusion**

This small pilot study shows that ERPs can be successfully implemented with significant shorter hospital stays without any increase in postoperative complications in trauma patients undergoing laparotomy for penetrating abdominal trauma. Furthermore, the study shows that ERP can also be applied to patients undergoing emergency surgery.

## **MAIN PAPER**

### **Introduction**

Enhanced recovery after surgery (ERAS) or enhanced recovery protocols (ERP) is a concept first described by Kehlet in the early 1990's (1). The approach employs a multimodal peri-operative care pathway designed to attenuate the surgical stress response and accelerate post-operative recovery (2). Implementation of ERPs across a range of surgical disciplines has led to improved patient outcomes including reductions in post-operative complications and hospital length of stay.

Trauma centres in developing countries constantly battle with reduced bed availability and restricted health care budgets. Optimization of health care practice is therefore urgent, particularly in trauma surgery. Since its introduction 15 years ago, enhanced recovery after surgery (ERAS) protocols have been successfully used in elective gastrointestinal surgery (colorectal, hepatobiliary and gastric), and, there has been widespread acceptance and implementation in other surgical disciplines too (urology, vascular, thoracic and orthopaedics) (3,4,5,6,7). The benefits of ERAS/ERPs are well established. They have shown faster physiological patient recovery, and reduced length of hospital stay without an increase in complications (7,8). These benefits should be easily transferrable to the trauma patient population, if not greater, since trauma patients are generally younger, fitter and metabolically stable. Penetrating abdominal trauma is a major cause of morbidity and mortality in large urban trauma centres and accounts for a significant number of hospital admissions and consumes a large portion of the health care budget. We developed and implemented an ERP for patients undergoing emergency laparotomy for isolated penetrating abdominal trauma and analysed the effect of this protocol.

### **Patients and Methods**

Stable patients presenting with isolated penetrating abdominal trauma (stab and gunshot wounds) that required an emergency laparotomy over a one year period from 1 January 2013 to 31 December 2013 were analysed. Patients with extra-abdominal injuries, those that required damage control surgery, and patients that requiring intensive care unit admission for postoperative support were excluded from the study. Based on ERAS consensus guidelines an ERP was designed (appendix 1) (2). The ERP included: early nasogastric tube removal, early urine catheter removal, early intravenous line removal, early feeding with early fluid and solid diet initiation, early mobilization/physiotherapy, and early optimal oral analgesia. Criteria for early discharge included: tolerance of solid diet, pain control on oral analgesia and independent mobilization.

In our study, the post-operative pain protocol consisted of a morphine infusion for up to 48 hours and paracetamol infusion for 24 hours. Thereafter patients were converted to oral analgesia (paracetamol and

tramadol) and intramuscular morphine for breakthrough pain. All patients were mobilized on the first post-operative day with the help of nursing staff and physiotherapists, with the goal of having all patients fully independent by day 3. This approach to post-operative pain control and mobilization was already well established in our unit and all patients in both the control and study group benefited from it. Early mobilization and early optimal oral analgesia was therefore similar for both groups and not significant.

The ERP was implemented and a prospective cohort of 38 consecutive patients analysed. This group was compared to a historical control group of 40 consecutive patients undergoing emergency laparotomy for penetrating abdominal trauma, prior to introduction of the ERP. Demographic data, adherence to the ERP, length of hospital stay and postoperative complications as per Clavien-Dindo classification (appendix 2) were analysed. These primary end-points were the length of hospital stay and incidence of post-operative complications. Statistical analysis was done using Microsoft Excel and Stata. T-test was performed comparing means and statistical significance was defined as a p-value < 0.05.

## **Results**

The study included 78 patients (38 – ERAS and 40 – non ERAS). The 2 groups were comparable with regard to age, gender, mechanism of injury, injury severity scores (ISS), penetrating abdominal trauma index (PATI) score and time to laparotomy (Table 1).

