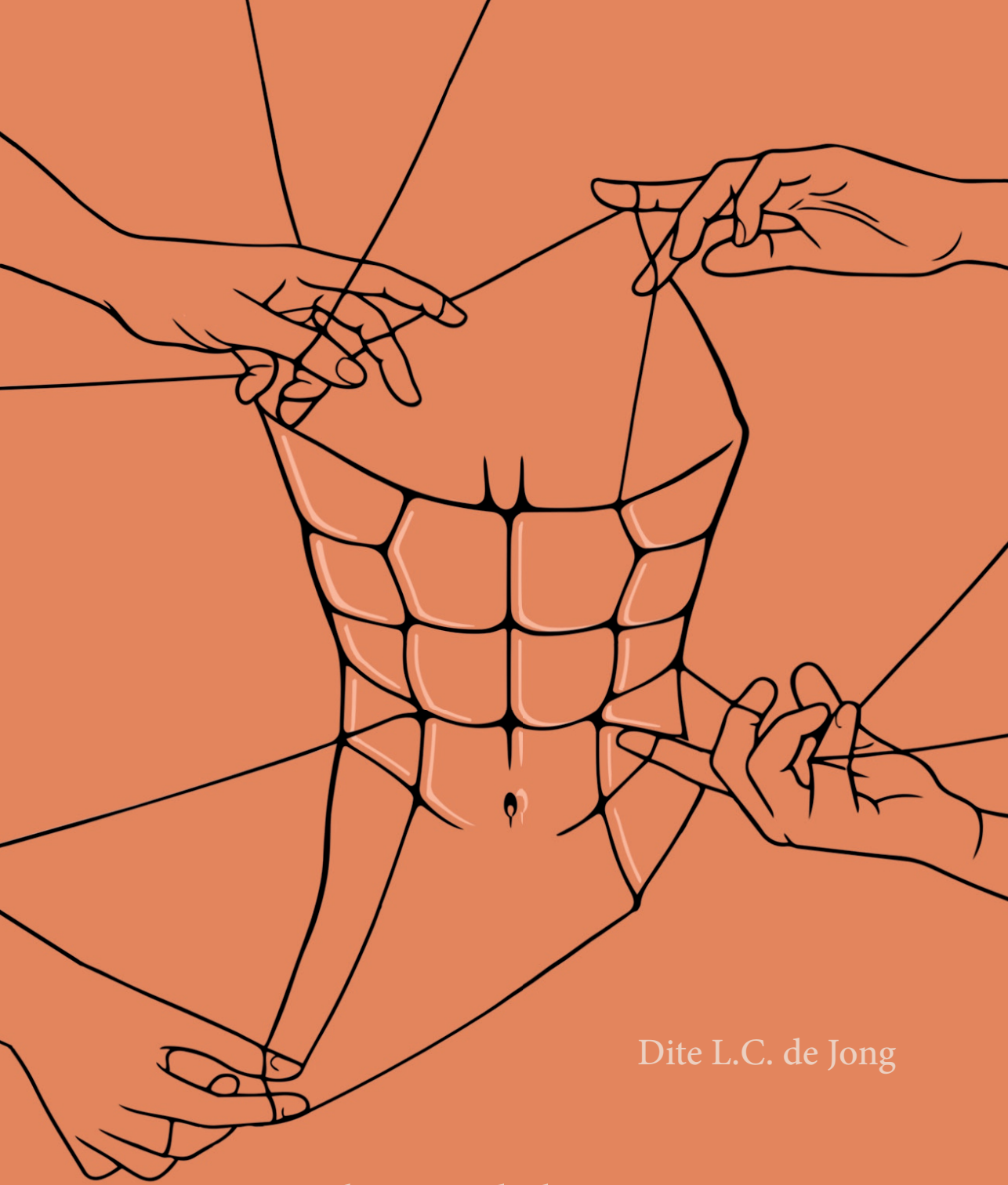




Dite L.C. de Jong

Multimodal optimization in abdominal wall surgery

Stellingen horende bij het proefschrift
Multimodal optimization in abdominal wall surgery
D.L.C. de Jong

1. De chirurgische benadering van complexe buikwandbreuken is verschillend per individu en dient weloverwogen gekozen te worden aan de hand van anatomische en patiëntgerelateerde factoren. *(dit proefschrift)*
2. Psychologische kwetsbaarheid vóór operatie is een belangrijk onderdeel van de preoperatieve risicostratificatie bij patiënten met een complexe buikwandhernia. *(dit proefschrift)*
3. De indicatiestelling en planning van IC opname na complexe buikwandchirurgie wordt verbeterd door multidisciplinair overleg. *(dit proefschrift)*
4. Technische haalbaarheid, perioperatief risico en verwachte winst op kwaliteit van leven vormen de drie-eenheid van belang voor indicatiestelling van chirurgische interventie bij complexe buikwandhernia's. *(dit proefschrift)*
5. Prehabilitatie met Botox verbetert de chirurgische resultaten van complexe buikwandhernia operaties. *(dit proefschrift)*
6. Gestandaardiseerde perioperatieve protocollen verhogen de patiëntveiligheid, maar klinisch oordeel blijft onmisbaar voor individuele risicoprofielen. *(Ghanmi, 2024)*
7. Een cultuur van continue reflectie en feedback binnen het OK- en IC- team is cruciaal voor duurzame kwaliteitsverbetering en optimale patiëntuitkomsten. *(Pasquer, 2024)*
8. Een systematische evaluatie van kwaliteit van leven verschuift de definitie van succes in de buikwandchirurgie van technische uitkomsten naar patiëntgerichte resultaten.
9. Het onderbuikgevoel hoeft niet altijd uit de onderbuik te komen.
10. Overzicht creëren door een stap terug te doen is soms de enige manier om echte winst te boeken.
11. De geneeskunde kan leren van topsport: herstel is minstens zo belangrijk als inspanning.

Multimodal Optimization in Abdominal Wall Surgery

D.L.C. de Jong

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Multimodal Optimization

in Abdominal Wall Surgery

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Aan mijn ouders, Aan Fleur,

De aanhouder wint.

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1

Introduction

This thesis focusses on a late complication of abdominal surgery: incisional hernia. Occurring between 10-30% after laparotomy, incisional hernias remain a common condition in surgical practice. Some incisional hernias, particularly those with a large abdominal wall defect, significant evisceration and/or concurrent infection, are considered a complex abdominal wall hernia (CAWH) [1]. Symptomatic CAWHs lead to morbidity, recurrent hospitalizations, and operations. These hernias burden patients, the health care system, and society as a whole, due to reduced quality of life, increased healthcare costs, and long-term work disability [2]. Surgical management of CAWHs can be very demanding. This chapter explores the considerations and challenges that guide surgical decision-making.

INCISIONAL HERNIA

An incisional hernia (IH) is defined as a defect in the abdominal wall, with or without a bulge, at the site of a previous surgical scar. It can be detected by clinical examination or radiological imaging [3]. A review by Bosanquet et al. reported development of an IH in 12.8% of all patients after any type of midline abdominal incision, with approximately one-third (35%) undergoing subsequently repair [4].

The burden of incisional hernia to both patients and society should not be underestimated [5]. Patients undergoing incisional hernia repair often enter a circle of recurrence and reoperation, with increasingly poor outcomes [6]. The cost of this typical surgical complication to healthcare services is huge, with hernia-related healthcare expenditure in the United States reaching \$3.2 billion annually [7]. In France, a retrospective study showed hospital costs amounted to €4153 per repair, totaling nearly €67.7 million per year [8].

COMPLEX ABDOMINAL WALL HERNIA

Some authors define difficult-to-close IHs as complex abdominal wall hernias (CAWHs), while others focus on patient-related factors that impair healing and reduce abdominal wall strength [9]. A clear-cut definition is lacking; however, it is evident that patient-related, disease-related, and technical factors all contribute [10]. The following definition for a CAWH, as described by the European Hernia Society (EHS), is used in this thesis: any IH with one or more of the following characteristics: a large defect (>10cm, or several hernias situated anatomically apart from each other adding up to a width >10cm), located near a bony structure, with loss of domain (LOD), associated with local infection or an entero-atmospheric fistula, re-recurrence and presence of co-or multimorbidity [11, 12]. Using this definition, Deerenberg estimated the prevalence of CAWHs to be at 15% of all incisional hernias [13, 14].

CLASSIFICATION OF CAWH

To compare treatment outcomes, the Ventral Hernia Working Group (VHWG) proposed a grading system for ventral hernias in 2010. This system ordinarily ranks patients in groups with increasing risk of postoperative surgical site complications or recurrences [15]. Hernias are graded from 1 (clean defects in healthy patients) to 4 (contaminated defects). Though VHWG does not account for hernia characteristics, which is an independent risk factor for postoperative complications. Moreover, the system lacks external validation (table 1) [16]. In 2012, the VHWG classification was revised into a simplified three-tiered system that integrates key patient-related factors, such as obesity, diabetes, immunosuppression, and smoking. By categorizing patient into low-, moderate-, and high-risk groups, this updated version allows for more practical risk stratification (table 2) [17].

Table 1: VHWG grading system 2010 [15]

Grade	Risk category	Characteristics
1	Low risk	- Low risk of complications - No history of wound infection
2	Co-morbid Conditions	- Diabetes - COPD - Immunosuppression - Active smoker - Obese
3	Potentially Contaminated	- Previous wound infection - Stoma present - Violation of the gastrointestinal tract
4	Infected	- Infected mesh - Septic dehiscence

Table 2: VHWG grading system 2012 [15]

Grade	Risk category	Characteristics
1	Low risk	- Low risk of complications - No history of wound infection
2	Co-morbid	- Diabetes - COPD - Immunosuppression - Active smoker - Obese
3	Contaminated	- Previous wound infection - Septic dehiscence - Stoma present - Violation of the gastrointestinal tract

To provide a more accurate risk prediction for postoperative complications such as surgical site occurrences (SSOs) and recurrence, incorporating hernia size, Petro et al. developed the Hernia, Patient, Wound (HPW) classification (table 3)[18]. A stepwise risk increases for

both SSOs and recurrence is seen at cut-off values for hernia width of <10cm, 10-20cm, and >20cm [19].

Table 3: HPW classification for incisional hernias [20]

	Hernia	Patient	Wound	HPW stage
Stage 1	1	0	0	H1, P0, W0
Stage 2	1 or 2	Any	0	H1, P1, W0 H2, any P, W0
Stage 3	Any	Any	0 or 1	H1, any P, W1 H2, any P, W1 H3, P0, W0
Stage 4	3	Any	0 or 1	H3, P1, W0 H3, any P, W1

The VHWG grading system standardizes hernia assessment based on size, location, and complexity. This provides a standardized approach to hernia assessment and treatment planning. In contrast, the HPW system evaluates the condition and postoperative complication risks. While VHWG focuses on hernia characteristics, the HPW extends this by also focusing on patient and wound characteristics possibly influencing postoperative outcomes.

Another classification tool is the Carolinas Equation for Determining Associated Risks (CeDAR), which predicts the risk of wound complications after CAWR. This algorithm demonstrates that wound complication rates increase with the presence of increasingly more risk factors, like smoking, obesity, diabetes, poor nutritional status, and previous abdominal surgeries [21].

Preoperative patient assessment using VHWG 2012, HPW or CeDAR helps identify risks for complications following CAWR. Modulating these risk factors preoperatively may improve outcomes.

PATIENT FACTORS

Patient factors that may hamper successful CAWR are age, active smoking, diabetes, obesity, cardiopulmonary disease, malnutrition, and the use of anticoagulative and/or immunosuppressive drugs [19].

Smoking

In general surgery, preoperative smoking is found to be associated with an increased risk of general morbidity, wound complications, general infections, pulmonary complications, neurological complications, and admission to the intensive care unit [22]. In abdominal wall surgery, it is found that current smokers have an increased likelihood of 30-day mortality

(OR 1.42), overall morbidity (OR 1.39), wound (OR 1.40), respiratory (OR 1.14), or cardiac morbidity (OR 1.88) compared to non/ex-smokers ($p < 0.05$) [23]. Recurrence rates post-IH repair are also higher [24]. Though a few studies question its clinical impact [25], smoking is generally deemed detrimental.

Diabetes

Patients with diabetes mellitus (DM) are considered to have impaired wound healing. DM is therefore contemplated to be a risk factor for not only the development of IH, but also for SSIs and a risk factor for recurrence [26, 27]. Glycated hemoglobin (HbA1c) is a commonly used metric for assessing long-term blood glucose levels and predicting postoperative complications [28]. An expert consensus advised against elective CAWR in patients if HbA1c $> 8\%$ (64mmol/mol) [29]. Another study suggests that an elevated preoperative glucose level was associated with an elevated risk of complications following ambulatory hernia surgery [30]. It is found that DM significantly increases the risk (OR 3.54; 1-12.56) of IH recurrence after laparoscopic repair [31]. Additionally, HbA1c $> 64\text{mmol/mol}$ is associated with an increased risk of postoperative complications, including infections and mortality [32].

Obesity

Obesity raises risks for developing IH and complications before and after IH and CAWR, including incarceration, surgical site infections (SSIs), and recurrence [33-35]. Body mass indexes (BMI) as low as 30 kg/m² have demonstrated in large studies to increase the risks of medical and surgical complications [36]. Patients with BMI $> 40\text{kg/m}^2$ face over double the risk for complications, with odds ratios increasing with BMI [37]. Morbid obesity is associated with an increased 90-day wound morbidity [38-41].

Pulmonary condition

Pulmonary comorbidities (e.g., COPD, asthma) heighten risks of pulmonary complications, longer recovery, and ICU stays after IH repair. COPD is linked to SSOs, recurrence, and respiratory failure. Poor lung function impairs wound healing and abdominal wall mechanics.

Mental health

Conditions like depression, anxiety, and PTSD may impair surgical recovery by disrupting immune function and wound healing via chronic stress and HPA-axis dysregulation. They can also reduce adherence to care and rehabilitation. Despite these mechanisms, their role in hernia outcomes remains largely unstudied [42].

PREHABILITATION

Prehabilitation encompasses a set of best practices, before elective surgery, to optimize the patient's health during and after surgery with the potential to positively impact long-

term health [43]. Collaboration with other medical and surgical specialties like geriatric-, infectious disease and bariatric physicians, as well as physical therapist is often warranted to achieve best results [44]. Smoking cessation and weight loss reduce complications following CAWR in one study [45]. Delaying surgery for preoperative optimizing reduced surgical complication rates up to 40% [46-48]. Increased exercise frequency (versus no reported exercise) was associated with significantly lower rate of postoperative complications, as well as readmissions [49, 50].

Prehabilitation also encompasses preoperative injection of botulinum toxin A (BTA), especially in patients with large hernias (>10 cm) or with significant LOD [44]. BTA, a neurotoxin with established therapeutic applications in various medical fields, inhibits acetylcholine release at neuromuscular junctions, leading to an inability to contract the muscle. Thus, a flaccid and temporary paralysis of muscles develops [51]. When administered preoperatively, BTA induces a reversible elongation of the lateral abdominal wall muscles which facilitate a reduction in abdominal wall stiffness (compliance). The efficacy of BTA relies on reducing the circumferential tension, which facilitates primary fascial closure (PFC) in the midline [52, 53]. The use of BTA could be opted for patients with expected difficulty for PFC [54, 55]. However, while BTA has shown promise in improving PFC rates, its precise role, optimal patient selection, and long-term benefits remain areas of ongoing investigation. Questions persist regarding the durability of its effects, potential complications, and whether all patients with anticipated PFC difficulty truly benefit from its use.

Despite evidence, prehabilitation is underused: only 20–53% of high-risk CAWH patients received optimization in a US study [70]. Financial concerns and lack of awareness are major barriers [50].

It may be beneficial to implement a quality improvement intervention under guidance of a multidisciplinary team that discusses patient optimization and prehabilitation targets [71]. Extending the focus beyond prehabilitation alone to the broader care pathway, could ensure optimal patient management from diagnosis to recovery. In the Netherlands, this approach is increasingly emphasized through multidisciplinary care models, integrating prehabilitation, surgical planning, and postoperative rehabilitation to enhance overall patient outcomes. In the Dutch Midline incisional hernia guideline, it is advised to preoperatively counsel patients for surgery, and to involve relevant patient- and hernia factors, such as obesity, DM, LOD, and contamination [72]. Elective CAWR should only be performed after optimization [73].

Only a few Dutch hospitals qualify as tertiary referral hospital for CAWR. However, a descriptive analysis demonstrated that hernia surgery is performed in every hospital, by surgeons with different backgrounds (abdominal, trauma, vascular), using many different techniques [39]. No common preoperative care pathway exists. If the European Hernia Society (EHS)

requirements to be accredited as a hernia center for CAWR are used as a measuring rod, only 3% of the Dutch hospitals could actually be accredited.

MDTs are increasingly applied in abdominal wall surgery; however little evidence is available on its use in the Netherlands. An MDT might facilitate the indication of a preconditioning program prior to CAWR [71, 74]. In our center, this MDT is thoroughly prepared: each involved specialist- including the pulmonologist, intensivist, anesthesiologist, cardiologist, physiotherapist and surgeon- has assessed the patient in an outpatient setting when relevant, with the surgeon, physiotherapist and anesthesiologist evaluating every patient as a standard part of the pathway. This structured, pre-assessed approach allows for a well-informed discussion on further optimization and surgical eligibility.

The long-term impact of prehabilitation strategies, including psychological and physical optimization, on patient outcomes remain underexplored. Risk factor interventions and centralized care models also warrant evaluation.

PATIENTS WITH CAWH

CAWHs severely affect patients' quality of life (QoL), with impacts on physical function, pain, and psychosocial wellbeing [56-61].

Patients with CAWH often experience substantial restrictions in mobility and daily activities. The presence of a large hernia can lead to discomfort, postural changes, and difficulties in performing basic tasks such as lifting, bending or prolonged standing [62]. Moreover, beyond physical symptoms, CAWH significantly affects mental health and social functioning. Many patients report feelings of embarrassment or social withdrawal due to the visible bulge of the hernia. Anxiety and depression seem to be more prevalent in this population; however evidence is lacking on prevalence. The loss of independence and work-related disabilities could contribute to reduced QoL scores in assessments such as the Hernia-Related Quality of Life Survey (HerQLeS) and EQ5D-3L/5L. This is a standardized questionnaire that measures QoL related to hernias across different dimensions [63]. Other questionnaires to measure QoL encompass the short form 36 (SF-36), which assess physical and mental health across eight domains. Hernia specific tools like the Carolinas Comfort Scale (CCS) and HerQLeS evaluate symptoms, movement limitations, and the impact of hernias on daily life.

For example, mental health components of the SF-36 showed 20-30% lower scores in patients with CAWH compared to the general population. Patients reported social isolation, depression, and anxiety, partly due to physical limitation and the cosmetic aspect of the hernia [64].

Although some authors have already documented complex abdominal wall repair (CAWR) to be beneficial in terms of QoL, variations in measurement instruments and surgical techniques still lead to inconsistent evidence due to non-comparability of questionnaires, patients' groups and surgical techniques [65].

Incorporating psychological interventions as part of prehabilitation could also be beneficial to optimize psychological well-being potentially leading to postoperative outcomes. Preoperative anxiety, depression and low self-efficacy are not just mental health concerns- they have been associated with worse physiological surgical outcomes and postoperative QoL [66]. A growing body of research highlights the positive impact of psychological interventions, such as cognitive behavioral therapy (CBT), mindfulness-based stress reduction (MBSR), and relaxation techniques, on preoperative patients, especially those undergoing major surgeries [67, 68]. These interventions aim to reduce preoperative anxiety, improve coping mechanisms, and increase a patient's sense of control and self-efficacy, all of which can contribute to better surgical outcomes. A systematic review focusing on patients undergoing surgery for cancer found that preoperative psychological interventions positively affected patients' immunologic function and reported outcomes, including psychological well-being and QoL [69]. Moreover, interventions aimed at enhancing self-efficacy—patients' belief in their ability to manage their health and recovery—are associated with more positive recovery trajectories.

COMPLEX ABDOMINAL WALL REPAIR

Hernia repair is one of the most common surgical procedures [4, 64]. In the Netherlands, approximately 4200 IHs were repaired between 2012-2014 [75]. A systematic review from Deerenberg et al. estimated that 15% of these repairs were CAWHs [14], equating to ~600 yearly CAWRs. Treatment can be conservative or surgical.

To understand the technique behind (surgical) treatment, one must understand the anatomy of the abdominal wall. The abdominal wall –including the sixpack - includes the anterolateral and posterior muscle groups, which function both in truncal stabilization and respiration (image 1) [76]. The anterolateral abdominal muscles consist of five major, paired muscles: M. Obliquus Externus, M. Obliquus Internus, M. Transversus Abdominis (these three forming the lateral abdominal wall musculature (LAWM)), M. Rectus Abdominis, and M. Pyramidalis. The anterolateral abdominal wall is primarily supplied by the superior and inferior epigastric arteries (branches of the internal thoracic and external iliac arteries, respectively) and the intercostal, subcostal, and deep circumflex iliac arteries. Venous drainage parallels the arterial supply. Innervation is provided by the lower six thoracoabdominal nerves (T7–T11), the subcostal nerve (T12), and the iliohypogastric and ilioinguinal nerves (L1), which supply motor and sensory function [77, 78]. Together, these muscles generate intra-abdominal pressure and assist with respiration, trunk stability, and forceful exhalations [76].

Conservative treatment

Abdominal binders may relieve symptoms but are symptomatic only and may worsen pressure [80]. Also, a strategy of watchful waiting (WW) might be considered in some patients [81]. However, studies show that WW leads to high crossover rates with significantly greater incidence of intraoperative problems, particularly in patients who require emergency repair of IH owing to incarceration [82]. A 1-year cumulative incidence of incarceration was found at 1.24%, increasing with present risk factors. However, this is associated with a significant risk of death [83, 84]. Other studies report WW to be a safe strategy in the treatment of IH [85]. Furthermore, it has been hypothesized that physical prehabilitation could reduce hernia symptoms due to increased fitness, and with that abate the need for CAWR.

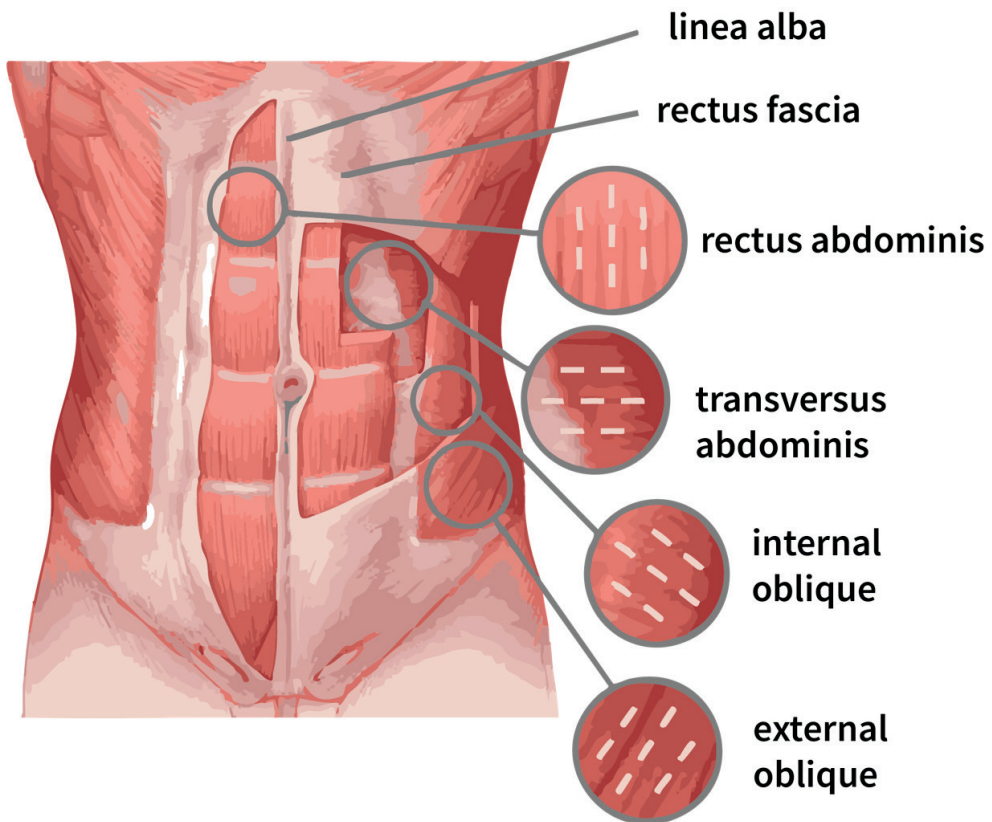


Image 1: Anatomy of the anterolateral abdominal wall [79]

Surgical treatment

Surgery is the only curative option. Over the past few decades, the approach to abdominal wall hernias has undergone significant changes. Key was the introduction of a non-resorbable mesh to augment a primary closed defect. The most widely applied open surgical technique is retrorectus dissection, followed by midline reconstruction and retromuscular mesh im-

plantation (image 2), as described by Rives and Stoppa, with favorable outcomes compared to any other open technique [86, 87]. The development of the retromuscular mesh marked an important advancement in minimizing complications and improving outcomes in hernia surgery [88]. Despite, meshes were also associated with new complications like infections and mesh migration [89].

In the years that followed, attention was given to laparoscopic techniques, with bridging intra-abdominal meshes becoming increasingly common.

Primary fascial closure (PFC) of midline hernias (< 10 cm) is often feasible. For CAWH without the possibility of primary fascial closure, numerous techniques have been developed. The transversus abdominis release (TAR) by Novitsky et al. [90], has the advantage of closing very large defects up to 20 cm, or defects near bony structures.

Open and (robot-assisted) laparoscopic or endoscopic techniques are nowadays used, tailored to patient and hernia characteristics [91].

There is limited consensus on the timing and criteria for surgical intervention in incisional hernia (IH) patients, particularly when comparing elective and emergency procedures. Current data on watchful waiting (WW) versus surgical repair fail to provide conclusive recommendations for specific patient subgroups

Eindsituatie na TAR met retromusculaire mesh

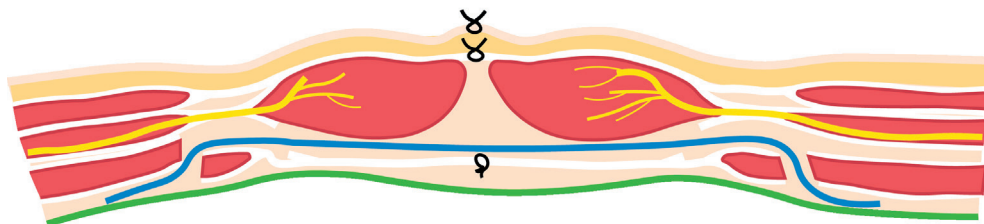


Image 2: Retromuscular mesh after TAR [92]

OUTLINE OF THIS THESIS

The physical and psychological impact of CAWH generally decreases the quality of life (QoL) in these patients. Although prevention of strangulated hernia or mesh infections are strong indications for repairing a CAWH, improving the QoL is ultimately the most important indication to perform a complex abdominal wall reconstruction (CAWR). However, to what extent a CAWR contributes to changing QoL is little known. **Chapter 2** explores pre- and postoperative QoL outcomes in CAWR, by means of a systematic review and meta-analysis.

Psychological prehabilitation is another underexplored aspect of preoperative care in CAWR. **Chapter 3** and **chapter 4** delve into this topic, combining a letter to the editor summarizing the existing literature on psychological prehabilitation in abdominal wall surgery with a snapshot study investigating the incidence and risk factors of psychological distress among these patients. Together, these chapters highlight the importance of addressing psychological factors as part of a comprehensive prehabilitation approach.

Beyond psychological prehabilitation, improving a patient's overall physical and psychological capacity preoperatively through multidisciplinary collaboration is key to optimizing outcomes. **Chapter 5** evaluates the impact of multidisciplinary team meetings (MDT) and prehabilitation strategies on outcomes in CAWR, while **chapter 6** investigates the role of MDT in planning intensive care unit (ICU) admissions for patients undergoing CAWR. Tailored approaches are essential in addressing the wide variability of incisional hernia (IH) presentations, despite standardized guidelines. In cases with significant loss of domain (LOD) or concerns about achieving primary fascial closure (PFC), the preoperative administration of Botulinum Toxin A (BTA) may play a role in preventing the need for component separation techniques. This strategy is discussed in **chapter 7**.

Further advancements in surgical techniques are analyzed in **chapter 8** and **chapter 9**, where the indications, expertise, and outcomes of two distinct component separation methods are examined.

In patients with perineal incision hernias after an abdominoperineal rectal resection it is unclear which operative technique has a better outcome in terms of recurrence: a mesh alone or use of synthetic mesh to mesh combined with tissue flaps. **Chapter 10** compares these methods in perineal hernia repair.

Delaying elective hernia surgery, due to non-patient related factors, may affect patient care in terms of increasing rates of emergency surgeries. The impact of delay by environmental factors (COVID-19 pandemic) on outcomes in hernia surgery is discussed in **chapter 11**.

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2

Does quality of life improve after complex incisional hernia repair? A systematic review

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Introduction

Health-related quality of life (QoL) is an essential patient-reported outcome in abdominal wall surgery. The aim of this systematic review was to evaluate short term outcome of QoL after complex incisional hernia repair (IHR), focusing on open surgery.

Methods

A multi-database systematic search was performed on patients treated for complex IHR. Studies evaluating the outcome in terms of QoL using validated questionnaires, at least three months postoperatively, were included. The methodology was graded, and patients' operative and outcome details were extracted.

Results

Seven studies were included, encompassing 729 patients, all of whom underwent an open approach. A significant increase in QoL was found in all types of questionnaires (Short Form-36 (SF-36), Carolinas Comfort Scale, Hernia Related QoL, and Numeric Rating Scale). SF-36 was used most frequently. A pooled standardized mean difference (SMD) of 0.70 (95% CI: 0.08-1.47 $p < 0.00001$) was yielded, indicating a moderate to large effect of the intervention compared to preoperative scores.

Conclusion

A limited number of studies have included QoL measurement after incisional hernia repair. In all studies, a significant increase was seen in QoL postoperatively. This review highlights the substantial benefits of open surgery in improving QoL, while emphasizing the need for further research to standardize outcome measurement and explore long-term results.

INTRODUCTION

An incisional hernia impairs abdominal wall function to varying degrees, depending on size and location of the defect. As a consequence, a range of physical and emotional factors, including pain, limited mobility, gastrointestinal issues, cosmetic concerns, psychological stress, and anxiety about potential complications may lead to a reduced quality of life (QoL) in a patient [1-6]. Surgically restoring the abdominal wall anatomy and function prevents strangulation of hernia contents and enhances truncal stability, both improving QoL [7-9]. Given the fact that a patients' primary goal of a surgical intervention for any incisional hernia is ultimately improving one's quality of life, this outcome measurement requires more attention [10, 11].

While traditional clinical measures like complication and recurrence rates are the most commonly reported outcome measurements after IHR, these metrics fail to fully capture patients subjective experience [10, 12, 13]. Although some authors have already documented IHR to be beneficial in terms of QoL, variations in measurement instruments and surgical techniques still lead to inconsistent evidence due to non-comparability of questionnaires, patients' groups and surgical techniques [13]. Due to large heterogeneity of available instruments, determination or standardization of instruments is preferred [14]. Therefore, recent hernia guidelines unambiguously highlighted the need of more argumentative research for QoL after incisional hernia repair in terms of the abovementioned categories [15].

QoL after IHR is assessed with patient-reported outcome measures (PROMs) mostly described by questionnaires. Two frequently used *general* health surveys that evaluate overall physical and mental health and depict a broad view of patient's well-being and functioning in daily life, are the Short-Form 36 (SF-36) and EQ-5D-5L [16, 17]. Two commonly used *hernia-specific* health surveys that measures discomfort, pain, physical function, emotional distress, caused by the hernia during rest, movement and daily activities, are the Hernia-Related Quality of Life Survey (HerQLes), and The Carolinas Comfort Scale (CCS) [14, 18]. Other available questionnaires encompass the Ventral Hernia Pain Questionnaire (VHPQ) and the Activities Assessment Scale (AAS), and the EuraHS QoL [14, 15, 19]. These health surveys should be applied at well-defined points in time before and after IHR to ensure that evidence remains consistent and that all results are interpreted uniformly [20, 21].

As mentioned before, incisional hernia can reduce QoL due to pain, mobility issues, and psychological stress. While IHR aims to enhance QoL, current studies often rely on complication and recurrence rates, which overlook patients' subjective experiences. Inconsistent measurement tools and techniques further complicate the evidence proving an increase in QoL after IHR, revealing a significant gap in standardized, patient-centered QoL data.

When comparing techniques, it could be hypothesized that laparoscopic surgery promotes recovery and body image due to minimally invasive scars, which might suggest that PROMs

improve more significantly after laparoscopic surgery, when compared to open surgery. However, open surgery might be more beneficial in more complex cases, due to an increased liberty in the form of intraoperative visualization [16]. However, recent literature does not support a conclusion on differences between open and laparoscopic surgery [22].

The aim of this systematic review was to assess the improvements in quality of life (QoL) in patients undergoing elective incisional hernia (IH) mesh repair within one year post-surgery.

METHODS

A systematic literature search was conducted under the guidance of a medical librarian, covering PubMed, EMBASE, and Cochrane Library from January 1st, 2000, to October 1st, 2024. Terms for “incisional hernia” and “patient-reported outcomes” were combined, including both MeSH and free-text terms (detailed search terms in Appendices).

Additionally, reference lists were manually reviewed to identify any missed studies. Inclusion and exclusion criteria were predefined, and duplicate records were removed. Two authors independently screened, selected, and reviewed studies, with consensus discussions held for final inclusions. For quality assessment, the MINORS criteria were used for non-randomized studies, and the Cochrane Risk of Bias Tool for randomized studies. A third reviewer resolved any disagreements.

Data extraction

Selection criteria for inclusions were patients with complex hernias (e.g., defects >10cm, patient risk factors, recurrent hernias, large loss of domain, infection or contamination in the surgical field) undergoing open or laparoscopic IHR [23]. Studies evaluating outcomes solely for laparoscopic procedures or including mixed groups without separate data for open repair were excluded. Additionally, studies reporting only pre- or postoperative data were excluded. Data extracted included study design, sample size, hernia size, surgical technique, follow-up period, PROMs, and outcome measures, following PRISMA guidelines. All efforts were taken to contact authors, when information was missing. Data was extracted for QoL measurement instruments.

Data analysis

The methodical heterogeneity of the studies was examined, regarding the measure of PROM used, and the outcomes of the specific PROM metric used. All continuous data was reported by a mean, together with standard deviation (SD).

A meta-analysis was conducted to synthesize the results. Effects sizes were pooled using a random-effects model to account for heterogeneity, and the summary statistic was a pooled standardized mean difference (SMD). Statistical analyses, including tests for heterogeneity (I^2 statistic) were performed to evaluate consistency across studies, using RevMan (Cochrane, 5.4.1, 2020) due to the expected likelihood in methodological differences. Heterogeneity was assessed using Chi^2 . A p-value of <0.05 was considered statistically significant.

RESULTS

The systematic search yielded 118 articles, with an additional 11 identified through hand searching, as detailed in Figure 1. After screening, seven articles met the selection criteria and were agreed upon by all reviewers for final analysis [3, 14, 20-23].

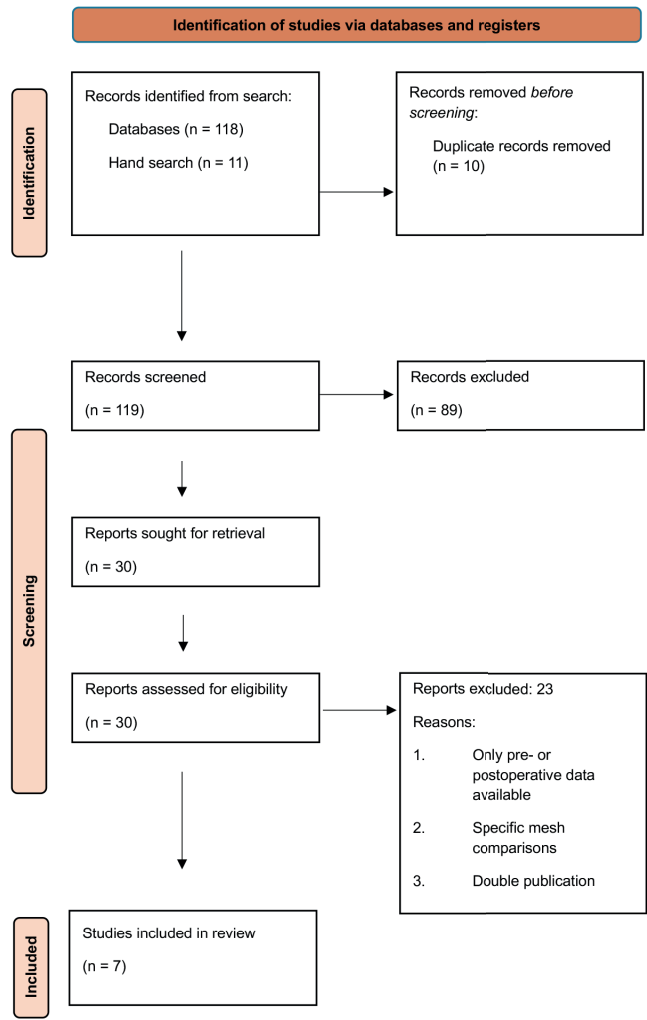


Figure 1: Process of inclusions

Characteristics

Among the included articles, two were prospective, and five were retrospective studies, encompassing a total of 729 patients who underwent open incisional hernia repair (Table 1). All studies included both male and female participants. Five studies described specific hernia size,

ranging from 138.5cm² to 300cm². One study described the inclusions of large hernias, but not the exact size. Another study did not mention hernia size. Studies that included laparoscopic procedures or mixed groups without separate data for open repair were excluded from analysis.

Study quality and risk of bias assessment

The Minors score for the non-comparative study was median 11 out of maximum 16 points and median 17(range 15-24) for the four comparative studies out of maximum 24, both indicating good study quality (table 2).

The Cochrane Risk of Bias Tool showed low concerns for bias in the randomized study (table 3).

Quality of life assessment tools

There was clinical heterogeneity in the tools for assessment of QoL throughout the included articles. QoL was measured using SF-36 in 337 patients, the Carolinas Comfort Scale in 381 patients, and the EQ-5D-3L in 233 patients. Additional tools included the Hernia-Related Quality of Life Survey in 91 patients, and EuraHS QoL, also used in 91 patients. One study utilized an NRS for pain classification in 142 patients. QoL data were described after six months in three studies and after twelve months in four studies.

Outcome measures

The SF-36, used in most studies, showed statistically significant improvements across all domains post-surgery ($p < 0.0001$). Improvements were particularly notable in role physical, general health, and role emotional domains (Table 4).

Other QoL instruments, including EQ-5D-3L, HerQLes, EuraHS QoL, and CCS, reported significant improvements in pain reduction, activity limitation, and mesh sensation, with p -values < 0.0001 . The CCS specifically showed significant improvements in pain ($p = 0.0004$) and activity limitation ($p = 0.0001$) (Table 5).

Overall Effect Size

The meta-analysis included 7 studies, all focused on open procedures, yielding a pooled standardized mean difference (SMD) of 0.70 (95% CI: 0.13 to 1.30, $p < 0.04$), indicating a moderate to large effect of the intervention compared to the preoperative values group (Figure 2).

The I^2 test showed a heterogeneity of 96%, indicating a high level of heterogeneity in the meta-analysis.