The mean time to initiation of solid diet, urinary catheter removal and NGT removal was 3.6 (non ERAS) and 2.8 (ERAS) days [ $p < 0.035$ ], 3.3 (non ERAS) and 1.9 (ERAS) days [ $p < 0.00003$ ], 2.1 (non ERAS) and 1.2 (ERAS) days [ $p < 0.0042$ ], respectively (Figure 1). Patients in the ERAS group had statistically significant earlier removal of nasogastric tubes, urinary catheters and earlier initiation of solid diet.

The Clavien-Dindo classification system was used to record post-operative complications (Table 2, Figure 2). There were 11 and 12 complications in the non ERAS and ERAS group, respectively. When graded as per the Clavien-Dindo classification there was no statistically significant difference in post-operative complications grade for grade and overall between the non ERAS group and ERAS group ( $p < 0.59$ ).

Mean hospital length of stay was 5.5 days (SD 1.8) in the ERAS group and 8.4 days (SD 4.2) in the non ERAS group (Figure 3). The shorter length of hospital stay in the ERAS group was statistically significant, ( $p < 0.00021$ ).

	Control group (non ERAS)	Study group (ERAS)	P-value
<b>No. of patients</b>	40	38	
<b>Mean age</b>	27.6 years	28.3 years	NS
<b>Gender: male/female</b>	36/4	38/0	NS
<b>Mechanism</b>			
<b>Gunshot wound</b>	25 (62.5%)	28 (73.7%)	NS
<b>Stab wound</b>	15 (37.5%)	10 (26.3%)	NS
<b>Mean ISS</b>	16	16	NS
<b>PATI: GSW</b>	21.7	22.5	NS
<b>PATI: SW</b>	13.9	13.7	NS
<b>Time to laparotomy</b>	313.6 minutes	358.9 minutes	NS

Table 1: Demographic and descriptive data

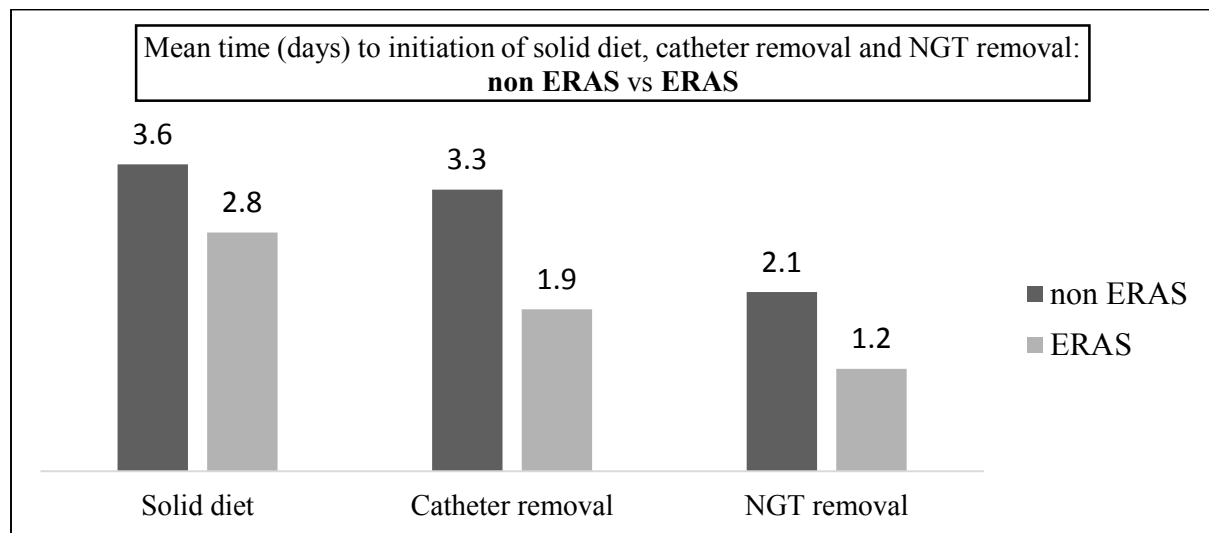


Figure 1: Effect of implementation of ERP

Grade	Complication	Control group (non ERAS)	Study group (ERAS)
1	Ileus	2	4
	SSI – superficial	3	3
2	Pneumonia	0	2
	Entero-cutaneous fistula	1	0
3a	SSI – deep	2	0
3b	Re-operation	3	3
<b>Total</b>		11	12

Table 2: Post-operative complications

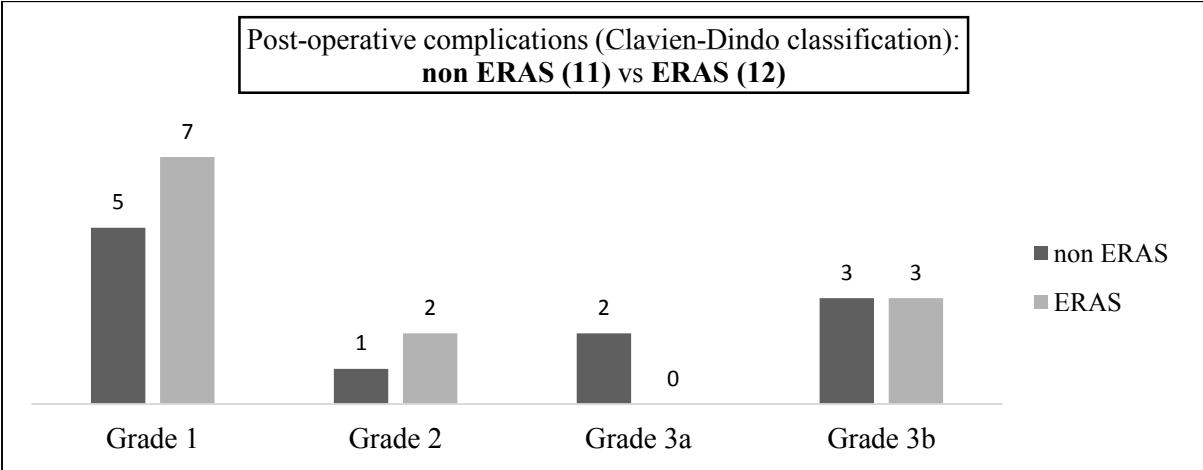
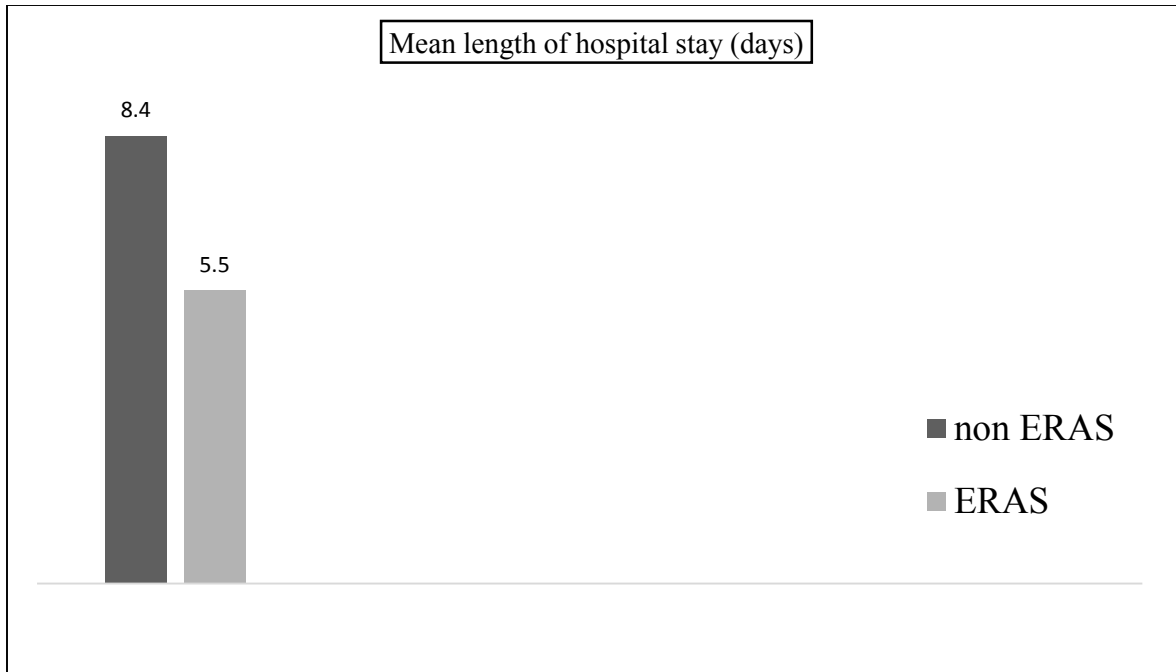