Table 1. Characteristics of the included studies

Study	Year	Study design	Number of patients	Open surgery (%)	Laparoscopic surgery (%)	Follow up time (months)	Hernia size, cm ² , mean (range or SD)	BMI, kg/m ² , median (range or SD)	Outcome measures	Questionnaire used
Licari et al. [29]	2019	RC	142	142 (100)	0 (0)	6	138.5 + 2.63	29 + 3.74	QoL, pain	SF-36, NRS
Mussack et al. [30]	2006	Matched control	48	24 (50)	24 (50)	12	135 (45-1050)	32 (21-44)	QoL	SF-36
Antic et al. [13]	2022	PR	91	91 (100)	0 (0)	6	11.7+8.4	26.4 + 5.9	QoL	SF-36, EQ5D3L, HerQLES, EuraHS QoL
Blair et al. [31]	2017	RC	292	292 (100)	0 (0)	12	291.2 + 236.2	34 + 7.9	QoL	CCS
Klima et al. [6]	2014	RC	74	74 (100)	0 (0)	12	300 + 183.5	33.5 + 8	QoL	CCS
Hope et al. [32]	2008	RC	56	15 (27)	41 (73)	6	-	-	QoL	SF-36, CCS
Toma et al [5]	2024	PC	91	91 (100)	0 (0)	12	-	12.6 ± 6.88 (3-30)	QoL	EQ5D

BMI: Body Mass Index, QoL: Quality of Life, SF-36: Short-Form-36, NRS: numeric rating scale, HerQLES: Hernia related Quality of Life, CCS: Carolinas Comfort Scale
RD: retrospective cohort, PD: prospective cohort, PR: prospective randomized

Table 2. Study quality grading according to MINORS criteria for non-randomized studies

Study	Year	1	2	3	4	5	6	7	8	9	10	11	12	MINORS score
Licari et al. [29]	2019	2	2	2	2	0	2	1	0	N/A	N/A	N/A	N/A	11
Mussack et al. [30]	2006	2	0	1	2	0	2	0	0	2	2	2	2	15
Blair et al. [31]	2017	2	1	2	2	1	2	0	0	2	2	1	2	17
Klima et al. [6]	2014	2	2	2	2	2	2	0	0	2	2	2	2	20
Hope et al. [32]	2008	2	1	2	2	0	2	0	0	2	2	2	2	17
Toma et al. [5]	2024	2	2	2	2	2	2	2	2	2	2	2	2	24

MINORS: methodological index for non-randomized studies

Table 3. Study quality grading according to the Cochrane Risk of Bias Tool for randomized studies

Study	Year	Risk of bias from randomization process	Risk of bias due to effect of assignment	Risk of bias due to effect of adherence	Missing outcome data	Risk of bias in measurement of the outcome	Risk of bias in selection of the reported result	Overall risk of bias
Antic et al. [13]	2022	Low	Some concerns	Some concerns	Low	Some concerns	Low	Some concerns

Table 4. SF-36 comparison pre- and postoperatively

Outcome	Studies (n)	Participants (n)	Effect estimate (MD, 95%-CI)	p
Physical functioning	4	337	-29.06 [-43.19, -14.93]	<0.0001
Role physical	4	337	-35.21 [-59.90, -10.51]	0.005
Bodily pain	4	337	-25.30 [-61.23, 10.62]	0.17
General health	4	337	-17.92 [-29.18, -6.65]	0.002
Vitality	4	337	-11.47 [-22.05, -0.89]	0.03
Social functioning	4	337	-29.73 [-33.24, -26.21]	<0.0001
Role emotional	4	337	-35.66 [-59.86, -11.46]	<0.0001
Mental health	4	337	2.40 [-4.12, 8.92]	0.47

Table 5. Other quality of life questionnaires

Outcome	Studies (n)	Participants (n)	Total effect estimate (MD, 95%-CI)	p
NRS	1	91	-0.29 [-0.98, 0.40]	0.41
EQ5D	1	233	-0.29 [-0.33, -0.25]	<0.00001
HerQles	1	142	-23.10 [-25.72, -20.48]	<0.00001
EuraHS	1	142	33.70 [29.42, 37.98]	<0.00001
CCS-P	2	443	0.59 [0.27, 0.91]	0.0004
CCS-AL	2	443	0.64 [0.32, 0.96]	0.0001
CCS-MS	2	406	Not estimable	NA

NRS: numeric rating scale, EQ5D: Euro Quality of Life Five Dimensions, HerQles: Hernia related quality of life, EuraHS: European Hernia Society Quality of Life, CCS-P: Carolinas Comfort Scale Pain, CCS-AL: Carolinas Comfort Scale Activity Limitation, CCS-MS: Carolinas Comfort Scale Mesh Sensation

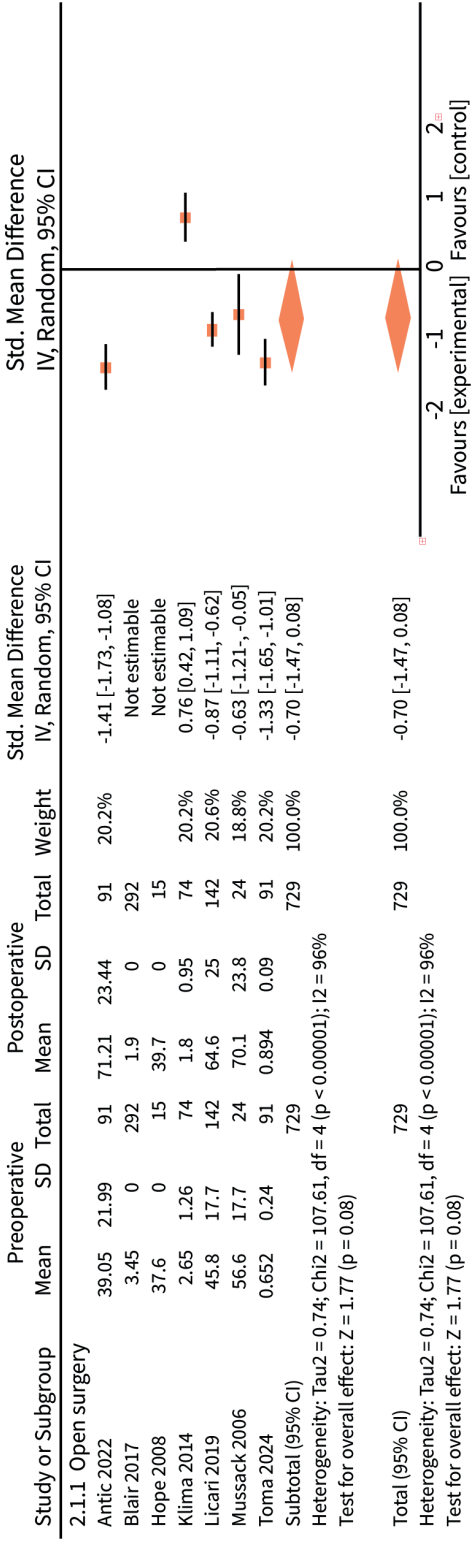


Figure 2: Forest plot of total effect size

DISCUSSION

QoL after IHR is an important indicator of surgical success [5]. This study demonstrates that IHR positively affects multiple QoL aspects for patients. By excluding laparoscopic procedures, the analysis focuses solely on open procedures, providing a clearer understanding of their impact. The observed improvements in physical, emotional, and general health domains underscore the effectiveness of open surgery in restoring patients' QoL.

A variety of validated QoL instruments were employed across the studies, such as the SF-36 and CCS. While the heterogeneity of tools introduces some variability, consistent improvements were observed regardless of the instrument used. The pooled standardized mean difference (SMD) of 0.70 highlights the moderate to large effect of open IHR on QoL outcomes.

Questionnaires

While this study identified several validated QoL tools, including SF-36, EQ-5D, CCS, and HerQLes, the heterogeneity in their application across studies complicates direct comparisons. Generic QoL questionnaires, like SF-36 and EQ-5D, provide a broad overview of patient well-being but may fail to capture specific hernia-related complaints, such as mesh sensation or abdominal function. Hernia-specific PROMs like CCS and HerQLes focus more on symptoms directly impacted by IHR, such as pain and mobility limitations, allowing for a tailored approach to hernia care. The inconsistency in assessment methods suggests the need for standardized PROMs in future research [17].

The difficulty of comparing QoL outcomes across studies is compounded by the use of different surveys that measure distinct aspects of patient well-being. While a universal QoL survey for hernia repair would streamline comparisons and enhance consistency, it must strike a balance between capturing generic health outcomes and addressing hernia-specific concerns. Developing such a tool, endorsed by international hernia societies, would greatly benefit future research and clinical practice.

Time of measurement

There is no ideal time to measure QoL after surgery, as each period provides different insights [15]. The early postoperative period (1-3 months) captures immediate recovery factors, including pain, mobility and satisfaction, but also complications. This is important for acute recovery. The intermediate period (6-12 months) shows the ongoing effect of surgery: pain, functional outcome and psychological effects tend to stabilize in this period. Moreover, effectiveness of the hernia repair and sustained relief from preoperative symptoms can be measured. Recurrence is best measured in a later stadium, 1-5 years postoperatively. The studies included in this meta-analysis all provided data from the intermediate period (6-12 months), deliberately excluding patients in the acute recovery phase to focus on sustained

QoL outcomes. Recurrence data, critical for long-term outcomes, was not uniformly addressed in the included studies, which represents a notable gap in the current evidence base.

Limitations

This study has several limitations that impact the strength of its conclusions. First, the high heterogeneity ($I^2 = 96\%$) in the meta-analysis indicates significant variability among the included studies, complicating direct comparisons. Furthermore, the small number of high-quality prospective studies included limits the strength of the findings, underscoring the need for more robust research on QoL following IHR. A significant number of the studies do not focus specifically on complex hernias, resulting in the exclusion of many articles from the initial search. The decision was made to focus exclusively on complex hernias, as the quality of life in these patients may be notably impacted by factors such as multiple surgeries, reduced trust in healthcare, and a sense of losing control over their own condition [27].

Additionally, the variation in QoL assessment tools across studies complicates direct comparisons. While generic tools like the SF-36 offer a broad overview of patient well-being, they may not capture specific hernia-related concerns, such as mesh sensation or abdominal function. In contrast, hernia-specific tools focus more on symptoms directly impacted by IHR, including pain and mobility limitations [28]. This inconsistency in assessment methods suggests that using hernia-specific PROMs is critical, as using solely generic questionnaires, may fail to reveal differences in QoL outcomes between surgical techniques [3]. Despite these limitations, this study maintains a high level of quality by focusing on a more homogenous patient group, allowing for a clearer understanding of QoL outcomes specific to IHR. By addressing this gap, a solid foundation was provided for future research to build upon, encouraging more standardized and patient-centered approaches in assessing QoL following hernia repair.

Future perspectives

This work establishes a starting point for further studies to explore the nuances of surgical technique and patient experience, ultimately enhancing the evidence base for improving PROMs in abdominal wall hernia repair. Additionally, exploring the psychological impact of hernia surgery—such as anxiety, depression, and body image concerns—could provide valuable insights into how these factors influence overall QoL [14, 17]. In conclusion, this review highlights that IHR significantly improves QoL for patients. Future studies focusing on patient-centered outcomes will be essential for optimizing surgical decision-making and tailoring approaches to enhance patient well-being.

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3

Making the case for Psychological Prehabilitation in Complex Abdominal Wall Surgery: a letter to the editor

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Hernia, 2024

Dear editor,

The treatment of complex abdominal wall hernias is extensive and has yet emerged to a multimodal approach. This approach consists of optimizing a care pathway that has been laid out for complex abdominal wall reconstruction. Multiple studies describe the essence of familiarization with ways to preoperatively optimize a patient: smoking cessation and weight loss have been proven to reduce complication risks after complex abdominal wall reconstruction [1]. However, preoperative optimization strategies have concentrated exclusively on addressing physical comorbidities. Besides physical prehabilitation, the preoperative period presents a window of opportunity during which psychological stress responses can be moderated, which may improve long term outcomes, due to a potentially improved immune function [2].

The connection between mental and physical health is widely acknowledged. Enhancing mental health before surgery is commonly referred to as psychological prehabilitation. This has shown to improve patient and healthcare system outcomes in mainly oncological surgery, but also neurosurgical interventions: better pain control, less anxiety, faster recovery, decreased length of stay, decreased healthcare costs, and less complications [3].

Several psychological factors such as subclinical depression, are associated with complicated recovery, while other factors such as dispositional optimism, seem to promote healing [4]. In my opinion, these findings emphasize the potential significance of early identification and intervention concerning these psychological factors, enabling the utilization of the preoperative period effectively.

A recent study synthesized the evidence of psychological prehabilitation in oncological surgery: the comprehensive analysis revealed a substantial improvement in patient-related outcomes [5]. I would like to emphasize the educational value of previous developments in colorectal cancer care pathways, like physical prehabilitation, that have been integrated in complex abdominal wall reconstruction standards.

There is an urgent requirement for meticulous, contemporaneous prospective trials with baseline psychological evaluation, well-described interventions, and assessments of effects on postoperative complex abdominal wall reconstruction outcomes.

I would like to propose instigating a call to assess these additional pillars in the preoperative optimization of patients undergoing complex abdominal wall reconstruction.

Thank you for your consideration,

Kind regards

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4

Exploring psychological prehabilitation in complex abdominal wall surgery (PETTICOAT): a pilot study

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Introduction

Prehabilitation strategies for patients with complex abdominal wall hernias primarily target physical optimization. However, existing psychological factors like anxiety, depression, and post-traumatic stress disorder are commonly observed in this population. Despite this, they remain underexplored notwithstanding their impact on recovery, complications, and quality of life. This study investigates the prevalence of psychological comorbidities in patients undergoing complex abdominal wall repair (CAWR).

Methods

In this prospective cohort study, consecutive patients planned for CAWR (September 2024-June 2025) were recruited. Complex hernias were predefined. Preoperative assessments focused on the presence of anxiety, depression, post-traumatic stress disorders, self-efficacy and quality of life by validated questionnaires: HADS, Mastery and PCL-5. Associations between psychological factors and postoperative pain scores, opioid use, length of stay and complications were explored.

Results

A total of 16 (46%) out of 35 eligible patients completed all preoperative psychological questionnaires. Sixty-nine percent of patients screened positive for at least one psychological risk factor: sixty percent for anxiety and/or depression, thirteen percent for PTSD and fifty-three percent of patients had low self-efficacy. Median QoL score was 47/120.

Conclusion

This study identified that the threshold to participate in this study was very high. Secondly, two-thirds of patients assessed experienced one or more psychological comorbidities. A relation in these patients with prolonged postoperative pain was observed. These findings suggest that psychological comorbidities may represent a clinically relevant risk factor. Further research is warranted to better understand their role and to evaluate whether targeted psychological prehabilitation could improve outcomes.

INTRODUCTION

Current multimodal approaches of patients with complex abdominal wall hernias predominantly focus on improving the preoperative *physical* condition [1, 2]. Protocolized prehabilitation interventions such as smoking cessation, weight loss programs, or abdominal wall muscle elongation by Botulinum Toxin A (BTA) injection, have clearly demonstrated to reduce postoperative complications [3-8]. However, while many patients with complex abdominal wall hernias have experienced multiple, mostly negative, events in the healthcare system, their neurocognitive and emotional well-being may also have been significantly impacted [9]. Any pre-existing anxiety, depression, or other psychological condition will also play a role in outcome after every subsequent surgery.

High levels of preoperative anxiety are associated with heightened sensory sensitivity, lower pain thresholds, and increased postoperative complications and opioid use [10]. In line with this, psychological conditions like depression contribute to delayed recovery, extended hospital stays, and elevated readmission rates [11]. Emerging evidence highlights how psychological comorbidities, including self-efficacy - a person's belief in their ability to influence their own health - play a crucial role in promoting better health behaviours and overall wellbeing [12].

While addressing a patient's preoperative *psychological* status has potential to further improve postoperative outcomes, a comprehensive prehabilitation approach addressing both physical and psychological comorbidities by a multidisciplinary team is needed [13]. Although evaluation and optimization of physical health have become a cornerstone of prehabilitation, the preoperative period also offers a unique opportunity to address psychological factors [14, 15].

Incorporation of mental health interventions during the preoperative period to enhance psychological resilience and improve surgical outcomes is termed *psychological prehabilitation* [16]. Psychological prehabilitation has shown promise in other surgical domains, such as oncological and neurosurgical care pathways [17]. Psychological prehabilitation has been shown to reduce stress responses, improve immune function, and enhance postoperative recovery. This includes reduction in length of stay, pain, anxiety, and depression [16, 18]. While complication rates may remain unaffected, previous studies have consistently demonstrated improvements in quality of life (QoL) and psychological resilience after psychological prehabilitation [19, 20].

Patients undergoing complex abdominal wall repair (CAWR) often face complex and prolonged surgical trajectories, characterized by multiple previous operations, longstanding symptoms, and significant impacts on daily activities. Furthermore, trust issues and doubts about recovery, can worsen psychological distress [19, 21][22]. The high postoperative

complication rates associated with CAWR amplify the need for a structured prehabilitation trajectory. Preoperative management of psychological comorbidities could improve patients' surgical experience and recovery [23].

Despite a lack of specific research on psychological prehabilitation for abdominal wall surgery, exploring the influence of psychological factors on postoperative outcomes, a foundation for the development of evidence-based psychological prehabilitation protocols tailored to CAWR patients is pursued. Utilizing the waitlist to identify psychosocial risk factors can guide personalized care and reduce treatment failure risks [24].

Given the interplay of psychological and physical factors in CAWR patients, and the promising results of psychological prehabilitation in other surgical fields, this pilot study aimed to assess the prevalence of anxiety, depression, and post-traumatic stress symptoms in patients undergoing CAWR.

METHODS

Design

This study was designed as a prospective cohort study. The primary aim was to explore the presence of psychological comorbidities, anxiety, depression, Post-Traumatic Stress Disorder (PTSD) and low self-efficacy in patients potentially undergoing CAWR. Secondary objectives included the Length of Hospital Stay (LOS), Postoperative Opioid Use, and short-term (≤ 30 days postoperative) complications.

Study population

This study was conducted in an expert centre for CAWR patients. Participants were recruited from the outpatient clinic, between September 2024 and June 2025. Patients were considered eligible if they met the following criteria: adults aged 18 years or older, diagnosis of complex abdominal wall hernia (CAWH) (defect size $>10\text{cm}$, recurrence, presence of a stoma or infection, or patient-related comorbidities (BMI $>30\text{kg/m}^2$, poorly controlled diabetes mellitus, chronic obstructive pulmonary disease requiring inhalation therapy, cardiovascular disease, or immunosuppressive therapy) [25]), and the ability to read and write Dutch. Patients were excluded if urgent or emergency surgical repair was required, in case of pregnancy, or inability to provide informed consent.

Patients received verbal and written information about the study and were given two weeks to consider participation, after which informed consent was signed.

Preoperative assessment

In case of consent, baseline data were collected, including age, sex, BMI, comorbidities, hernia factors, previous surgeries, and surgical details (duration, open or laparoscopic approach, as well as mesh-type, preoperative BTA administration, Component Separation Technique (CST) used). The Hernia Patient Wound (HPW) classification was assessed for each patient. Additionally, all cases were discussed in an MDT.

Patients who did not complete all three additional preoperative psychological questionnaires were contacted and requested to complete the questionnaires again by email, by phone and in person, during any visit at the outpatient clinic. Only patients who completed the full preoperative screening, including all psychological questionnaires, were included in the analysis of postoperative outcomes.

Furthermore, the HerQLes QoL questionnaire – a hernia-specific QoL questionnaire consisting of 12 items, each scored from 0 to 10 – was filled in, which is standard of care in the recruiting hospital. Non-participating patients received the standard course of treatment.

Psychological assessment

Participants were presented three additional validated questionnaires preoperatively.

The first was the *Hospital Anxiety and Depression Scale* (HADS), a 14-item tool designed to assess symptoms of anxiety and depression. It consists of two subscales, one for anxiety (HADS-A) and one for depression (HADS-D), with scores ranging from 0 to 21 for each subscale. A score above 7 on either subscale was used as a cut-off to identify clinically significant symptoms, as it has been widely validated as a threshold indicating moderate levels of anxiety or depression.

The second questionnaire, the *Mastery*, is a 7-item scale measuring self-efficacy, with scores ranging from 7 to 35. A score below 20 was considered indicative of a lower self-efficacy, which has been associated with greater vulnerability to psychological distress. This threshold was selected to identify individuals who may benefit from psychological support.

The third tool used was the *Posttraumatic Stress Disorder Checklist* for DSM-5 (PCL-5), a 20-item questionnaire designed to assess PTSD symptoms based on the DSM-5 criteria. Scores range from 0 to 80, with a score greater than 31 used as a cut-off for clinically significant PTSD symptoms.

These questionnaires were completed prior to any surgical intervention, allowing for the identification of psychological distress early in the preoperative process. The questionnaires are attached in the Appendix.

Postoperative assessment

Postoperative outcomes were assessed through the Visual Analog Scale (VAS) for pain on postoperative days 1 and 2, POU calculated as Morphine-Equivalent Dose (MED) mg/kg/12h using an opioid conversion chart, QoL changes measured preoperatively and at 3, 6 and 12 months postoperatively, and postoperative complications within 30 days, classified by the Clavien-Dindo system. As a composite measure of optimal perioperative recovery, Textbook Outcome was assessed, defined as a postoperative hospital stay of less than five days without any complications.

Ethical Considerations

Participation was voluntary, and patients had the opportunity to withdraw at any time without consequences. Evaluation by the medical ethics committee concluded that the study did not fall under the Medical Research Involving Human Subjects Act (Reference number: MECU W.24.094). As a result, ethical approval was not required. This study adhered to the principles of the Declaration of Helsinki.

Data Analysis

Due to the limited expected sample size, statistical analysis primarily focused on descriptive statistics and effect sizes. This approach aimed to provide preliminary insights into the relationships between psychological factors and postoperative outcomes. Sample size was set at 35 patients, based on the expected number of eligible cases presenting at the outpatient clinic over the inclusion period. Descriptive outcomes are reported using median and interquartile range (IQR), as the data were not assumed to be normally distributed. IQR was preferred over standard deviation or range to provide a more robust summary of central tendency and variability, especially for ordinal data. Primary outcomes included questionnaire completion rates and scores. Secondary analyses explored associations between psychological conditions and postoperative outcomes and pre- to postoperative QoL changes. Given the pilot nature of this study, these outcomes are presented descriptively, and no formal comparative analysis was performed.

RESULTS

A total of 35 patients were included in the study. All patients provided informed consent to participate with this study. Sixteen patients (46%) completed the full set of the three additional preoperative psychological questionnaires, despite three or more attempts to contact eligible patients again. Five patients explicitly declined participation. Seven patients failed to return questionnaires for unclear reasons despite initial informed consent. The remaining four patients could not be reached (figure 1).

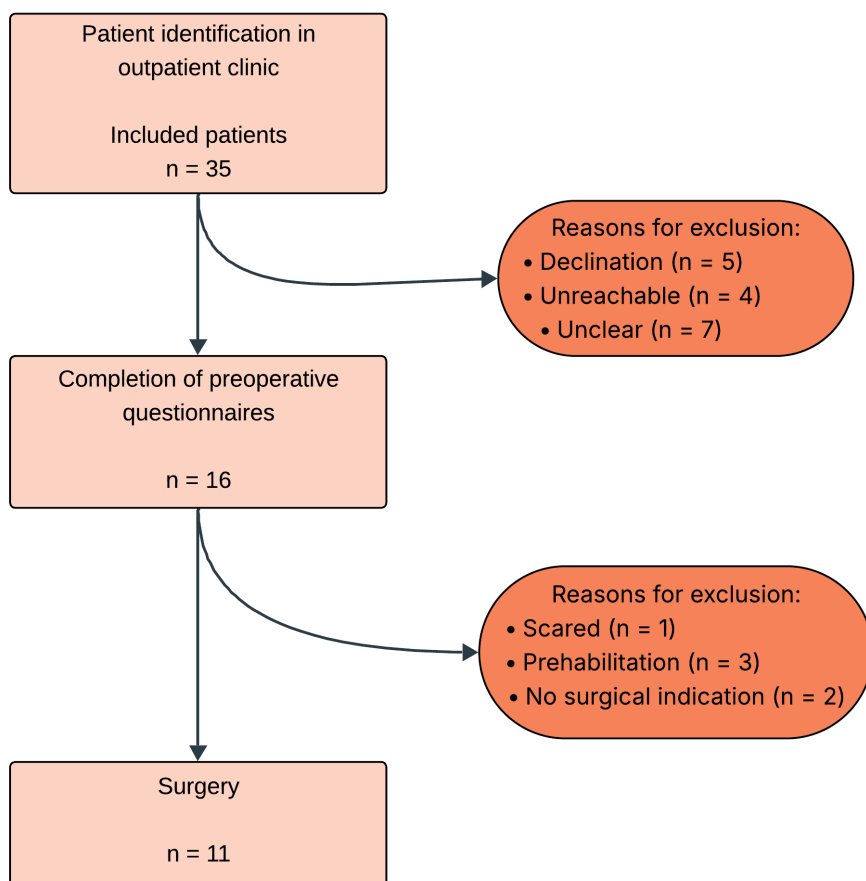


Figure 1: Patient inclusions

The baseline characteristics of the participants are presented in Table 1. The mean age of participants was 62.3 years, with equal gender distribution. The mean BMI was 27.8 kg/m², with 25% of patients classified as obese (BMI >30). Median HPW-stage was 2. Surgical details are provided in Table 1. Not all included patients underwent surgery; only a subset of the cohort

proceeded to operative treatment. In some cases, this was due to planned prehabilitation prior to surgery, while in others, the burden of complaints did not outweigh the operative risks.

Table 1: Baseline Characteristics

n	16	(%)	Mean	SD
Patient				
Female sex	8	(50)		
Age (y)			62.3	± 9
BMI (kg/m ²)			27.8	± 4.7
BMI > 30	4	(25)		
Active smoker	4	(25)		
Use of immunosuppressives	3	(19)		
Diabetes	2	(13)		
COPD/asthma	2	(13)		
Cardiovascular history	7	(44)		
Hernia				
Width (cm)			8.3	± 5.6
Loss of domain >20%	1	(6)		
Wound				
Stoma present	5	(31)		
<i>CDC classification</i>				
I	9	(56)		
II	1	(6)		
III	5	(31)		
IV	1	(6)		
<i>HPW</i>				
I	3	(19)		
II	7	(44)		
III	6	(38)		
IV	0	(0)		
MDT evaluation				
Green	11	(69)		
Orange	5	(31)		
Red	0	(0)		
Surgery				
OVHR	4	(25)		
CST	7	(44)		
Mesh	7	(44)		
Concomitant procedure	4	(25)		

CDC: centres for disease control classification, HPW: hernia, patient wound

MDT: multidisciplinary team meeting

OVHR: open ventral hernia repair. CST: component separation technique.

Table 2: Questionnaires

Questionnaire (n)	Median score	IQR	Above cut-off (%)
HADS (16)	8	3-13	9 (56)
Mastery (16)	19.5	15-25	8 (50)
PCL-5 (16)	9	2-15	2 (13)
Any of the above (16)	-		11 (69)

HADS: hospital anxiety and depression score (cut-off >8), Mastery: self-efficacy (cut-off >20), PCL-5: post-traumatic stress disorder screening tool according to DSM-5 (cut-off <31)

Table 3: Positive questionnaires

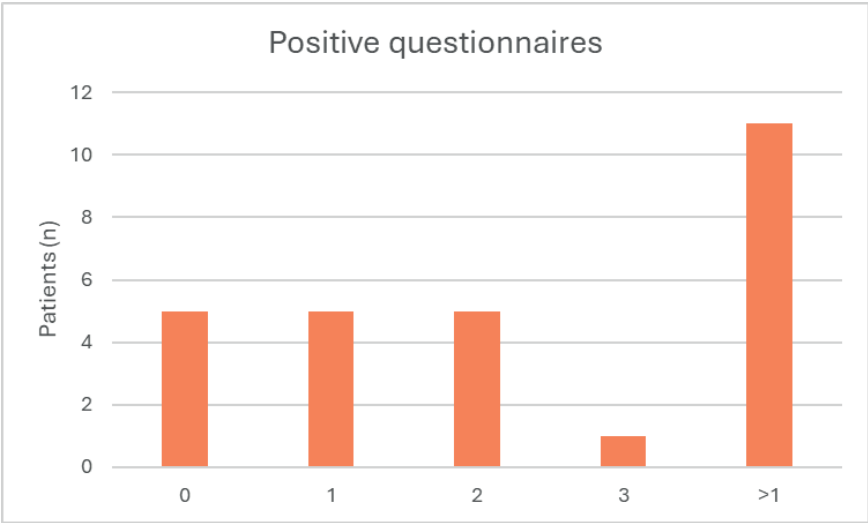


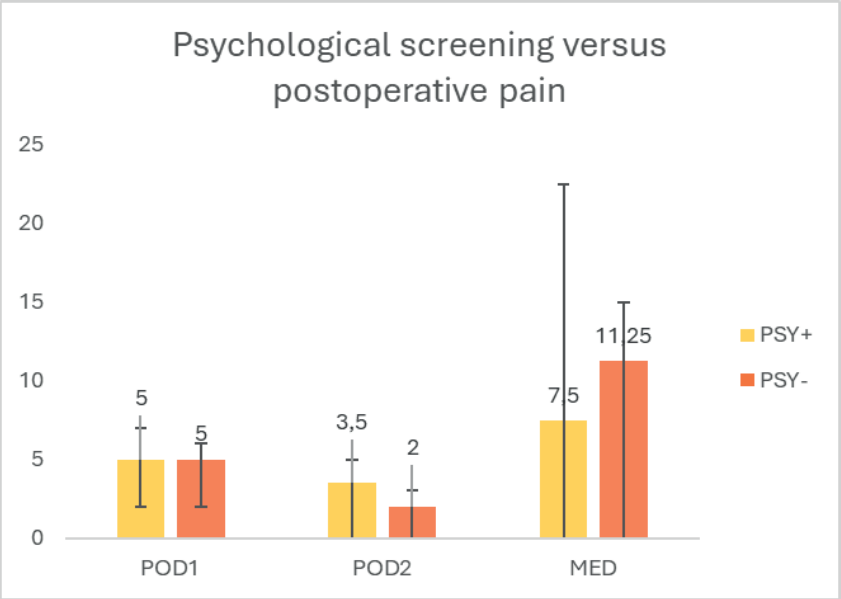
Table 4: Postoperative Outcomes

	n	11	(%)	Median	IQR
VAS POD1				5.5	2-6
VAS POD2				2.5	0-5
Complication	4		(36)		
Length of stay (LOS)				5.5	5-7
LOS > 5days	6		(55)		
Epidural	6		(55)		
Days of epidural				1	0-3
Morphine use (MED)				5.6	0-15
Morphine prescription	3		(16)		
Other analgetics	3		(16)		
Textbook outcome*	5		(45)		

*Textbook outcome is defined as LOS<5days without complications.

LOS: length of stay. MED: morphine equivalent daily dose (mg/12h)

Table 5: Psychological screening versus postoperative pain



POD1: postoperative day 1, POD2: postoperative day 2, MED: morphine equivalent dose, mg/12h
PSY+: positive screening on psychological questionnaires, **PSY -:** negative screening on psychological questionnaires

The results of the psychological assessments are summarized in Table 2. Of the 16 patients who completed the full psychological screening, eleven (69%) screened positive on at least one of the questionnaires. The HADS revealed a median anxiety score of 3.5 (IQR 0-7.5) and a median depression score of 3.5 (IQR 2-6.5). The Mastery questionnaire indicated reduced self-efficacy in 50% of patients, with a median score of 19.5 (IQR 15-25). PCL-5 screening suggested PTSD-consistent symptoms in 12.5% (median 9, IQR 2-15). Preoperative QoL was scored at a median score of 47 (IQR 38-53). Furthermore, 6 patients (38%) screened positive for more than one psychological comorbidity (table 3).

The postoperative outcomes are summarized in Table 4. All patients underwent open ventral hernia repair (OVHR). The median length of hospital stay (LOS) was 5.5 days (IQR 5-7). Postoperative pain, measured using the Visual Analog Scale (VAS), was reported as follow: the median pain score on postoperative day was 5.5 (IQR 2-6), and on day 2, the median score was 2.5 (IQR 0-5). POU was calculated as morphine equivalent X mg/kg/12h, with a median value of 5.6 (IQR 0-15) (table 5). Within 30 days post-surgery, 36% of patients experienced postoperative complications.

DISCUSSION

Although all patients provided informed consent, the response rate was limited, highlighting a potential barrier in feasibility. This underlines the relevance of this pilot phase, which not only aimed to explore the prevalence of psychological risk factors, but also to assess the feasibility and acceptability of administering standardized psychological questionnaires in this patient population. The uptake of PROMs in this cohort was encouraging. Nonetheless, a high prevalence of psychological burden was observed in patients awaiting CAWR. At least 33% of the entire cohort had relevant psychological burden, while among respondents 69% of respondents screened positive for at least one psychological risk factor. Fifty-six percent screened positive for anxiety or depression, and thirteen percent for possible PTSD. Additionally, fifty percent of patients had low Mastery scores, indication limited self-efficacy and coping capability. Given the pilot design and limited sample size, these findings should be interpreted with caution. Still, they support the rationale for further exploration of integrating psychological assessment in surgical pathways, although clinical benefit has not yet been demonstrated.

Psychological comorbidities may represent an additional layer of vulnerability in this population. For example, previous literature shows that smoking and obesity- prevalent in approximately 25-50% of CAWR patients - are important risk factors for poor surgical outcomes. While our pilot data did not demonstrate a statistically significant correlation between psychological status and surgical outcomes, these findings underscore the need to investigate psychological comorbidity with similar rigour as established physical risk factors in larger-scale studies [1].

The main findings in this study unveil a hidden dimension of patient morbidity. While we previously highlighted the lack of existing literature on this subject, this pilot study represents the first systematic attempt to quantify psychological distress in this surgical population [23]. The holistic approach of this study offers a comprehensive perspective on the interplay between mental health and surgical recovery. This is supported using validated psychological questionnaires, prospective data collection, and the integration of both psychological and physical postoperative outcomes.

Our cohort shows equal or higher psychological burden compared to other surgical fields such as oncological (35-46%), cardiac (15-37%), and bariatric surgery (12-19%), suggesting potential underlying psychological issues [16-18]. Prior studies have identified clear associations between preoperative mental health and postoperative recovery, including reduced pain tolerance, increased opioid consumption, delayed return to function, and impaired immune response [10, 11, 23]. Notably, the prevalence of anxiety and depressive symptoms in our cohort exceeds that of the general population, where estimates range between 10-20%

depending on age and gender, using the same cut-off values [26]. Our data support the notion that similar mechanisms may be relevant in CAWR.

Psychological distress may influence coping mechanisms, reduce adherence to rehabilitation protocols, and lower motivation to engage in self-care- all of which may contribute to suboptimal surgical outcomes.

Our data suggest that certain subgroups- such as patients with larger hernia width, higher BMI, or multiple previous surgeries- may be particularly vulnerable to psychological burden. This emphasizes the need for individualized preoperative assessments and interventions, ideally embedded in a multidisciplinary care framework. The preoperative period- particularly the waiting list- offers a valuable window for the risk assessment for both physical and psychological risk factors.

Several limitations to our main conclusion should be acknowledged. The small sample size and low response rate of 46% limit the statistical power and generalizability of the study. Low participation may introduce selection bias: psychologically healthy patients might have declined participation, considering the questionnaires irrelevant, while some patients with psychological distress might have avoided participation due to stigma concerns. Moreover, psychological status may itself influence how patients respond to questionnaires, which could distort the true clinical picture. In addition, the burden of completing multiple questionnaires and the need for repeated contact attempts may have further contributed to the limited response rate. Insights into which tools were more burdensome or confusing would inform the design of future studies, however data on this was not available. This reinforces previous literature, that suggests patients facing CAWR often endure longstanding functional impairment, recurrent surgical failures, and substantial disruption in daily life [21, 22]. Additionally, the cross-sectional nature of preoperative assessments provides only a momentary view, as psychological symptoms can fluctuate over time. Postoperative QoL changes are not assessed in this pilot due to the small sample and incomplete follow-up. Similarly, pain outcomes must be interpreted with caution, as we were unable to account for surgical approach, anesthesia, pre-emptive analgesia, or postoperative pain management protocols, all of which are known to affect pain perception. Future studies could incorporate these factors to explore their potential impact on outcomes. Furthermore, surgical details such as operative approach, mesh type, and preoperative BTA administration were collected but not included in the current analysis, as this study did not aim to perform comparative analyses. Data on wound status was not collected, which could have influenced the choice of surgical technique and may have worsened psychological outcomes in patients with chronic wound issues. Including such data in future studies would provide a more complete understanding of factors affecting both surgical decision-making and PROMs. These limitations indicate the exploratory nature of this pilot study, which cannot yet establish causal associations or determine the prognostic impact of psychological factors on surgical outcomes.

Nevertheless, the findings suggest that psychological comorbidity is a considerable issue in CAWR patients, and advocate for the routine implementation of structured preoperative psychological assessment.

At least one-third of the entire patient population experiences relevant psychological symptoms, a prevalence comparable to traditional risk factors such as smoking or obesity. This indicates that psychological distress should be considered a potential risk factor in preoperative risk stratification and management. Future studies should therefore not only optimise feasibility of questionnaire administration (reducing burden, improving timing both pre- and postoperatively, and minimising dropout), but also analyse outcomes in distinct domains—QoL, pain, complications, and LOS—within more homogeneous patient populations and with larger sample sizes to allow meaningful comparisons.

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5

The influence of a Multidisciplinary Team Meeting and Prehabilitation on Complex Abdominal Wall Hernia Repair Outcomes

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Aim

Surgical site occurrences after transversus abdominis release are still up to 15%. Previous research has attributed this to inadequate patient preparation. Consideration of improvement of any factors that might contribute to optimal patient recovery is evidenced by an increasing body of evidence. Data suggest that it can reduce complication rates by as much as 40%. The goal of this study was to determine whether prehabilitation has a favorable effect on the risk on wound and medical complications, and whether it can reduce length of stay.

Methods

A retrospective cohort study was performed. All patients discussed at multidisciplinary team meetings between 2015 and 2019 in Elkerliek were included. Comparison of two groups (prehabilitation vs no prehabilitation) on baseline level, and afterwards the outcome measures, was performed.

Results

A total of 259 patients were included: 126 patients were prehabilitated. Baseline characteristics between the two groups were statistically significantly different on patient factors: the second group had higher median BMI (28 vs 30, $p<0.001$), higher HbA1c (41 vs 48, $p=0.014$), more smokers (4% vs 25%, $p<0.001$) and more patient factors (14% vs 48%, $p<0.001$). There were no significant differences in perioperative and postoperative outcome measures.

Conclusions

Literature demonstrates a higher complication rate in patients undergoing complex abdominal wall reconstruction with patient factors; however, this study shows that prehabilitation helps comorbid patients achieve the same results as non-comorbid patients. Further research is advised in the form of a randomized controlled trial.

INTRODUCTION

Incisional hernias following any kind of abdominal surgery remain an unremitting surgical challenge. This is most applicable in patients with large size (>10cm) hernias, recurrent hernias and hernias with a compromised surgical field, like an entero-atmospheric fistulas or an infected prosthetic mesh [1]. Recent studies report up to 33% of surgical site occurrences (SSO) after repair with open anterior component separation techniques of these complex abdominal wall hernias [3-6]. After posterior component separation techniques with a trans-versus abdominis release (TAR), SSOs occur still in up to 15% of patients [7].

Previous studies have demonstrated that SSOs occur mainly in patients having a high-risk characteristic at the time of surgery [8, 9, 36]. Numerous studies have unambiguously reported that preoperative smoking, obesity, or a low physical activity level influence incisional hernia repair negatively, in terms of SSO and recurrence [10-15]. Breaking the “vicious circle” of subsequent hernia repairs in a single patient, can be achieved by rigorously addressing these risk factors [4, 13]. Evidence is rising that preoperative modification of any of these risk factors, known as *prehabilitation*, increases patient recovery and diminishes complications [4, 16-21].

In 2018, Liang et al. completed the first randomized controlled trial on prehabilitation in ventral hernia repair. This study demonstrated that prehabilitated patients were more likely to be without complications after one month compared to non-prehabilitated patients (70% vs 48%, $p=0.015$) [37]. Renshaw et al. described that patient prosecuting greater exercise frequency before surgery proved decreased risk of complications and readmission after ventral hernia repair [22, 23]. Delaying surgery and optimizing or improving the aforementioned risk factors may reduce complication rates by as much as 40% [15, 22, 24-26].

These results emphasize the potential effect of prehabilitation. It has even been suggested that prehabilitation of high-risk patients is as important as, if not more important than, the surgical technique itself [27-29].

The aim of this study was to evaluate whether prehabilitation of complex hernia patients with modifiable risk factors has a favorable effect on outcome in patients undergoing complex abdominal wall repair.

METHODS

This retrospective cohort study was performed in a referral center for complex abdominal wall surgery. All consecutive patients surgically treated for complex abdominal wall hernias between December 2015 and December 2019 were included. Patients undergoing laparoscopic repair were excluded.

Abdominal wall hernias were defined complex if there was at least one of the following factors present: width > 10 cm, parastomal hernia, infected mesh, presence of a stoma, fistula or abscess, or loss of domain greater than 20% [31]. Patients with at least one modifiable risk factor like body mass index (BMI) > 30 kg/m², active nicotine abuses, diabetes mellitus (with HbA1c >65), COPD (> Gold I), usage of immunosuppressive medication or MET score <4, were also considered complex hernia patients.

All patients were discussed at least once in a multidisciplinary team meeting (MDT) by a surgeon, pulmonologist, cardiologist, anesthesiologist, and physiotherapist. Assays such as a CT-scan, an EKG, blood tests for hemoglobin, HbA1c and albumin were prosecuted on beforehand. Hernias were anatomically graded by the EHS classification and HPW classification [32, 41].

During the MDT, a color code is allocated to each patient. Patients without any risk factors are allocated green and considered fit for surgery. Patients with at least one modifiable risk factor are allocated orange, and are eligible for surgery, only after successful prehabilitation. Patients with too many (or unmodifiable) risk factors are allocated red.

All *orange* patients were offered a preconditioning program, which was covered by patients' insurance. Such a program comprised weight loss counseling, smoking cessation counseling, glycemic control by a specialized nurse, pulmonary preparation, and physiotherapy [table 1]. After prehabilitation, the patient was discussed again in the MDT. If prehabilitation was deemed successful by the MDT, the allocated color code shifted from orange to green.

Outcome after complex hernia repair was compared between two consecutive patient cohorts: green patients (without risk factors nor prehabilitation) versus orange patients (after successful prehabilitation). Endpoints were differences in baseline and intra-operative characteristics, and postoperative outcome (90-day complications such as SSO, SSI, SSE, pulmonary embolism, pneumonia, ileus/gastroparesis, or other systemic complications; length of hospital stay and readmission and reoperation).

Data were retrieved from a database in which every patient with a complex abdominal wall defect was registered prospectively since 2014. Differences between demographic groups of categorical data were tested using the chi-squared or Fisher's exact test. The summary statis-

tic was the p-value. The patient demographics were judged and continuous variables such as age, BMI and MET score were kept continuous, to prevent loss of data associated with categorizing. These variables were analyzed using an independent unpaired T-test. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 418 consecutive patients were discussed in the four-year study period [Figure 1]. The MDT allocated 230 patients (55%) orange, 144 patients (34%) green and 44 patients (11%) red. Almost half (45%) of all primarily coded orange patients, did eventually not undergo surgery. Being unable to adequately finish prehabilitation was the most important reason. Other reasons to refrain from surgery were a concomitant disease requiring therapy, decrease of hernia related complaints as a result of prehabilitation, or choosing another hospital. Eventually, 259 operated patients were included in this study: 133 primary green patients (group I), and 126 primarily orange patients after successful prehabilitation (group II).