Figure 2: Post-operative complications



*Figure 3: Hospital length of stay*

## **Discussion**

ERAS programs have consistently been shown to have both cost-related and patient-related benefits. King et al. examined the influence of an ERP on clinical outcome, cost and quality of life after surgery for colorectal surgery (9). They found that hospital stay was significantly reduced when patients were managed according to an ERP, with a 49% reduction in length of stay in the ERP group compared to the conventional care arm. They also showed no transfer of costs onto another health care industry. In a meta-analysis of randomized controlled trials evaluating health outcomes and resource utilization, patients adhering to the ERP had reduced length of stay of 2.5 days, and this was a reproducible improvement in the quality of care by enabling standardization of health care processes (10). Similarly, our study confirms this concept with a 35% reduction in hospital stay.

Duration of hospital stay and peri-operative morbidity and complication rate are key determinants of cost. Abdominal surgery is associated with postoperative pain, paralytic ileus, reduced pulmonary function and loss of muscle mass and function, all of which may contribute to postoperative morbidity and need for prolonged hospital stay. ERPs aim to reduce these postoperative complications by preserving the normal

preoperative physiology. Thus, by improving patient outcome with early discharge and reduced morbidity we are able to reduce the cost of treating this group of patients.

The presence of trans-urethral catheters increase incidence of urinary tract infection and hinder patient mobilization. Urine catheters were consistently removed earlier in the ERAS arm of our study after 1.9 days compared to 3.3 days in the traditionally treated arm. There were no urinary tract infections observed in our group of patients, and all patients achieved early independent mobilization after removal of urinary catheter.

Preservation of body composition is vital in order to reduce post-operative morbidity. Early oral nutrition with protein drinks will preserve lean body mass and maintain work performance. All our patients were started on protein drinks on post-operative day 1, and then stepped up to full ward diet by day 2 to 3. In the ERAS arm of our study patients were initiated on solid diet by 2.8 days compared to 3.6 days in the traditionally treated arm, showing earlier initiation of solid diet if patients are managed as per the ERP. Another factor shown to hinder initiation of oral intake is the presence of a nasogastric tube. As per our ERP, nasogastric tubes were consistently removed early. In the ERAS arm of our study, nasogastric tubes were removed after 1.2 days compared to 2.1 days in the traditionally treated arm. This earlier removal of nasogastric tubes facilitated earlier initiation of oral intake. Early removal of nasogastric tubes, early initiation of liquid diet and early ambulation is associated with earlier return of bowel function and earlier discharge from hospital. In our study, 4 patients in the ERAS arm and 2 patients in the traditionally treated arm developed post-operative ileus. We were able to demonstrate early removal of nasogastric tubes with early initiation of oral nutrition and early mobilization.

Early optimal analgesia and early mobilization with physiotherapy are means of improving pulmonary function. Our patients received dedicated chest physiotherapy and were given and taught how to administer a PEEP bottle which has been shown to reduce pulmonary atelectasis. However, 2 patients developed nosocomial pneumonia requiring antibiotics. This was diagnosed by the increased oxygen requirements, pulmonary crepitations, radiological changes on chest radiograph, and elevated white cell counts.

Implementation of ERAS programmes are feasible as long as they are safe. The shortened length of hospital stay is of no benefit if it leads to increase incidence of post-operative complications. There were 12 complications in the ERAS arm and 11 in the traditionally treated arm. However, when analysed there was no statistically significant difference between the 2 groups. This showed that the benefit of reduced length of hospital stay can be achieved without any increase in incidence of post-operative complications.

## Conclusion

This small pilot study shows that early recovery programs can be successfully implemented with significant shorter hospital stays without any increase in postoperative complications in trauma patients undergoing emergency laparotomy for penetrating abdominal trauma. Furthermore, the study shows that early recovery programs can also be applied to patients undergoing emergency surgery. Given the fact that penetrating abdominal trauma remains a substantial burden of disease, especially in developing countries such as South Africa, this proven approach to patient care in elective surgery can now be safely employed in the trauma and emergency setting.

## References

1. Kehlet H. Multimodal approach to control postoperative pathophysiology and rehabilitation. *Br J Anaesth.* 1997;78:606-617. doi:10.1097/00132586-199808000-00048.
2. Lassen K, Soop M, Nygren J, et al. Consensus review of optimal perioperative care in colorectal surgery: Enhanced Recovery After Surgery (ERAS) Group recommendations. *Arch Surg.* 2009;144(10):961-969. doi:10.1001/archsurg.2009.170.
3. Wind J, Polle SW, Fung Kon Jin PHP, et al. Systematic review of enhanced recovery programmes in colonic surgery. *Br J Surg.* 2006;800-809. doi:10.1002/bjs.5384.
4. Throop PP; E. Infrarenal aortic surgery with a 3-day hospital stay: a report of success with a clinical pathway. *J Vasc Surg.* 1999;(29):787-792.
5. Tovar EA, Roethe RA, Weissig MD, Lloyd RE, Patel GR. One-day admission for lung lobectomy: An incidental result of a clinical pathway. *Ann Thorac Surg.* 1998;(65):803-806. doi:10.1016/S0003-4975(97)01381-7.
6. Arumainayagam N, McGrath J, Jefferson KP, Gillatt DA. Introduction of an enhanced recovery protocol for radical cystectomy. *BJU Int.* 2008;(101):698-701. doi:10.1111/j.1464-410X.2007.07319.x.
7. Nicholson a., Lowe MC, Parker J, Lewis SR, Alderson P, Smith a. F. Systematic review and meta-analysis of enhanced recovery programmes in surgical patients. *Br J Surg.* 2014;101(3):172-188. doi:10.1002/bjs.9394.
8. Anderson ADG, McNaught CE, MacFie J, Tring I, Barker P, Mitchell CJ. Randomized clinical trial of multimodal optimization and standard perioperative surgical care. *Br J Surg.* 2003;(90):1497-1504. doi:10.1002/bjs.4371.
9. King PM, Blazeby JM, Ewings P, et al. The influence of an enhanced recovery programme on clinical outcomes, costs and quality of life after surgery for colorectal cancer. *Color Dis.* 2006;(8):506-513. doi:10.1111/j.1463-1318.2006.00963.x.

10. Adamina M, Kehlet H, Tomlinson GA, Senagore AJ, Delaney CP. Enhanced recovery pathways optimize health outcomes and resource utilization: A meta-analysis of randomized controlled trials in colorectal surgery. *Surgery*. 2011;830-840. doi:10.1016/j.surg.2010.11.003.