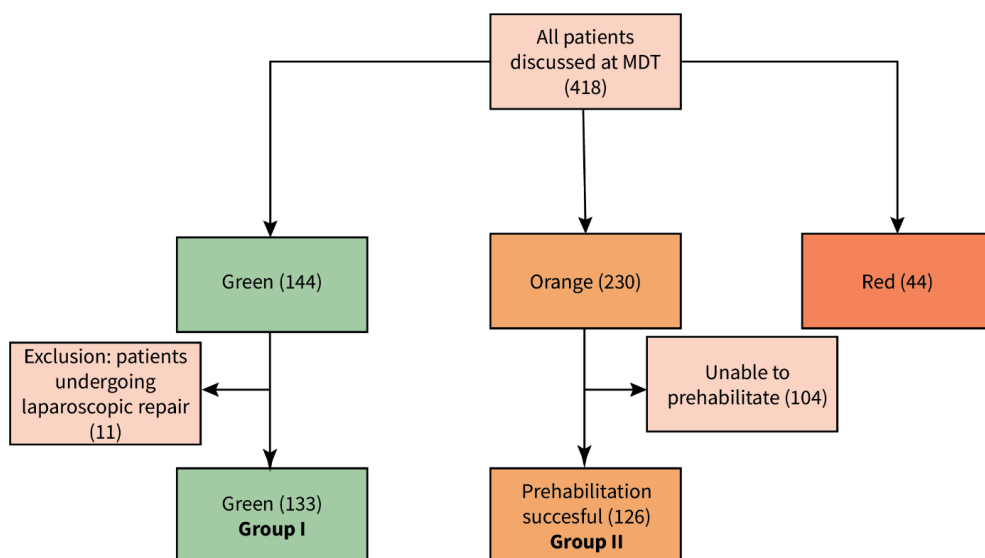


Figure 1: Flowchart patient inclusions

Baseline characteristics between the group I and II were different in BMI (median 28 versus 30, $p < 0.001$), HbA1c (mean 41 versus 48, $p = 0.014$) and the rate of active smokers (4% versus 25%, $p < 0.001$) [Table 2]. After prehabilitation of orange patients, BMI and nicotine abuse both significantly decreased [Table 3]. No differences in intra-operative conditions, like the rate of component separation techniques, were demonstrated [Table 4].

No significant differences in short term complications were noted between the groups in the convalescence period [Table 5]. The length of hospital stay was comparable between the groups: 6 days ($p = 0.908$).

Table 1. Modifiable risk factors and prehabilitation interventions

Risk factor	Defined by	Intervention	Achieved if
Smoking	≥ 1 cigarette/day	Nicotine substitute Quit smoking programme	Quitted smoking ≥ 4 weeks prior to surgery
Morbid obesity	BMI ≥35	Dietician Physical activity Bariatric surgery	BMI ≤ 35 or ≤ 5% weight loss
Physical condition	MET score ≤ 4	Physiotherapist Sports physician	MET score > 4
Diabetes, glycemic levels	HbA1c ≥ 65	Diabetes nurse Medication optimization	HbA1c < 65
Pulmonary condition	COPD II-IV Other obstructive pulmonary diseases	Consultation of pulmonologist Medication alteration	Optimal pulmonal condition consented by pulomonologist
Cardial condition	EKG abnormalities	Consultation of cardiologist Medication alteration	Optimal cardiac condition consented by cardiologist

Table 2. Preoperative characteristics of patients that underwent complex abdominal wall surgery

	Total	I (no risk factors)	II (preha- bilitated patients)	p
n	259	133	126	
Hernia factors				
Width <10cm (n,%)	137 (53)	77 (58)	60 (48)	
Width 10-20 cm (n,%)	109 (42)	50 (38)	59 (47)	0.254
Width >20cm (n,%)	13 (5)	6 (5)	7 (6)	
Recurrent hernia (n,%)	79 (31)	38 (29)	41 (33)	0.488
Patient factors				
Age (median, IQR)	128 (54-68)	63 (54-68)	65 (57-72)	0.052
Smoking (n,%)	37 (14)	5 (4)	32 (25)	<0.001
BMI (median, IQR)	58 (25-29.5)	28 (25-29.5)	30 (27-33)	<0.001
BMI >30 (n,%)	87 (34)	22 (17)	65 (52)	<0.001
BMI >35 (n,%)	17 (7)	3 (34)	14 (11)	0.004
Diabetes (n,%)	29 (11)	10 (8)	19 (15)	0.054
HbA1c (median, IQR)	89 (34-54)	41 (34-54)	48 (42-57)	0.014

Table 2. Continued

	Total	I (no risk factors)	II (preha- bilitated patients)	p
HbA1c > 65 (n,%)	3 (34)	0 (0)	3 (34)	0.094
Immunosuppressives (n,%)	14 (5)	4 (3)	10 (8)	0.079
COPD (II-IV) (n,%)	42 (16)	17 (13)	25 (20)	0.123
Pulmonary preparation (n,%)	62 (24)	24 (18)	38 (30)	0.022
MET score (median, IQR)	13 (6-8)	7 (6-8)	6 (5-7)	0.004
MET score < 4 (n,%)	20 (8)	8 (6)	12 (10)	0.290
cP 0 (n,%)	179 (69)	114 (86)	65 (52)	<0.001
cP 1 (n,%)	80 (31)	19 (14)	61 (48)	
Wound factors				
cW 0 (n,%)	212 (82)	111 (83)	101 (80)	0.491
cW 1 (n,%)	47 (18)	22 (17)	25 (20)	
Previous wound infection (n,%)	94 (36)	44 (33)	50 (40)	0.270
HPW Classification				
HPW 1 (n,%)	80 (31)	54 (41)	26 (21)	0.003
HPW 2 (n,%)	129 (50)	54 (41)	75 (60)	
HPW 3 (n,%)	42 (16)	22 (17)	20 (16)	
HPW 4 (n,%)	8 (3)	3 (34)	5 (4)	
BMI: Body Mass Index (kg/m ²), COPD: chronic obstructive pulmonary disease, MET: metabolic equivalents, cW 1: contaminated field, HPW: hernia, patient, wound cP1: at least one patient risk factor present (BMI>35, active smoker, use of immunosuppressives, diabetes) cW1: CDC2-4 wound classifications (clean-contaminated, dirty-contaminated or dirty surgical field)				

Table 3. Effect of prehabilitation in patients with modifiable risk factors in 126 patients

n =126	I	Before	II	After	p
Patient factors					
Smoking (n,%)	32	(25)	16	(13)	0.0103
BMI (median, IQR)	30	(27-33)	29	(27-31)	<0.001
BMI >30 (n,%)	65	(52)	48	(38)	0.0312
BMI >35 (n,%)	14	(11)	7	(6)	0.1106
Diabetes (n,%)	19	(15)	19	(15)	1.000
HbA1c (median, IQR)	48	(34-54)	47.5	(42-55)	0.065
HbA1c > 65 (n,%)	3	(1)	1	(1)	0.3134
Immunosuppressives (n,%)*	10	(8)	5	(4)	0.1831
MET score < 4 (n,%)	12	(10)	5	(4)	0.0787

Table 4. Perioperative characteristics of patients that underwent complex abdominal wall surgery

	Total	I (no risk factors)		II (preha- bilitated patients)		p
n	259	133		126		
Surgery time (mean, minutes)	135.5	(90- 168)	132.9	(87-164)	138.2	(92.5-173) 0.244
Type of myofascial release						
Retrorectus (n, %)	132	(51)	71	(53)	61	(48)
Unilateral TAR (n, %)	18	(7)	6	(5)	12	(10)
Bilateral TAR (n, %)	48	(19)	21	(16)	27	(21)
eCST (n, %)	56	(22)	33	(25)	23	(18)
Ramirez (n, %)	5	(34)	2	(34)	3	(34) 0.257
Contamination of the surgical field (n, %)	39	(15)	22	(17)	17	(13) 0.493
Infected mesh (n,%)	21	(8)	11	(8)	10	(8) 0.921
TAR: Transversus Abdominis Release, eCST: endoscopic Component Separation Technique						

Table 5. Postoperative Outcome Measures

	Total	I (no risk factors)		II (preha- bilitated patients)		p
n	259	133		126		
SSO (n,%)	87	(34)	43	(32)	44	(35) 0.659
Seroma I-II (n,%)	22	(8)	9	(7)	13	(10) 0.306
Seroma III-IV (n,%)	19	(7)	10	(8)	9	(7) 0.908
Hematoma I-II (n,%)	28	(11)	12	(9)	16	(13) 0.341
Hematoma III-IV (n,%)	8	(3)	3	(2)	5	(4) 0.426
SSE	18	(7)	6	(5)	12	(10) 0.113
SSI	31	(12)	14	(11)	17	(13) 0.462
SSOPI	13	(5)	6	(5)	7	(6) 0.700
Systemic complications						
0 (n,%)	165	(64)	81	(61)	84	(67)
1 (n,%)	60	(23)	31	(23)	29	(23) 0.190
2 (n,%)	17	(7)	13	(10)	4	(3)
>2 (n,%)	17	(7)	8	(6)	9	(7)
Airway infection (n,%)	54	(21)	28	(21)	26	(21) 0.934

Table 5. Continued.

	Total		I (no risk factors)		II (preha- bilitated patients)		p
Pulmonary embolism (n,%)	6	(34)	5	(4)	1	(34)	0.113
Gastrointestinal (n,%)	24	(9)	10	(8)	14	(11)	0.319
Cardial (n,%)	10	(4)	7	(5)	3	(34)	0.229
Other complications (n,%)	45	(17)	24	(18)	21	(17)	0.769
Mortality (n,%)	4	(2)	3	(2)	1	(1)	0.340
Length of stay (median, IQR)	6	(5-8)	6	(5-8)	6	(5-8)	0.401
Admission >7 days (n,%)	57	(22)	27	(20)	30	(24)	0.496
Reoperation (n,%)	14	(5)	4	(3)	10	(8)	0.079
Readmission (n,%)	12	(5)	4	(3)	8	(6)	0.201

SSO: surgical site occurrence, seroma/hematoma I-II: no clinical significance, seroma/hematoma III-IV: clinical significance- needing intervention, SSE: surgical site event, SSI: surgical site infection, SSOPI: surgical site occurrence requiring procedural interventions

DISCUSSION

This study demonstrated that outcome of complex ventral hernia repair in patients who underwent pre-operative prehabilitation of modifiable risk factors was similar to patients without those risk factors. This finding is in line with studies reporting that prehabilitation might facilitate amelioration of the pre-operative condition of patients undergoing complex abdominal wall repair [15, 22, 26, 27]. A recent systematic review performed by Jensen also concluded that smoking cessation and weight loss for obese patients led to reduced complication risks, as was seen in this study [28].

The conclusion of this study is based on patients operated before the COVID-19 pandemic, because during the pandemic patients were not able to prehabilitate accurately under supervision, nor could bariatric surgery be performed to correct morbid obesity, before definitive hernia repair. The conclusion is limited by the retrospective nature of this study and the fact that outcome of prehabilitated patients with risk factors could not be compared to non-prehabilitated patients with risk factors. In our cohort, all patients with modifiable risk factors were treated with prehabilitation.

The multidisciplinary team meeting provides comprehensive, patient-centered care and acts as a platform to discuss the optimal treatment strategy for a patient. Implementing this multidisciplinary team meeting to a complex hernia care pathway was promoted by several authors and even demonstrated improved outcomes after complex abdominal wall reconstruction [30, 39, 40]. Improved outcome may be a consequence of optimized patient selection by the MDT.

In our experience, the process of optimizing patient selection in the MDT passes a learning curve [9, 42]. First, it was noticed that outcome could be improved by sticking tighter to the predetermined prehabilitation goals. In particular, the requirement to have a BMI <30, and completely refrain from smoking, became, over time, an absolute prerequisite to be eligible for hernia repair. Improved adherence to the prehabilitation protocol, may have contributed to the good outcome in the high-risk patients. Second, the decision not to operate a complex hernia patient with (unmodifiable) risk factors are difficult. Formerly, these decisions were made by a surgeon in 'splendid isolation' [43]. By sharing in a team approach to care, these decisions became better substantiated over time. Subsequential analysis of these decisions improved the decision-making process in the MDT. Third, increased attention for other risk factors developed over time [38]. Involving a geriatric physician in the multidisciplinary team meetings aids in addressing age-related risk factors [33]. Likewise, involving a psychiatrist, psychologist, or mental caretaker may decrease anxiety, medication usage, withdrawal symptoms or delirium in patient with mental diseases [35]. Finally, positive patient feedback, in combination with the results of this study, led to the continuation of the prehabilitation process. Noticeably, in some patients, increased exercises, a lower weight or stopped nicotine

abuse (no more coughing) led to disappearance of hernia related symptoms, which even dissolved their quest for repair.

To analyze the effects of prehabilitation, comparing centers that use a strict prehabilitation protocol, versus centers that do not use such a protocol, may shine light on this topic. However, as suggested in this study, the positive relation between prehabilitation and outcome may also be strongly influenced by the presence of an MDT with optimal patient selection. A lot of uncovered ground in this area of surgery is present, and further extensive research should be conducted to establish the best care pathway for this patient population.

While balancing patients demands and expectations, against the risk of surgery, the most difficult part of prehabilitation proves to be motivating and persuading the patient and preventing the surgeon from instant surgery. Prehabilitation is a promising tool to improve outcome in complex hernia patients. “First treat the patient, then treat the hernia”.

CONCLUSION

Prehabilitation of patients with modifiable risk factors may downstage complex hernia patients from high risk to low-risk patients. Prehabilitation may have a favorable effect on outcome and the indication of a such preconditioning program might be at the discretion of a multidisciplinary team meeting. Future research could focus on the extent of such program to assess its value.

CONFLICT OF INTEREST

There is no conflict of interest from any of the authors.

ETHICS APPROVAL

Not necessary given the retrospective nature of the study. No changes were made in the original care pathway for patients.

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6

Impact of a Multidisciplinary Team Discussion on Planned ICU Admissions after Complex Abdominal Wall Reconstruction

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Background

Patients often need admission at an Intensive Care Unit (ICU), immediately after complex abdominal wall reconstruction (CAWR). Lack of ICU resources requires adequate patient selection for a planned postoperative ICU admission. Risk stratification tools like Fischer score and Hernia Patient Wound (HPW) classification may improve patient selection. This study evaluates the decision-making process in a multidisciplinary team (MDT) on justified ICU admissions for patients after CAWR.

Methods

A pre-Covid-19 pandemic cohort of patients, discussed in an MDT and subsequently underwent CAWR between 2016 and 2019, was analyzed. A justified ICU admission was defined by any intervention within the first 24 h postoperatively, considered not suitable for a nursing ward. The Fischer score predicts postoperative respiratory failure by eight parameters and a high score (> 2) warrants ICU admission. The HPW classification ranks complexity of hernia (size), patient (comorbidities) and wound (infected surgical field) in four stages, with increasing risk for postoperative complications. Stages II–IV point to ICU admission. Accuracy of the MDT decision and (modifications of) risk-stratification tools on justified ICU admissions were analyzed by backward stepwise multivariate logistic regression analysis.

Results

Pre-operatively, the MDT decided a planned ICU admission in 38% of all 232 CAWR patients. Intra-operative events changed the MDT decision in 15% of all CAWR patients. MDT overestimated ICU need in 45% of ICU planned patients and underestimated in 10% of nursing ward planned patients. Ultimately, 42% went to the ICU and 27% of all 232 CAWR patients were justified ICU patients. MDT accuracy was higher than the Fischer score, HPW classification or any modification of these risk stratification tools.

Conclusion

An MDT's decision for a planned ICU admission after complex abdominal wall reconstruction was more accurate than any of the other risk-stratifying tools. Fifteen percent of the patients experienced unexpected operative events that changed the MDT decision. This study demonstrated the added value of an MDT in the care pathway of patients with complex abdominal wall hernias.

BACKGROUND

Incisional hernias develop in 13% (0–36%) of all patients after any type of midline abdominal incision; one-third (35%) will undergo subsequent repair [1–4]. Approximately 150,000 incisional hernia repairs are hospitalized each year in the USA and this number is increasing in the past two decades [2, 5, 6]. This ‘unremitting incisional hernia epidemic’ is probably fueled by performing more abdominal operations in the ageing and increasingly obese population with multiple comorbidities, although signs of a stabilized incidence are recently reported [2, 4].

The rate of such hernias that are complex, depends on the definitions used [7, 8]. A European Collaborative for abdominal wall reconstruction defined complex hernias as ‘any hernia, complicated by any negative factors’ (> 10 cm, previous repair, previous mesh, infection, and co-morbidities), and complex abdominal wall reconstruction (CAWR) as ‘any repair, complicated by large hernia, need for component separation, adhesiolysis or flap reconstruction’ [5]. The Danish Ventral Hernia Database reported 15% of all repairs were in patients with an incisional hernia > 15 cm [9]. In a systematic review by Deerenberg, large hernias (> 10 cm) were distinguished between ‘simple’, in 80%, and ‘complex’ (loss of tissue, intra-abdominal infection, infected mesh, parastomal hernia repair) in 20% of the cases [10].

CAWR leads to respiratory failure in 6–20% of patients, especially in case of risk factors like a large hernia, loss of domain (LOD), recurrent incarcerations, elderly patient, male, high ASA score, high BMI, COPD, infected wound or a concurrent intra-abdominal procedure (Table 1) [11–18].

Table 1: HPW-staging

	Hernia	Patient	Wound	HPW stage
Stage 1	1	0	0	H1, PO, WO
Stage 2	1 or 2	Any	0	H1, P1, WO H2, any P, Wo
Stage 3	Any	Any	0 or 1	H1, any P, W1 H2, any P, W1 H3, PO, WO
Stage 4	3	Any	0 or 1	H3, P1, WO H3, any P, W1

In the absence of any guideline for ICU admission after CAWR, the European Collaborative strongly recommended, that ‘intensive care beds must be available for all patients after CAWR’ [5]. This statement implies cancelation of planned CAWRs, in case of limited Intensive Care Unit capacity, like during the COVID-19 pandemic. While empty critical care beds

with adequate personnel staffing will always be a coveted resource, optimal risk-stratifying remains very essential [16].

In our hospital, the multidisciplinary team (MDT) decides whether a postoperative ICU bed needs to be planned for a specific patient. However, many patients were discharged from the ICU within 24 h after CAWR, without having been submitted to any specific ICU intervention, like monitoring vital signs by intravascular lines, applying hemodynamic support with vasopressor medication and/or applying pulmonary support by (non) invasive mechanical ventilation [16].

Besides inefficient use of the ICU, unnecessary ICU admissions are undesirable, because frequent diagnostic procedures, sleep interruptions and room transfers lead to anxiety, increased delirium risk, a prolonged hospital stay and higher costs [19–21].

This study was aimed to evaluate the pre-operative decision-making process in the MDT to optimize risk-stratification of patients planned for ICU after CAWR and to give recommendations for the future.

METHODS

This study is a single-center retrospective review of all consecutive patients with a complex abdominal wall hernia, discussed at the multidisciplinary team meeting and subsequently underwent an open complex abdominal wall reconstruction before the COVID-19 pandemic, between 2016 and 2019. This abdominal wall center is a regional non-teaching hospital and referral center for abdominal wall surgery in the Netherlands, with 50–70 CAWRs performed annually. The hospital is equipped with an ICU department with eight beds for mechanical ventilation, and four beds at the intermediate care unit.

Outcomes of the standardized screening program in every patient, including CT-scan and pulmonary function tests, are discussed at the monthly multidisciplinary team (MDT) meeting. MDT consists of hernia surgeons, an intensive care physician, a pulmonologist, an anesthesiologist, a physical therapist and nurse practitioner [22, 23]. The structure and aspects considered in this MDT have been described previously [24]. In summary, the process starts with anatomical hernia staging by EHS and risk-stratification by the Hernia Patient Wound (HPW) classification and Fischer score [12, 25, 26]. Discussion continues surgical aspects like myofascial release, mesh type, and expected intraoperative difficulties, like enterolysis, mesh explantation and concomitant intra-abdominal procedures. Then, presence of modifiable factors (smoking, weight or mental, physical, cardiopulmonary and nutritional status) could induce a preconditioning program. In case of agreement to proceed for surgery, the necessity for postoperative intensive care is discussed. The dichotomic decision to plan an ICU bed is made by consensus in the MDT with aid of HPW classification and Fischer score.

HPW classification categorizes size of the hernia (H1: 0–10 cm; H2: > 10–20 cm; H3: > 20 cm), patient comorbidities (P0: absent; P1: diabetes, smoking, BMI > 35 or use of immunosuppressants present) and surgical field (W0: clean; W1 infected). These factors are subsequently ordinally ranked in four stages, with increasing risk for developing postoperative complications (see Table 1). Stages II–IV are considered complex hernia patients, which point to ICU admission. The Fischer score comprises eight risk-factors (ten point maximum) and is a validated clinical risk-stratifying tool that predicts postoperative respiratory failure rates after CAWR: 3% with a score of 0–2, 15% (score 3–4), and 50% (score > 4) (see Table 2) [12]. A Fischer score > 2 was used as indicator for postoperative ICU admission by the MDT.