## Appendix 1

### ERAS in Trauma: Perioperative Protocol

<b>Timing</b>	<b>Intervention</b>
<b>Preadmission</b>	Not applicable in the trauma setting
<b>Preoperative</b>	Perioperative care program information given to patient Preoperative fasting and carbohydrate loading not applicable Preoperative fluid resuscitation commenced in the trauma setting No premedication or thromboprophylaxis Preoperative antibiotic prophylaxis with Augmentin or Triple antibiotic combination (Penicillin, Gentamycin and Metronidazole)
<b>Intraoperative</b>	Thoracic epidural not applicable in the trauma setting Limited intraoperative intravenous fluids (1–2L crystalloids / colloids) Blood products as needed Midline laparotomy incisions Hypothermia prevented using active warming air blanket Insertion of nasogastric tube and urinary catheter Intra-abdominal drains not used if possible Calf stockings applied at the end of surgery
<b>Recovery room</b>	Postoperative analgesia with morphine infusion, intravenous paracetamol (Perfalgan), morphine for breakthrough pain
<b>Day of surgery</b>	Initiation of physiotherapy and patients are mobilized to a chair Oral intake of fluids is started 6 hours after surgery, aiming for > 500 ml Limit intravenous fluid (1L of General Maintenance Solution) Subcutaneous low molecular weight heparin started for thromboprophylaxis (Clexane® 40mg once daily until discharge)
<b>Day 1</b>	Urinary catheter removed Nasogastric tube removed Full solid oral ward diet Supplement nutritional drinks (Ensure, 2–3 per day until discharge) Active mobilization with nursing and physiotherapy input
<b>Day 2</b>	Regular oral multimodal analgesia: Paracetamol (1g 6hourly) and Tramadol (50mg

	<p>6hourly). Continued until discharge.</p> <p>Intramuscular opiates (morphine) for break-through pain only</p>
<b>Day 3 - 4</b>	<p>Discharged home if fulfill following criteria:</p> <p>Tolerating full solid oral diet</p> <p>Passing flatus or faeces</p> <p>Adequate postoperative pain control with oral analgesia</p> <p>Ambulating independently</p> <p>Satisfactory support at home</p>
<b>After discharge</b>	<p>Patient given a phone number for contacting the ward if required</p> <p>Follow up outpatient clinic appointment within 7 days of discharge</p>

## Appendix 2

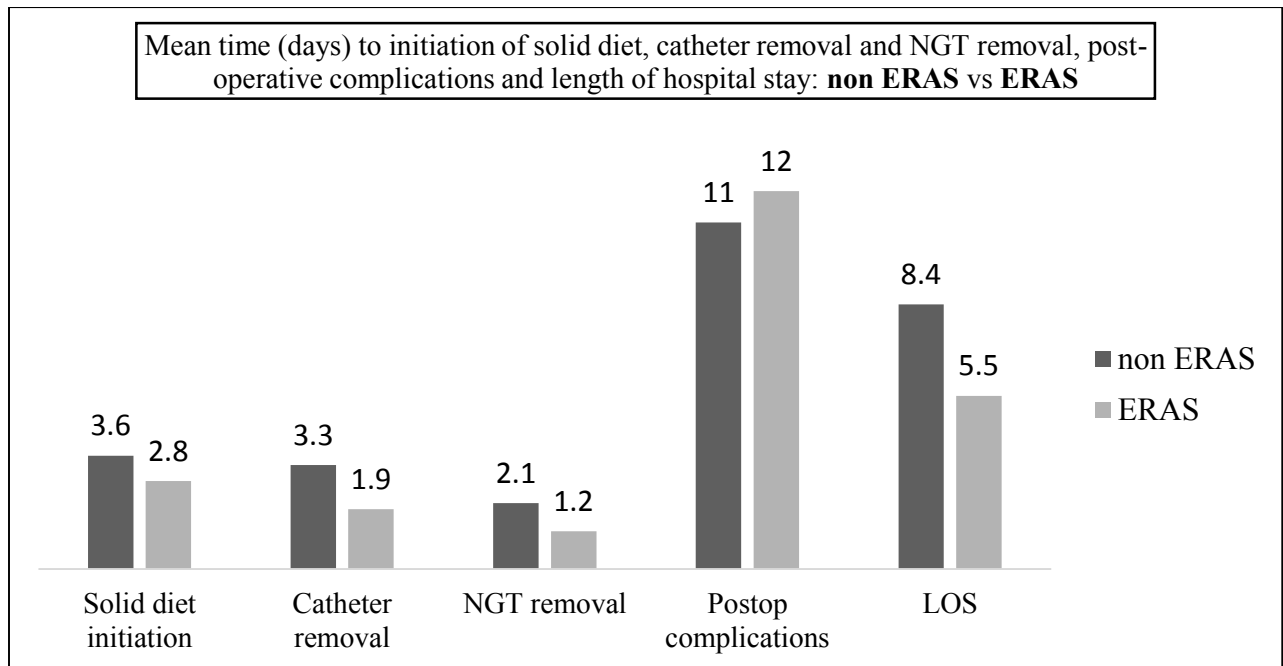
Clavien-Dindo grading system for the classification of surgical complications