Table 2. Fischer score to predict postoperative respiratory failure after complex abdominal wall reconstruction

	Points
Pre-operative factors	
COPD	2
Pre-existing dyspnea at rest	2
Dependent functional status	1
ASA score 4	1
Hypoalbuminemia	1
Recurrent incarcerated hernia	1
Intra-operative factors	
Concurrent intra-abdominal procedure	1
Operative time > 240 minutes	1
Respiratory failure is defined by an unanticipated intubation during the postoperative period or failure to wean from mechanical ventilation in 48 hours after CAWR, COPD Chronic Obstructive Pulmonary Disease, ASA American Society of Anesthesiologists.	

Included variables were etiology of the hernia, history of wound infection or recurrent incarcerated hernia, LOD (> 20%, calculated according to Tanaka) and presence of a parastomal hernia [27]. Furthermore, patients demographics, smoking status, dyspnea in rest (score 5, Likert scale) [28], functional status (≥ 4 points at the 10-point Metabolic Equivalent of Task (MET) score was defined as an independent functional status) [29], nutritional status (malnutrition if albuminemia < 30 g/L), ASA, use of immunosuppressants, anticoagulants, and comorbidities (diabetes, COPD confirmed by pulmonologist) were taken into account.

Altered decisions for (re-)admission to ICU and intervention applied there were noted as well.

Univariate analysis was performed between characteristics of patients with justified ICU admissions and the group that sufficed standard care (all unjustified ICU patients and nursing ward patients). Nominal values and ordinal subcategories are presented as number of cases. Ordinal values are presented as median (IQR). Continuous variables are presented as mean ($\pm$ SD) for parametric data and as median (IQR) for nonparametric data. Significance was set at $p < 0.05$. Nominal data were analyzed by means of crosstabulation with Chi-Square test, whereas Fisher's Exact Test was used in cases of unmet assumptions. Assumptions for continuous data were analyzed via eyeballing, Kolmogorov-Smirnov Test, and Skewness and Kurtosis values. Normally distributed data were analyzed via independent samples student's T-Test, whereas non-normally distributed data were analyzed via independent samples Mann-Whitney U Test.

Accuracy of the MDT in predicting justified ICU admissions, was calculated by positive and negative predictive values (PPP/NPV) and by Receiver Operative Characteristic analysis for the Area Under the Curve (AUC) and compared with the AUC of the Fischer score and HPW classification.

To optimize the risk-stratifying tools, significant unique and composite variables from the univariate analysis were tested by backward stepwise multivariate logistic regression analysis, with justified ICU admissions as dependent variable. Multiple modifications of the HPW and Fischer score were tested using different combinations of their mutual risk factors. Also, factors not included in HPW or Fischer score, but reported in similar studies as relevant risk factors (LOD, age and gender) were also tested [11–16]. Data were analyzed in RStudio (version 1.2.5001).

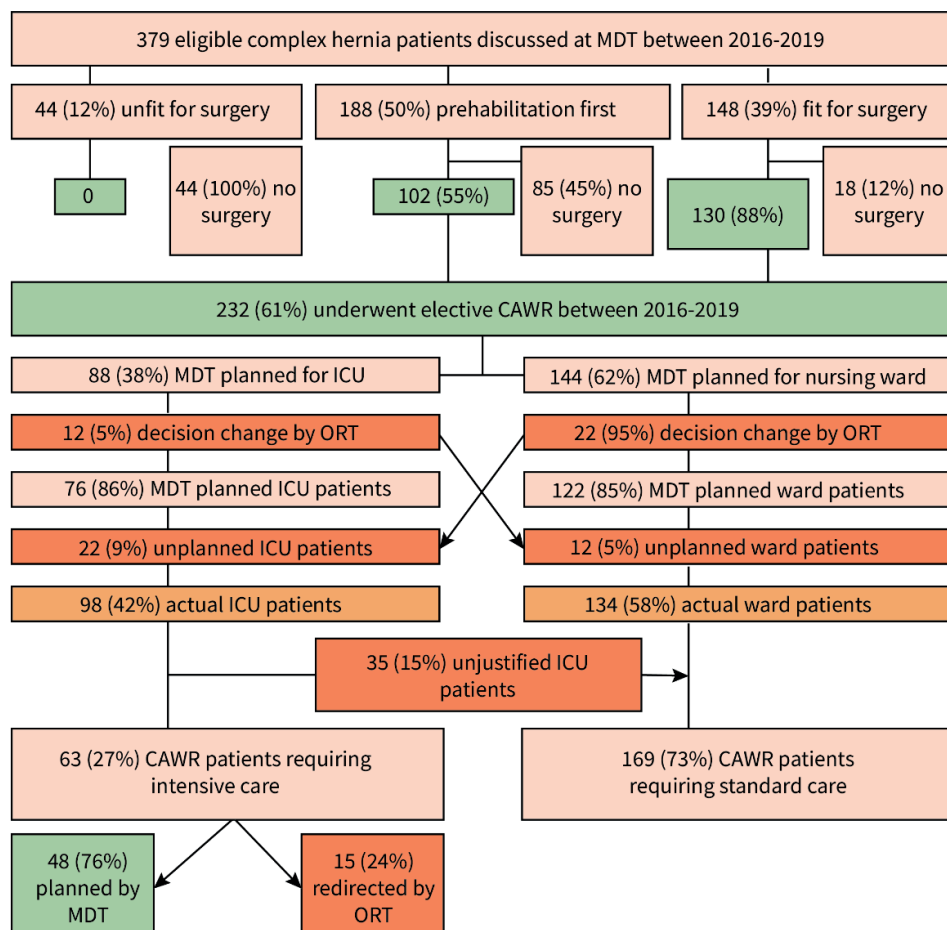


Figure 1: Impact of MDT and ORT on admission at ICU or nursing ward after CAWR. MDT: multidisciplinary team, ORT: operation room team, CAWR: complex abdominal wall reconstruction.

RESULTS

The MDT discussed 379 unique patients with a complex abdominal wall hernia and ultimately decided 232 (61%) patients fit for surgery, of whom 44% were prehabilitated. One-third of the discussed patients (39%) was not operated because they were deemed unfit for surgery due to non-modifiable comorbidities or unfinished prehabilitation. Patients with HPW stage I (hernia < 10 cm) still underwent complex reconstructions, due to hernia related factors (LOD, loss of substance need for a CST, mesh explant, concomitant abdominal procedures), co-morbidities not included in original HPW classification (COPD, fragility, age > 70, ASA III) or an expected extensive adhesiolysis. On average, 58 (48–75) CAWRs were performed annually in this selected and optimized group of CAWR patients. The rate of ICU planned patients decreased over the four years (52%, 51%, 40%, 30%) while the rate of justified ICU admissions increased (40%, 61%, 74%, 81%).

Justified ICU admissions

Ninety-eight patients, 42% of all 232 CAWRs, went immediately to the ICU after surgery (see Fig. 1). ICU specific interventions were performed in 63 of these 98 patients (64%), comprising 27% of all CAWRs.

Type of ICU specific interventions (n = 63)

- Hemodynamic instability (hypotension, oliguria, tachycardia) requiring fluid resuscitation and invasive monitoring occurred in 56/63 (90%).
- Norepinephrine in 29/63 (46%) and/or prolonged respiratory support with (non) invasive mechanical ventilation occurred in 10/63 (16%) patients.
- One patient required intensified monitoring and medication because a nodal heart rhythm had developed whilst closing the abdomen.

Causes of ICU specific interventions

- Hemodynamic instability and/or signs of a Systemic Inflammatory Response Syndrome (SIRS) were induced by a long operation time (> 3 h), due to complex reconstructions with CST, concurrent abdominal procedures, extensive enterolysis or (un)intended contamination.
- Significant blood loss with anemia requiring transfusion was present in three patients.
- Prolonged pulmonary support was required in six patients after tight midline closure with an imminent abdominal compartment syndrome.

- Pain management issues, due to malfunctioning or absent epidural catheters requiring high doses of intravenous morphine and ketamine, also led to increased monitoring in eleven patients.
- Five (planned and justified) ICU patients developed respiratory failure: three were ventilated > 48 h and two needed a reintubation, one due to exacerbation of COPD, and one due to a peritonitis induced SIRS.
- In 22 of the 144 (15%) nursing ward planned patients, the operation room team changed the initial plan, due to unexpected events intra-operatively.
- Ultimately, 15/144 (10%) of the nursing ward planned patients required ICU specific interventions.

Causes of unplanned ICU admissions

- Surgeons reported midline closure under a non-physiological high tension, contamination during enterolysis and mesh excision, or doubtful vitality of a partially strangulated bowel as reasons for referring a nursing ward planned patient to the ICU.
- Anesthetists reported a need for intensified pain management in case of absent or dysfunctional epidural catheter, a high consumption of parental fluids, increased Positive End Expiratory Pressure during midline closure or a significant anemia.
- Not in every patient a specified reason for the decision- change could be retrieved.

Unjustified ICU admissions

- Thirty-five (36%) from the 98 patients admitted at the ICU were labeled as unjustified ICU admissions, because monitoring of vital signs was the only intervention.
- Six patients with postoperative oliguria, without any other sign of hemodynamic instability, needed extra parental fluids, which is not an ICU specific intervention.

Another patient was monitored while using a continuous positive airway pressure device for obstructive sleep apnea syndrome. This device is also used at home and does not need specific ICU monitoring.

Follow-up after discharge from ICU

- None of these patients developed a SIRS within the first 24 h after the operation and all unjustified ICU patients remained at a maximum of 24 h at the ICU.

- One patient returned after 48 h from the nursing ward because of a pulmonary infection and needed reintubation.

Nursing ward patients

Causes of unplanned nursing ward admissions (instead of planned ICU admission) (n = 12)

The operation room team decided to monitor twelve ICU planned patients in the recovery room after surgery, instead of planned transfer to the ICU, due to an uneventful operative course. These patients were originally planned for ICU due to the expected complexity of the operation. But if adhesiolysis proved to be simple, an intended component separation technique was not necessary, or no relevant changes in vital signs occurred, prolonged monitoring in the recovery room was initiated. While no deterioration occurred, these patients were ultimately referred to the nursing ward. None of these patients returned to the ICU during their admission.

Follow-up of nursing ward patients (n = 134)

None of the 134 patients postoperatively sent to the nursing ward, were transferred back to the ICU within the first 24 h. One patient, primarily sent to the nursing ward, developed a myocardial infarction three days after CAWR, and was referred to the ICU for resuscitation and unanticipated intubation.

Accuracy of the MDT decision, Fischer score and HPW classification

The PPV of the MDT decision for justified ICU admissions was 55%, the NPV 90%, and the AUC 0.763 (see Fig. 2). AUC of the Fischer score was 0.703 and AUC of the HPW classification 0.688.

Univariate analysis of pre-operative characteristics, in patients requiring ICU after CAWR, demonstrated nine significant risk factors: six unique variables [hernia width, parastomal hernia in situ, hypoalbuminemia, infected wound, stoma in situ, and a planned concurrent intra-abdominal procedure) and three composed variables (ASA, Fischer score and HPW) (see Tables 3 and 4). Age, LOD, recurrent incarcerated hernia, gender, BMI and COPD, were not related to a justified ICU admission.

Table 3. Pre-operative characteristics in patients requiring intensive or standard care after CAWR

	All patients	Intensive care ^a	Standard care ^b	p-
n	232	63 (27,2%)	169 (72,8%)	value
Hernia characteristics				
Midline location (EHS M1-5)	188 (81,0%)	53 (84,1%)	135 (79,9%)	
Lateral location (EHS L1-4)	19 (8,2%)	3 (4,8%)	16 (9,5%)	.509
Mixed location	25 (10,8%)	7 (11,1%)	18 (10,7%)	
Hernia width (cm, median, IQR)	9 (6-12)	11 (7-15)	9 (6-11)	.004
0-9,9 cm (HPW: H1)	124 (53,4%)	26 (41,3%)	98 (58,0%)	
10-19,9 cm (HPW: H2)	96 (41,4%)	30 (47,6%)	66 (39,1%)	.009
>20 cm (HPW: H3)	12 (5,2%)	7 (11,1%)	5 (3,0%)	
Hernia surface (cm ² median, IQR)	74 (31-154)	120 (50-236)	57 (28-126)	.000
Loss of substance	64 (27,6%)	19 (30,2%)	45 (26,6%)	.592
Loss of domain >20%	36 (15,5%)	13 (20,6%)	23 (13,6%)	.186
Parastomal hernia	17 (7,3%)	13 (20,6%)	4 (2,4%)	.000
Patient characteristics				
Age (mean±SD)	61,3±10,4	64,1±10,8	60,4±10,3	.072
Female	105 (45,3%)	33 (52,4%)	72 (42,6%)	.183
History of malignancy	59 (25,4%)	15 (23,8%)	44 (26,0%)	.931
History of smoking	133 (58,1%)	36 (57,1%)	97 (58,4%)	.860
History of wound infection	81 (34,9%)	28 (44,4%)	53 (31,4%)	.063
Anticoagulation use	60 (25,9%)	19 (30,2%)	41 (24,3%)	.361
BMI (mean±SD)	28,6±3,8	29,2±4,0	28,6±3,8	.288
ASA I	24 (10,4%)	2 (3,2%)	22 (13,1%)	
ASA II	160 (69,3%)	38 (60,3%)	122 (72,6%)	.000
ASA III	47 (20,3%)	23 (36,5%)	24 (14,3%)	
At least one (HPW) P-factor present	64 (27,6%)	20 (31,7%)	44 (26,0%)	.387
Obese (BMI≥35) (HPW: P1)	14 (6,0%)	6 (9,5%)	8 (4,7%)	.173
Diabetic (HPW: P1)	25 (10,8%)	10 (15,9%)	15 (8,9%)	.126
Current smoker (HPW: P1)	24 (10,3%)	5 (7,9%)	19 (11,2%)	.462
Immunosuppressants (HPW: P1)	12 (5,2%)	5 (7,9%)	7 (4,1%)	.246
Wound characteristics				
Presence of a stoma	31 (13,4%)	18 (28,6%)	13 (7,7%)	.000
Wound status CDC II-IV (HPW: W1)	43 (18,5%)	24 (38,1%)	19 (11,2%)	.000

Bold is p<.05. ^aJustified ICU admissions, ^bCompromising both unjustified ICU patients and nursing ward patients, SD Standard Deviation, IQR Interquartile Range

Table 4. Fischer score, HPW stage and peri-operative characteristics in CAWR patients requiring intensive or standard care

	All patients	Intensive care	Standard care	p-value
	232	63 (27,2%)	169 (72,8%)	
Fischerscore (med., IQR)	0 (0-2)	1 (0-2)	0 (0-1)	.000
COPD	38 (16,4%)	14 (22,2%)	24 (14,2%)	.142
Dyspnea at rest	5 (2,2%)	3 (4,8%)	2 (1,2%)	.095
Dependent functional status	25 (10,7%)	7 (11,1%)	18 (10,6%)	.129
ASA score >3	0	0	0	
Hypoalbuminemia	15 (7,3%)	10 (15,8%)	7 (4,1%)	.003
Recurrent incarcerated hernia	19 (8,2%)	8 (12,7%)	11 (6,5%)	.126
Planned conc. abdominal procedure	29 (12,5%)	18 (28,6%)	11 (6,5%)	.000
Operative time > 240 minutes ^a	19 (8,2%)	16 (25,4%)	3 (4,8%)	.000
Fischer score sum > 2 points	20 (8,6%)	14 (22,2%)	6 (3,6%)	.000
HPW-stage (median, IQR)	2 (1-2)	2 (2-3)	2 (1-2)	.000
I (H1P0W0), (non-)complex	75 (32,3%)	10 (15,9%)	65(38,5%)	
II (H1P1W0;H2P0-1W0), co-morbid	111 (47,8%)	28 (44,4%)	83 (49,1%)	
III (H1-2P0-1W1;H3P0W0), contam.	39 (16,8%)	19 (30,2%)	20 (11,8%)	.000
IV (H3P1W0;H3P0-1W1), giant	7 (3,0%)	6 (9,5%)	1 (0,6%)	
Intraoperative characteristics				
Operation time (min., med., IQR)	124 (89-167)	163 (125-240)	111 (81-148)	.000
Extirpation of previous placed mesh	47 (20,3%)	20 (31,7%)	27 (16,0%)	.008
Extirpation of an infected mesh	19 (8,2%)	9 (14,3%)	10 (5,9%)	.039
Unintended bowel lesions	16 (6,9%)	11 (17,5%)	5 (3,0%)	.000
Concurrent abdominal procedure	32 (13,8%)	20 (31,7%)	12 (7,1%)	.000
Component Separation Technique	109 (47,0%)	43 (68,3%)	66 (39,1%)	.000
Use of a biosynthetic mesh	35 (15,1%)	20 (31,7%)	15 (8,9%)	.000
Bridged repair	5 (2,2%)	4 (6,3%)	1 (0,6%)	.007
Post-operative characteristics				
Hospital stay (days, med., IQR)	6 (5-8)	9 (7-13)	6 (5-7)	.000
Respiratory failure	7 (3,0%)	5 (7,9%)	2 (1,2%)	.008
Unanticipated intubation	4 (1,7%)	2 (3,2%)	2 (1,2%)	.300
Failure to wean < 48 hours	3 (1,3%)	3 (4,8%)	0	

Bold are values $p < 0.05$. ^aJustified ICU admissions, med. Median, IQR Interquartile Range, ^aPost operative parameter, contam. contaminated

Figure 2: ROC curves on justified ICU admission after CAWR

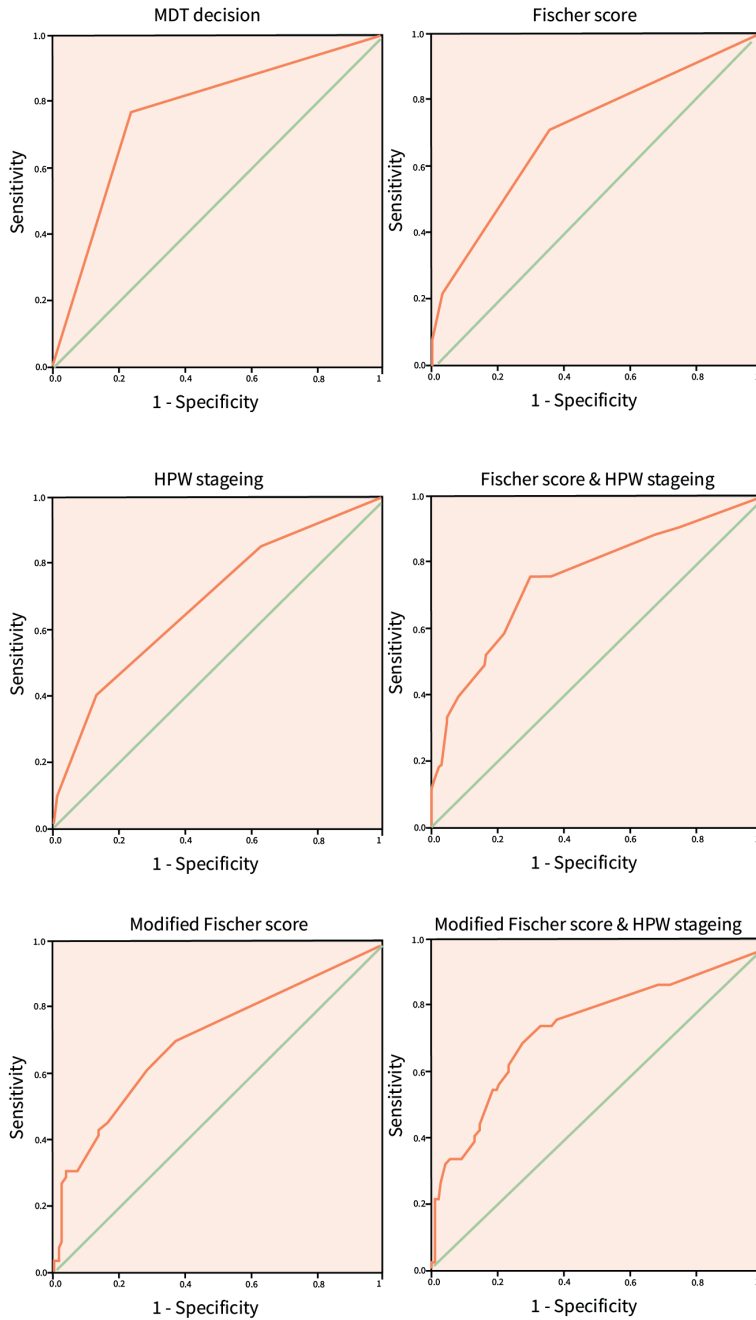


Table 5 demonstrates different combinations of (composite) variables and summarizes the AUC's after backward stepwise multivariate logistic regression analysis with these variables (see Fig. 2 and Fig. 1) The Fischer score was modified by excluding dyspnea at rest ($p = 0.095$) and dependent functional status ($p = 0.98$). Also, operative time > 240 min ($p < 0.01$) was excluded because this is not a pre-operative variable. ASA score was limited to ASA III patients, because ASA IV patients were not included in this study. The HPW was adjusted by excluding small hernias (H1) and non-significant P-factors like BMI ($p = 0.288$), diabetes ($p = 0.126$), smoking status ($p = 0.462$) and use of immunosuppressants ($p = 0.246$), as well as including age, LOD and COPD. No (modified) Fischer score, no (modified) HPW classification, or any other variation demonstrated a higher accuracy than the AUC of the MDT decision. Accuracy of the combined HPW and Fischer score (0.755) approached the accuracy of the MDT decision (0.763).

Table 5. Accuracy (ROC AUC) of (modified) risk-stratifying tools for justified ICU admission after CAWR

	items	included items	AUC
MDT decision	1	yes/no for ICU admission	76.3 [69.1-83.4]
Fischer score	1	0-7 score per patient	70.3 [62.5-78.1]
HPW-classification	1	I-IV score per patient	68.8 [60.9-76.6]
Fischer + HPW-classification	2		75.5 [68.1-82.9]
Modified Fischer	5	COPD, ASA III, HypoAlb, HRIH, PCIAP	71.4 [62.9-79.9]
Modified Fischer + HPW	6	COPD, ASA III, HypoAlb, HRIH, PCIAP, HPW	75.2 [67.2-83.2]
Modified HPW 1	3	H2+H3, P1, W1	68.3 [60.4-76.3]
Modified HPW 2	5	H1+H2+H3, W1, ASA III, HypoAlb, Age	74.0 [66.4-81.5]
Modified HPW 2 without age	4	H1+H2+H3, W1, ASA III, HypoAlb	72.0 [63.7-80.2]
Modified HPW 3	6	H2+H3, P1, W1, PSH, LOD, PCIAP	70.9 [63.0-78.7]
Variables from other studies 1	4	LOD, PCIAP, COPD, ASA III	71.3 [63.5-79.2]
Variables from other studies 2	5	H2+H3, W1, ASA III, COPD, PCIAP	74.1 [66.6-81.6]
Modified HPW 4	6	H2+H3, P1, W1, LOD, HRIH, ASA III, COPD, PCIAP	71.9 [64.1-79.6]

A maximum of six items could be tested, MDT Multidisciplinary Team, ICU Intensive Care Unit, HPW Hernia Patient Wound, H1 (0-9.9 cm), H2 (10-19.9 cm), H3 (>20.0 cm), P0 comorbidities (BMI >35 kg/m², nicotine abuse, diabetes or use of immunosuppression) absent, P1 at least one factor present, W0 clean surgical field, W1 contaminated field, HypoAlb Hypoalbuminemia (<30 g/L), HRIH History of Recurrent Incarcerated Hernia, PCIAP Planned Concurrent Intra-Abdominal Procedure, LOD Loss Of Domain $> 20\%$

DISCUSSION

Evaluation of the pre-operative decision-making process demonstrated that MDT advised ICU admission in 38% of the complex hernia patients. Intra-operative events changed the MDT decision in 15% of all CAWR patients. MDT overestimated ICU need in 45% of ICU planned patients and underestimated in 10% of nursing ward planned patients. Ultimately, 42% went to the ICU. Twenty-seven percent of all 232 CAWR patients were justified ICU patients. Risk-stratification by MDT could not be further optimized by the Fischer score, HPW classification, or any modification of these tools.

Firstly, it was observed that MDT appeared to have a very low threshold for allocation of ICU resources. Almost half (45%) of ICU planned patients did not undergo any intensive care specific intervention. The rate of ICU admissions (38%) was not only higher compared to similar studies (7–29%), patients were also much less complex, in terms of hernia size, LOD, comorbidities, infected wounds and concurrent operations, than reported in other studies [14, 16]. This high level of caution by the MDT may be the result of a learning curve. While, during subsequent years, more attention was put on accurate describing of clear and objective arguments for ICU allocation during MDT meetings, planned ICU admissions decreased and justified admission rates increased. Also, awareness of the MDT ‘prudence’, by its members, may have also calibrated decision-making over the years.

Secondly, overall accuracy was not high, while post-operative change of MDT’s initial decision occurred in one of every seven nursing ward planned patient (15%). This high rate of unexpected ICU transfers, due to unintended fecal spillage, significant bleeding or inadequate epidural functioning, is difficult to predict or prevent. Application of a transversus abdominis plane block may diminish systemic complications of intravenous pain medication [30]. Unexpected adhesions prolonging operation time could have been predicted by functional cine MRI-studies, but this method has not gained wide acceptance [31]. While not all reasons for decision-change could be retrieved, undocumented considerations like ‘gut-feeling’ may have also played a role. Patients then still may have a justified reason for ICU transfer, despite objective signs of (an imminent) SIRS are lacking [23]. To decrease the inaccuracy of pre-operative risk-stratification and learn from the unpredictability of intra-operative events, increased end-procedural attention was introduced. During ‘sign out’, at the end of the operation, the operation room team specifically appoints any unexpected intra-operative event, confirms or rejects presence of (an imminent) SIRS or abdominal compartment syndrome, and evaluates patient’s capability to cope up with a potential SIRS. Awareness of these findings may improve decision-making.

Thirdly, each (modified) risk-stratifying tool was less accurate than MDT’s decision. Fischer score is hampered by not including hernia size and wound contamination as risk factors. Applicability of the Fischer score is also lower in case of a few patients with an increased

Fischer score, like in this series (9% versus 19% in the original Fischer study). HPW is limited because it was not primarily designed to stratify for ICU admissions, nor does it include relevant risk factors like LOD, COPD or age. Moreover, effective prehabilitation on BMI, smoking, diabetes and use of immuno-suppressants ('P' factors), being present in our series, made these risk factors not significant, which decreased HPW accuracy.

While risk-stratification remains essential to patients, surgeons, health care, and clinical research, most risk models make often more “mathematical sense”, than clinical sense, especially when these models are validated externally [32]. Predicting a patient's likelihood of developing complications following CAWR remains difficult due to the unpredictability of intra-operative events [32–34]. Nevertheless, this study demonstrated that the combination of both tools approached MDT's accuracy, because together they incorporate most of the reported relevant risk factors for respiratory failure or ICU admission, after CAWR. Both tools do not include age and LOD, reported as relevant risk factors by other authors [11–18]. Probably, these factors should also be incorporated in any new risk-stratifying tool. Despite their limitations, the combination of Fischer score and HPW classification may still be helpful in selecting patients needing an ICU bed after CAWR.

Last observation by the authors is the added value of non-surgical specialists to the MDT. The capability of a patient to cope with postoperative changes in pulmonary plateau pressures, is a little explored field, in which surgeons can learn from pulmonologists [11]. It has also been noted that intensive care physicians appreciate involvement in the decision-making process before a complex surgical procedure is performed, rather than being presented with an unexpected difficult case in a postoperative acute setting [22, 23, 35, 36].

The conclusion that the MDT is more valuable in predicting ICU after CAWR than any risk-stratification tool, is based on detailed analysis of interventions performed at the ICU and multivariate logistic regression analysis of relevant pre-operative risk factors. The retrospective design, relatively small sample size compared with other publications, and the fact that several significant risk factors in this study did not correspond with previously reported risk factors in other publications, limited predictive risk modelling to further optimize the decision-making process.

The recommendation that for every planned complex abdominal wall reconstruction, an ICU bed must be available, is supported by the high rate of unexpected intra-operative events that led to decision changes in 15% of the nursing ward planned patients. On the other hand, putting this dogma into practice will lead to unnecessary reservation of ICU beds in 73% of all CAWR patients, or in 45% of all ICU planned CAWR patients. The clinical situation of a full ICU in the morning, while a complex hernia patient is waiting for elective repair, will make the surgeon reflect, whether complexity is a dichotomic scale, or if it varies between

light white and dark black. If zero risk is pursued, every CAWR patient should be cancelled in such a situation. Further improvement of the risk stratification tools is warranted.

CONCLUSION

This study was originally initiated to reduce the rate of unnecessary planned ICU beds and improve risk-stratification. Exploring the relationships between the MDT decision, outcome of risk-stratifying tools and the rate of justified ICU admissions, provided a deeper insight in the context and impact of the decisions made by the MDT and in the operation room. Ultimately, the MDT proved more accurate in predicting justified ICU admissions, than the Fischer score and HPW classification, although the combination of both tools approached MDT's accuracy. Overall, MDT's accuracy was not particularly high, due to the uncertainty of the intra-operative factor. Several options to further optimize risk-stratification are presented.

While in many other specialties, the presence of a MDT improved quality of care, in complex hernia surgery, MDTs are not omnipresent [36]. Although the profit of such multidisciplinary teams may be clear, its intrinsic value is difficult to measure [37]. This study demonstrated the value of a multidisciplinary team in risk-stratification. This unexpected finding can be an incentive for hernia centers to implement such a multidisciplinary team in their own complex hernia care pathway [23].

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7

Prevention of component separation in complex abdominal wall surgery by Botox prehabilitation: a propensity-matched study

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Aim

To facilitate midline fascial closure in complex abdominal wall surgery, component separation techniques (CST) are usually required. However, CST is associated with an enlarged morbidity. Prehabilitation could increase the compliance of the abdominal wall and thereby decrease the necessity of myofascial release. This can be accomplished by administration of Botulinum Toxin Type A (BTA) in the lateral abdominal wall musculature. The aim of this study was to determine the effect of BTA on the subsequent necessity to perform CST in patients with complex abdominal wall hernias.

Methods

Patients with a complex abdominal wall hernia, planned to undergo CST between July 2020 and November 2022 were included. Outcome of procedures with 300U of BTA 4 (2-6] weeks prior to surgery, were retrospectively analyzed by comparison with propensity matched subjects of an historical group. Hernia width difference was assessed by CT and operative details were included.

Results

A total of 13 patients with a median hernia width of 12 cm (IQR 9-14, range 24) were prehabilitated with BTA between July 2020 and November 2022. A CST was planned for all, however not required in 6/13 patients (46%) to accomplish midline fascial closure. A mean elongation of lateral abdominal wall musculature of 4.01cm was seen in patients not requiring CST. Compared to the propensity score matched control group, a 27% reduction ($p=0.08$) in the need for CST was observed.

Conclusion

There is a tendency for decrease of necessity for CST by preoperatively administered BTA in patients with complex abdominal wall defects. Although small, as this study used propensity matched comparison, further exploration of BTA should be encouraged.

INTRODUCTION

One of the main difficulties in reconstructing complex abdominal wall hernias is obtaining midline fascial closure. Chronic muscle retraction enlarges the defect size, precluding reduction of hernia sac contents and fascial closure during abdominal wall reconstruction [1]. Fascial medialization should be the goal in all hernia repair surgeries, however due to large defect size and muscle retraction this might not always be attainable [2]. Myofascial release (MFR) techniques encompass anterior or posterior component separation and have been described in literature to accomplish fascial medialization. However, these techniques are associated with higher surgical site morbidity, such as surgical site occurrences, wound morbidity, pneumonia, and ileus [3, 4, 16].

It has been theorized that chemical paralysis of lateral abdominal wall musculature could be a valuable adjunct in the repair of complex abdominal wall hernias [5]. Prehabilitation of the abdominal wall musculature to aid fascial medialization can be achieved by injecting Botulinum Toxin type A (BTA) into the lateral abdominal wall muscles (LAWM). When injected into muscle, BTA causes temporary muscle paralysis [6-7]. This is ascribable to the blocking of neurotransmitter acetylcholine release, resulting in flaccid paralysis and elongation of lateral abdominal wall muscles, increasing the rate of fascial closure during complex abdominal wall reconstruction (CAWR) [8]. The therapeutic effect is known to last for 2-12 weeks after injection. Recent literature shows possible elongation of the LAWM of up to 4.7 cm per side [4, 9-10]. Reported primary fascial closure rate after BTA prehabilitation is high, up to 75%, avoiding component separation techniques in two-third of the patients [11-12]. BTA prehabilitation is considered a safe abdominal wall stretcher, to optimize preoperative conditions [13].

The aim of this study was to determine the effect of BTA prehabilitation on the length of lateral abdominal wall muscles, and on the need for component separation techniques (CST), in patients scheduled for complex abdominal wall reconstruction.

METHODS

The performed study was a retrospective study in a tertiary referral center for CAWR. Patients who underwent complex abdominal wall reconstruction and were prehabilitated with BTA 4-6 weeks prior to surgery were included. Patients with preoperative progressive pneumoperitoneum (PPP) were excluded.

All patients were discussed at least once in a multidisciplinary team meeting (MDT) by an abdominal wall surgeon, pulmonologist, ICU physician, anesthesiologist, and physiotherapist, and assays such as a CT-scan, pulmonary testing, an EKG, blood tests for hemoglobin, HbA1c and albumin were performed.

At the MDT, a traffic light color code is allocated. Patients who are allocated green, are considered fit for surgery, and have no (increased) per-operative risk factors. Patients who are allocated orange, are eligible for surgery, only after prehabilitation measurements are taken. After prehabilitation, the patient is again discussed in the MDT, and if prehabilitation is successful, the color code will shift from orange to green [14]. Prehabilitation measures could consist of physical therapy, dietary advice, glycemic control, pulmonary preparations: in other words, optimization of all risk factors preoperatively.

Patients who are allocated red will not follow the complex hernia care pathway for surgical repair due to unmodifiable risk factors. Nor will they principally ever be operated on, due to the extremely high estimated morbidity and mortality risk.

BTA prehabilitation was considered necessary if the defect width was greater than 10 cm, or in specific cases if the MDT participants considered it to be a valuable addition.

All patients selected for BTA prehabilitation were administered pre-operative BTA 4-6 weeks prior to abdominal wall repair surgery as an outpatient procedure. Injection was executed by a surgeon or nurse practitioner and a radiologist, using ultrasonography to visualize the three lateral muscle layers. BTA was injected on 6 different injection sites: 3 in the left LAWM and 3 in the right LAWM. Per injection, a dilution of 17 Units BTA was used in a syringe of 12.5cc, which was fully injected: approximately 4 cc in each muscle layer (transversus abdominis muscle, internal oblique muscle, external oblique muscle).

CT scans were made prior to BTA injection and on the day of surgery, to determine length of abdominal wall muscles, as well as to calculate the volume of incisional hernia, and volume of abdominal cavity. CT scans were viewed by an experienced radiologist [Image 1]. CT scans were viewed retrospectively, all at once.

During surgery, the necessity for CST was estimated by the performing surgeon. All patients underwent open CAWR surgery with retromuscular mesh placement. If CST was assessed required, either endoscopically assisted component separation (eCST) or transversus abdominis release was executed.

A prospectively obtained database was used for analysis. Data acquired were patient characteristics, hernia characteristics pre- and post-BTA (most importantly defect width, loss of domain (LOD) (calculated with the Tanaka method) (17) in percentage, length of lateral abdominal wall musculature (LAWM)), and prediction of necessity for CST. Peri- and postoperatively collected data were length of operation time, CST needed, occurrence of complications.

Primary outcome measures were pre- and post-BTA length of the muscles, difference in loss of domain, and myofascial release performed. Secondary outcome measures were postoperative complications, length of operation time, and length of hospital stay.

All patients who underwent BTA prehabilitation were propensity matched to patients in an already existing database of all who underwent complex abdominal wall surgery. This was a prospectively maintained database, updated by a coordinating physician.

Data collected in this database is comparable to data as described above. The only noteworthy difference was the absence of a measured length of abdominal wall musculature.

Patients were propensity matched firstly using logistic regression to calculate their individual propensity scores, in Microsoft Excel. Covariates used in this calculation were age, mean BMI, hernia width and loss of domain > 20% (LOD). Patients were matched using a caliper of 0.02 for all parameters. Furthermore, a 1:2 (exposed: not exposed) matching ratio was used. Covariate balance was checked in both groups. The historical control group of subjects to choose from consisted of 135 patients.

Statistical analysis was executed using Microsoft Excel, with XLSTAT extension. Analysis was overseen by a statistic.

Ethical approval was not necessary given the retrospective nature of the study. No changes were made in the original care pathway for patients.

Table 1. Pre- and post BTA characteristics

n	Pre BTA 13	Post BTA 13	Δ	p
m. Obliquus externus (r) (cm)	11.92	15.04	-3.1230769	0.000054
m. Obliquus externus (l) (cm)	12.53	14.83	-2.2916667	0.013619
m. Obliquus internus (r) (cm)	11.70	15.68	-3.9769231	0.000473
m. Obliquus internus (l) (cm)	12.11	15.12	-3.0083333	0.003539
m. Transversus abdominis (r) (cm)	9.99	13.43	-3.4384615	0.000996
m. Transversus abdominis (l) (cm)	10.22	12.45	-2.2333333	0.102161
LOD (%)	15.00	12.00	3	0.258383

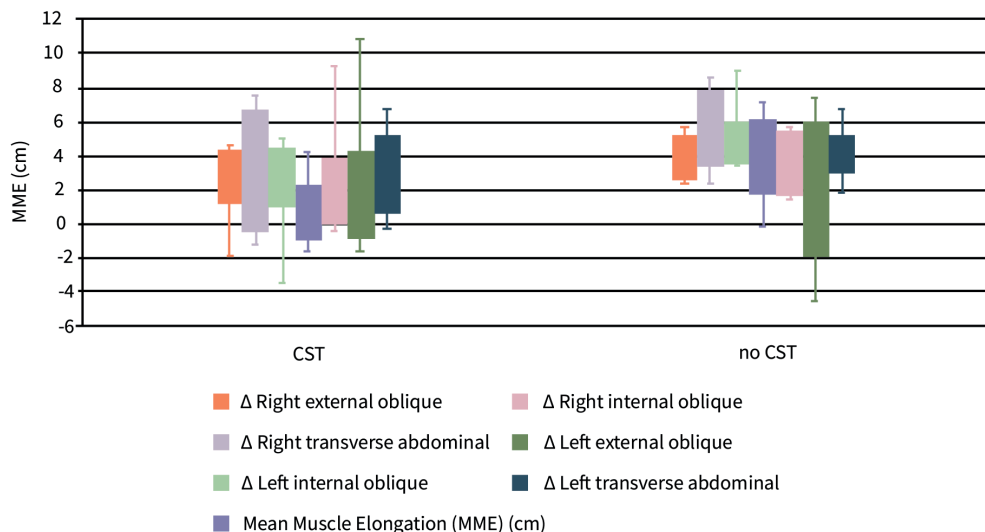
LOD = loss of domain

Table 2. Mean muscle elongation in patients who underwent CST compared to patients who didn't need CST.

n	CST 7	No CST 6	p
Muscle elongation (mean)	2.10	4.01	0.002538673
m. Obliquus externus (r) (cm)	2.37	4.00	
m. Obliquus externus (l) (cm)	3.07	5.03	
m. Obliquus internus (r) (cm)	2.13	4.97	
m. Obliquus internus (l) (cm)	0.83	3.75	
m. Transversus abdominis (r) (cm)	2.25	3.77	
m. Transversus abdominis (l) (cm)	1.92	2.55	
Time between BTA and surgery (weeks, mean)	4	4,5	0.258

Eight (62%) BTA prehabilitated patients developed postoperative complications, of which 2 (15%) were DINDO > 2. In propensity matched subjects, fifteen (58%) patients developed postoperative complications, of which 3 (12%) were DINDO > 2 ($p = 0.735$).

Graph 1: Mean muscle elongation in patients who underwent CST compared to patients who didn't need CST.



The 13 patients who underwent BTA prehabilitation were consequently matched to 26 patients from the pre-existent database [Table 5, supplementary material]. Covariates were equally divided [Supplementary material, Figure 1] and there were no statistically significant differences between the two groups on baseline level [Table 3] or in intraoperative characteristics [Table 4].

Compared to propensity matched subjects, an absolute risk reduction (ARR) of 27% [95%-CI 14.57% - 39.43%, $p = 0.078$] was found, and a NNT of 3.7 [95%-CI 2.5-6.9] was calculated.

Table 3. Baseline characteristics BTA-prehabilitated patients versus historical control group

n	Control		BTA		p-value
	26	100%	13	100%	
Sex					
Male	11	42%	5	38%	0.8179
Female	15	58%	8	62%	
Age (mean, SD)	63.99	11,64	63.923	11,934	0.9867
BMI (mean, SD)	27.431	3,894	27.458	3,064	0.9827
COPD	6	23%	3	23%	1.000
Diabetes	4	15%	3	23%	0.555126
Hernia width (mean, SD)	14.308	5,013	14.154	4,180	0.9246
Recurrent hernia	6	23%	4	31%	0.604027
LOD >20%	6	23%	3	23%	1.000

There was a non-significant decrease in surgery time (179.6min vs 161.9min), and a non-significant decrease in admission time was witnessed (9 days vs 6.2 days).

Table 4. Intra- and postoperative results of BTA-prehabilitation compared to historical control group

n	Control		BTA		p-value
	26	100%	13	100%	
Myofascial release executed	21	81%	7	54%	0.0781
Surgery time (mean, SD)	179.615	62.519	161.923	51,302	0.3840
Admission time (mean, SD)	9.077	6.203	7.154	1,951	0.2850
Complication	15	58%	8	62%	0.9732
Complication > DINDO 2	3	12%	2	15%	0.7348
Mortality	0	0%	0	0%	1.000
Recidive	1	4%	1	8%	0.6077

No difference was objectified in complications, admission time or hernia recurrence between the propensity matched groups [Table 4].