Grades	Definition
Grade I:	Any deviation from the normal postoperative course without the need for pharmacological treatment or surgical, endoscopic and radiological interventions. Allowed therapeutic regimens are: drugs as antiemetics, antipyretics, analgetics, diuretics and electrolytes and physiotherapy. This grade also includes wound infections opened at the bedside.
Grade II:	Requiring pharmacological treatment with drugs other than such allowed for grade I complications. Blood transfusions and total parenteral nutrition are also included.
Grade III:	Requiring surgical, endoscopic or radiological intervention
Grade III-a:	Intervention not under general anesthesia
Grade III-b:	Intervention under general anesthesia
Grade IV:	Life-threatening complication (including CNS complications: brain haemorrhage, ischaemic stroke, subarachnoid bleeding, but excluding transient ischaemic attacks) requiring IC/ICU management.
Grade IV-a:	Single organ dysfunction (including dialysis)
Grade IV-b:	Multi-organ dysfunction
Grade V:	Death of a patient
Suffix 'd':	If the patients suffers from a complication at the time of discharge, the suffix "d" (for 'disability') is added to the respective grade of complication. This label indicates the need for a follow-up to fully evaluate the complication.

For more information, visit [http://www.surgicalcomplication.info/templates\\_download.html](http://www.surgicalcomplication.info/templates_download.html)

### Appendix 3

#### Overall results summary



## STUDY APPROVALS

### HUMAN RESEARCH ETHICS COMMITTEE APPROVAL



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



Room ES2-24 Old Main Building  
Groote Schuur Hospital  
Observatory 7929  
Telephone (021) 406 6492 + Facsimile (021) 406 6411  
Email: Sumayyah.ariet@uct.ac.za  
Website: [www.health.uct.ac.za/research/humanethics/forms](http://www.health.uct.ac.za/research/humanethics/forms)

05 December 2013

HREC/REF: 707/2013

Dr MR Moydien  
c/o Prof P Navsaria  
Division of General Surgery  
J-Floor  
OMB

Dear Dr Moydien

**Project Title:** ENHANCED RECOVERY AFTER SURGERY (ERAS) IN PENETRATING ABDOMINAL TRAUMA

Thank you for your response letter dated 20 November 2013, addressing the issues raised by the Human Research Ethics Committee.

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

Approval is granted for one year until the 30 December 2014.

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

Please note that the on-going ethical conduct of the study remains the responsibility of the principal investigator

Please quote the HREC REF in all your correspondence.

Yours sincerely

PROFESSOR M BLOCKMAN  
CHAIRPERSON, HSF HUMAN ETHICS

**UCT POSTGRADUATE ADMINISTRATION APPROVAL**

**UCT POSTGRADUATE ADMINISTRATION APPROVAL**

Dear Dr Moydien

**Candidature Approval (MYDMAH001)**

	MMed in Surgery
Title	Early recovery after surgery (ERAS) in trauma surgery: a prospective single-center pilot study
Department	Surgery
Supervisor	A/Prof P Navsaria
Ethics Approval	707/2013

I am pleased to advise that the Chair of the Dissertations/Doctoral & Masters Committee has approved your candidature for the above degree on behalf of the Committee. Formal approval was obtained by publication in the Dean's Circular, PG-Med Nov – Dec2014.

Yours sincerely

Vuyi Mgoqi

**Vuyiseka Mgoqi | Receptionist: PG Academic Administration | Faculty of Health Sciences | University of Cape Town | Room N2.19, Wernher & Beit North, Health Sciences Campus, Anzio Rd, Observatory, 7925 | ☎ + 27 21 406 6751 6 + 27 21 406 6584 | Office Hours: 08h30 - 16h30 Unavailable Hours: 13h00 - 13h30**