DISCUSSION

There are only few studies reporting on the exact effect of the prehabilitation with BTA in the LAWM. Literature states the primary fascial closure rate appears high due to the temporary paralysis of the muscles, allowing the surgeon to close the anterior as well as the posterior fascia tension-free.

However, evidence is lacking on the effect of BTA on the prevention of CST. Furthermore, only Timmer et al. [4] describe an estimated effect of BTA on muscle elongation and LOD.

This study determined a favorable effect of BTA prehabilitation on the length and mass of LAWM, and on the need for CST (compared to patients without prehabilitation, propensity scored), in patients scheduled for CAWR.

Overall effects of BTA were favorable, and in 6 cases, CST was prevented by BTA prehabilitation.

Several studies have shown advantageous effects of BTA on the elongation of LAWM [4, 9–10]. Our research findings are in line with these studies: BTA stretches these muscles up to 34% [Table 1]. However, there were no previous studies reporting on the effect of BTA on the prevention of CST, whereas this study showed a significant decrease in the use of CST compared to the historical control group.

Studies have shown that abdominal wall hernias with LOD greater than 20% are at high risk for the need of a myofascial release [2]. Since CST is associated with higher postoperative (wound) morbidity, prevention could be favorable considering patients' recovery trajectory. It has been theorized that CST could be prevented by injecting BTA in the LAWM, hypothetically reducing LOD. The performed study showed a decrease of LOD of 3%, not statistically significant. Moreover, more importantly, this study highlights the effect of BTA on the elongation of LAWM. Lengthening or loosening these muscles could facilitate primary fascial closure, as is seen in the CST rate in BTA prehabilitated group compared to the historical control group: a 27% decrease was established. There was no correlation found between time before surgery (after BTA injection) and the prevention of CST.

BTA prehabilitation is described as a safe abdominal wall stretcher, to optimize preoperative conditions [13]. This study is in line with these previous findings, since no adverse effects on the BTA occurred during or after the procedures.

This is the first study in this field that compares patients who underwent prehabilitation with BTA to a historical control group using a propensity score to mimic a randomized controlled trial. It is therefore the first study that can quantify the effect on the necessity for CST.

Furthermore, this research sought to observe and objectify the effect of BTA administration on the muscle characteristics and was trying to seek a causality between the measured effect of BTA and the necessity for CST.

Moreover, a propensity matched historical control group was used to demonstrate the effect of BTA on the prevention off CST. Since the study was retrospective, and conduction of an RCT was unmanageable, propensity matching appeared to be the appropriate choice, and vigorously increases the weight of the evidence obtained from this data.

While these are useful findings, they are limited by the study's numbers. Because of the explorative nature of the use of BTA in CAWR, there are only small populations appropriate to conduct research on. Furthermore, the study population was, partly because of its size, a heterogenous group. This translates into a post-hoc power of only 42.7%, resulting in required caution whilst interpreting and applying these findings. Although characteristics between both groups are not significantly different, patient characteristics could have been very different when compared individually.

Additionally, the requirement for CST was estimated by the operating surgeon at the time of surgery, meaning besides expertise, there was no guideline or standardized value for this.

Thirdly, since the hospital where this study was acquired was initially new to the process of BTA administration, a learning curve must be considered, possibly causing underestimation of the actual effect of BTA.

Moreover, the exact effect of BTA could differ in individual patients. Although BTA is supposed to have the elongating and weakening effect on the muscles it is injected in by blocking neurotransmitter acetylcholine release, there is no evidence stating the consistency of this effect on an individual patient level.

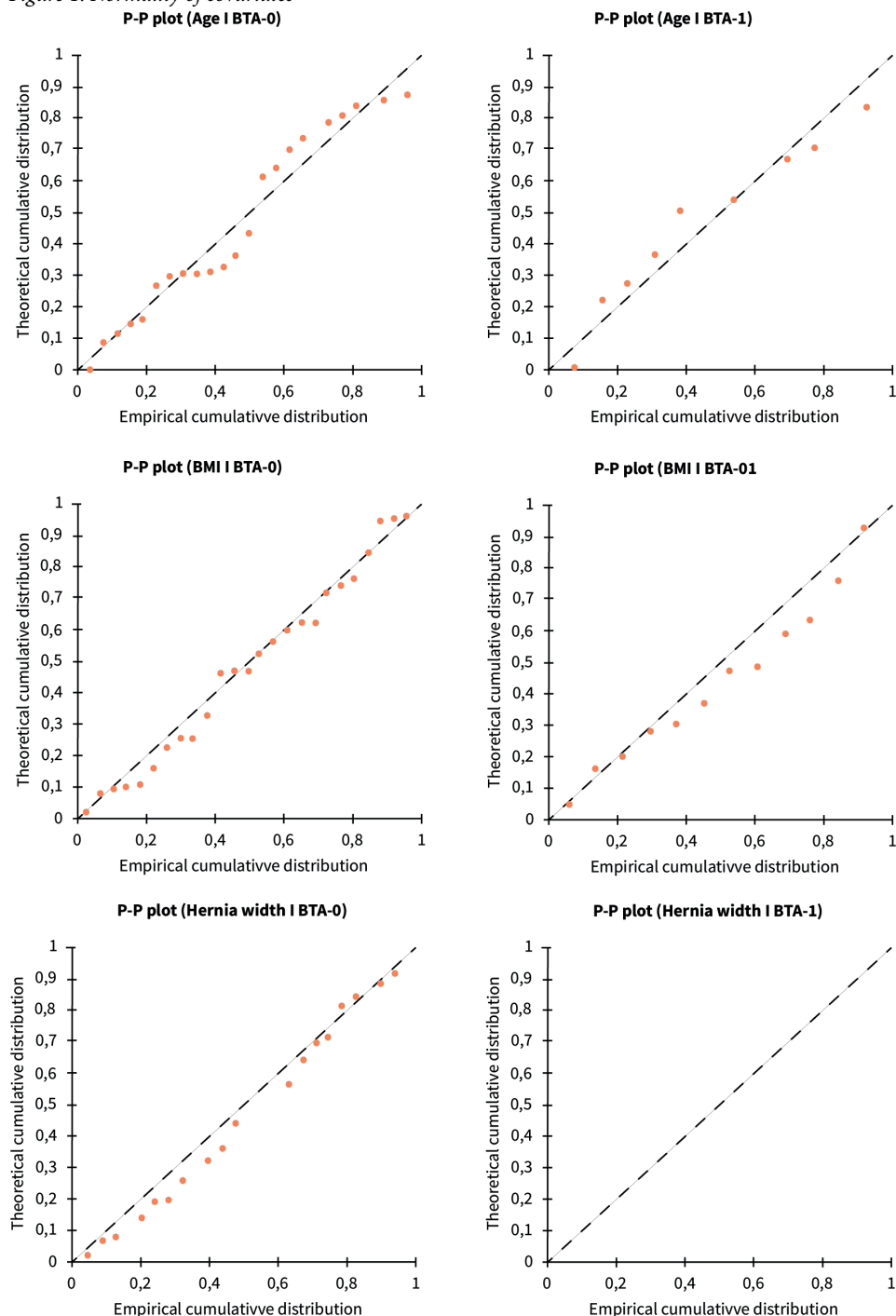
Finally, the choice to execute a myofascial release is always made intraoperatively, meaning the operating surgeon is determining whether there is a possibility of tension-free midline closure without the use of CST. Since this is a choice based on experience and expertise, there could be different "cutoff points" between surgeons for the use of CST. However, only three surgeons- FEBS-AWS certified- were operating these BTA-prehabilitated patients, so the difference is expected to be negligible.

CONCLUSION

There is a tendency for decrease of hernia width by preoperatively administered BTA and necessity for CST in patients with complex abdominal wall defects. Although small, as this study used propensity matched comparison, further exploration of BTA should be encouraged.

SUPPLEMENTARY MATERIAL

Figure 1: Normality of covariates



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8

eCST: The endoscopic assisted component separation technique for (complex) abdominal wall reconstruction

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Introduction

In 1990, Ramirez introduced his component separation technique (CST) based on enlargement of the abdominal wall for reconstruction of large abdominal wall defects. CST is prone to postoperative wound complications which lead to modification of the technique to an endoscopic assisted CST. The details of the technique are described in detail with illustrations and report the results of a 36-patient cohort.

Materials and Methods

Between 2014 and 2018, patients with midline hernias without previous subcutaneous dissection underwent endoscopic-assisted anterior components separation technique (eCST) with retro-rectus mesh enforcement in an expert center for abdominal wall reconstructions. Prospective data were gathered during inpatient care and at least 2 years of follow-up.

Results

A total of 36 eCST procedures were performed. Eight patients (22%) had post-operative seroma in the dissection plan between external and internal rectus muscle, 3 (8%) had a hematoma, 1 (3%) had wound dehiscence. Clinically relevant SSEs were present in 4 patients (11%) and consisted of 3 (8%) punctures in seroma, 1 (3%) patient needed a blood transfusion due to large hematoma. One patient was re-operated within 90 days; however, this was the placement of a surgical tracheostomy. Three patients had a recurrence in a mean follow-up length of 24 months.

Conclusion

eCST can be useful in selected patients.

INTRODUCTION

Over 20% of midline laparotomies cause an incisional hernia within 10 years [1,2]. Especially the larger ones can be challenging in preconditioning the patient, choosing, and performing an appropriate reconstruction. One of those options is the (anterior) components separation technique (CST) as described by Ramirez *et al.* in 1990 [3]. This technique is based on an open enlargement of the abdominal wall surface by transection of the external oblique muscle to create a compound flap of the internal oblique and transverse muscle that can be advanced towards the midline. CST can be used to close hernias up to 20 cm width in the waistline, however, due to the large wound surface patients are prone to postoperative wound complications (52%)[4]. Furthermore, reconstruction using the original technique (of Ramirez) without a mesh, resulted in a high recurrence rate in the long term[4,5]. The high incidence of wound complications is probably caused by transection of periumbilicular perforators, large skinflaps, and wound surfaces [4,5]. In an attempt to reduce postoperative wound complications, [an endoscopic-assisted version of the anterior component separation technique (eCST) was developed. Wound surface is hereby reduced and the periumbilicular perforators of the abdominal skin are spared. Ultimately, it was demonstrated that eCST was associated with a trend toward less wound complications compared to open anterior CST [6-15]. More recently, 20 years after the development of the eCST, the posterior component separation technique with transversus abdominis release (PCS-TAR) was developed. The PCS-TAR technique has gained huge popularity, which is demonstrated by the high number of PCS-TAR citations, derived from Pubmed between 2014 and September 2019, compared to CST and ECST, respectively, 116, 13, and 11.

This study aims to define indications for the use of eCST within the palet of current component separation techniques.

HISTORICAL OVERVIEW

Lowe *et al.* were the first who described an eCST [16]. Using this technique of Lowe a dissection balloon was placed in the subcutaneous space ventral to the anterior rectus fascia and fascia of the external oblique muscle. After removal of the balloon, the transection of the external oblique muscle was performed by endoscopic scissors and under direct endoscopic vision (top-down). Although the periumbilicular perforator was not damaged, there was still a large wound surface in the subcutaneous plane resulting in seromas [17] Maas *et al.* first described the technique where the dissection balloon was placed in the avascular plane between external and internal oblique muscle. After removal of the dissection balloon, an extra trocar was placed to dissect the insertion of the external oblique muscle by endoscopic scissors and under direct endoscopic vision (bottom-up) [17]. Both Lowe *et al.* and Maas *et al.* described a hybrid technique which means that the myofascial release was performed us-

ing the endoscopic technique after a laparotomy was performed for adhesiolysis and removing former scar [16,17].

Performing eCST

Step 1) ‘Indication’

Most important is proper patient selection. Only patients should be selected for an anterior (endoscopic assisted) CST with a longitudinal midline abdominal wall defect within the lateral borders of the rectus abdominus muscle.

Ideally, a multidisciplinary approach should define the general physical and mental condition of the patient, including pulmonary screening, radiological examination using abdominal CT-scans is a prerequisite (Table 1), preoperative screening by an anesthesiologist, and discussed in a multidisciplinary team meeting.

Table 1: Preoperative CT scan

• Size and Location of the defect using EHS classification [..]
• Presence of a diastase recti
• Condition of the muscle needed for reconstruction
• Amount of retraction (.. ratio)
• Percentage of evisceration
• Presence of old implants (mesh or tackers)
• Infection of abscess

A preoperative prehabilitation protocol, including preoperative physical therapy, is used to optimize the patient by reducing preoperative risk factors. Patients with chronic obstructive pulmonary disease (COPD; Tiffenau index <70%) should receive pre- or perioperative pulmonary preparation to prevent exacerbation. There might be some suggestions that preoperative inspiratory muscle training (IMT) reduces pulmonary complications [18]. Patients with severe obesity should be stimulated to lose weight under supervision of a physical therapist, ideally, the body mass index (BMI) should be below 30 kg/m² before surgery. Smoking should be stopped preoperatively at least for 4 weeks (Table 2).

Table 2: Patient related risk factors

• BMI > 30
• Smoking
• Diabetes
• COPD/astma/OSAS
• Heart disease
• anticoagulation
• Immunosuppressive medication

Step 2) 'Per-operative preparation'

The patient is placed in a supine position, both arms are tucked in alongside the trunk using a cotton sheet to be able to approach the lateral side of the abdomen easily.

It can be very useful to position the patient with pelvis just above the angulation of the operation table.

The operation field is created using sterile drapings and extends from the thorax to the pubic area and as far lateral as possible.

Step 3) 'Access the abdomen and perform adhesiolysis'

The midline scar is excised, and the hernia is reduced.

The hernia sac is removed.

Adhesiolysis was performed as far as the lateral peritoneal fold on both sides of the abdomen in order to investigate nonmidline defect (missed on pre-operative CT-scan), which could change the operative plane. To facilitate palpation of the abdominal wall from inside out (useful for trocar positioning) and for optimal sifting to the midline.

Step 4) 'Create the lateral endoscopic pockets'

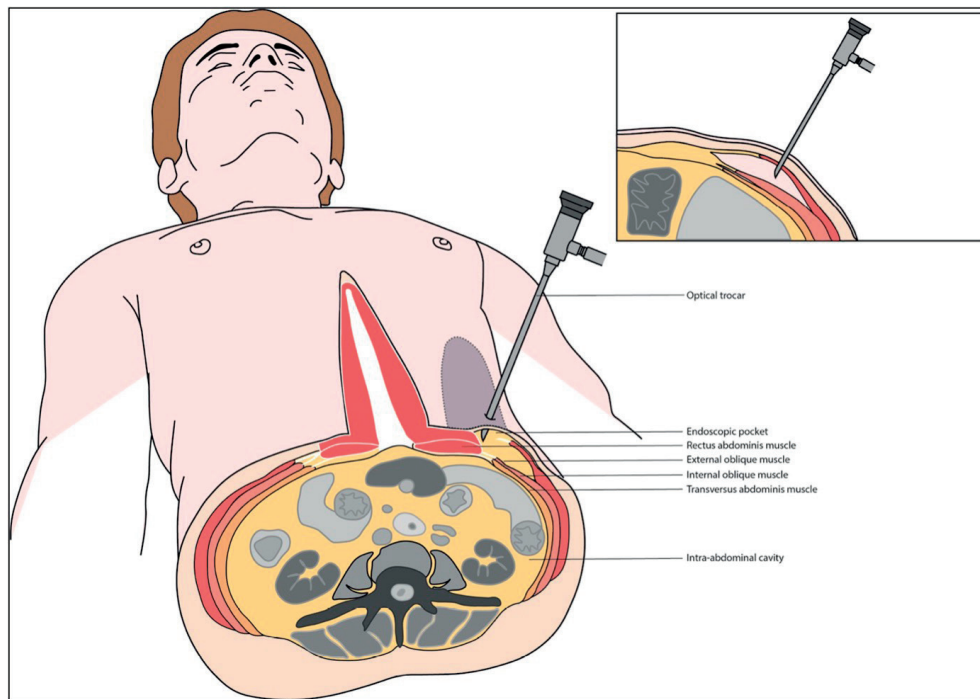
See (Figures 1 and 2) for optimal trocar placement of two trocars and position of the "endoscopic pocket."

Lower the legs by smooth "hyper" extension in the pelvis and angulate the patient a little bit to the opposite side.

A small 1.5 cm incision is made 2 cm subcostal, in line with the superior anterior iliac spine approximately 5 cm laterally from the rectus muscle. This can easily be checked by palpation "around" the rectus muscle. The fascia of the external oblique muscle is identified and incised, the muscle fibers are spread, and a blunt tip balloon trocar (10 mm AutoSuture BTT, Metronic[®]) is placed in the plane between the external and internal oblique muscle. Insufflation commences, a 5 or 10 mm 30° endoscope is introduced and used to separate the loose connective tissue between the external and internal oblique muscle, thus creating the "endoscopic pocket." One 5 mm trocar with balloon is placed under direct vision 3 cm distal to the blunt-tip trocar. Using (electrocoagulation) scissors the pocket is extended cranially 5 cm above the costal margin, distally toward the inguinal ligament and laterally to the aponeurosis of the external oblique muscle (Figure 1). Being careful on top of the costal margin for small vessels on the lateral side. The external oblique muscle is now released, using dissection hoke in combination with coagulation, approximately 1 cm lateral to the rectus abdominal muscle 5 cm cranial of the costal margin until the inguinal region in order to create a compound flap

consisting of the internal oblique and transverse muscle. See (figure 3) for an endoscopic view inside the endoscopic pocket after the external oblique muscle has been transacted. The same procedure is performed on the contralateral side. The trocars are removed, and the external oblique fascia is closed with a single resorbable suture.

Figure 1: Trocar position in eCST



Step 5) 'Create the lateral endoscopic pockets using a dissection balloon' following Jorgensen

Alternative is the technique as described by Jorgenson [19]. The first step is a small incision at the costal margin and splitting the external oblique muscle. (Figure 3) A dissection balloon is placed in distal direction and in the avascular plane between external and internal oblique muscle. Under video endoscopic vision the balloon is insufflated with care and kept in place for several minutes. After desufflation of the dissection balloon it can be changed for a blunt tip trocar and regular insufflation started. A second 5 mm trocar places just below and entrance to the pocket. The external oblique muscle is now released approximately 1 cm lateral to the rectus abdominal muscle. The last step in this approach is dissection of the external oblique muscle in the region using a clamp and electro-coagulation after removing the trocar. The trocars are removed, and the external oblique fascia cannot be closed.

Figure 2: Trocar position in eCST

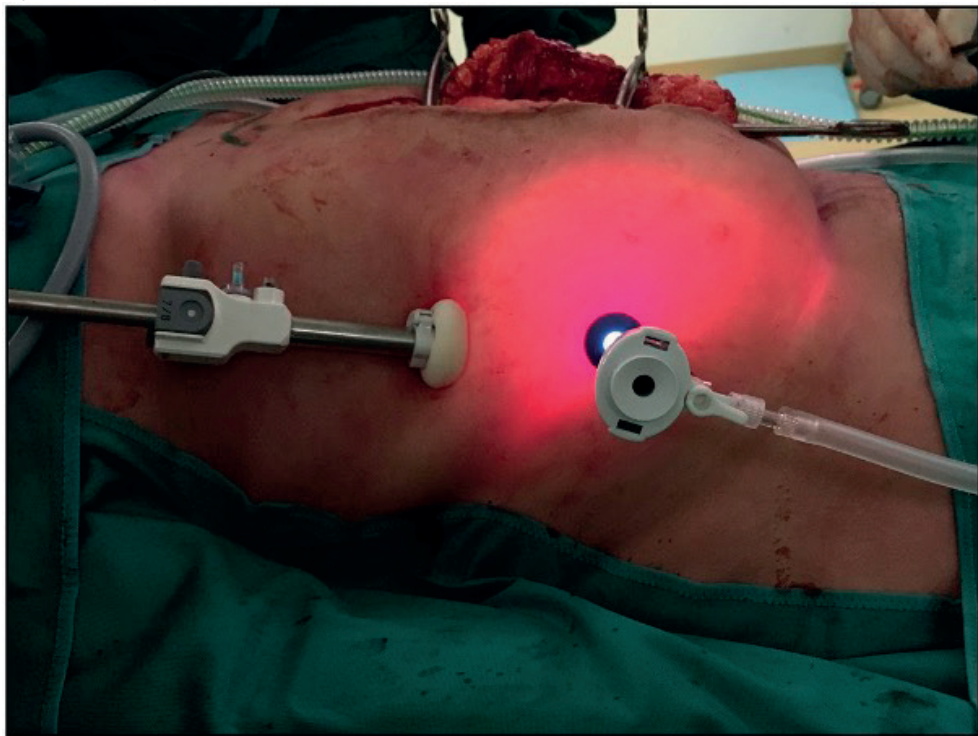
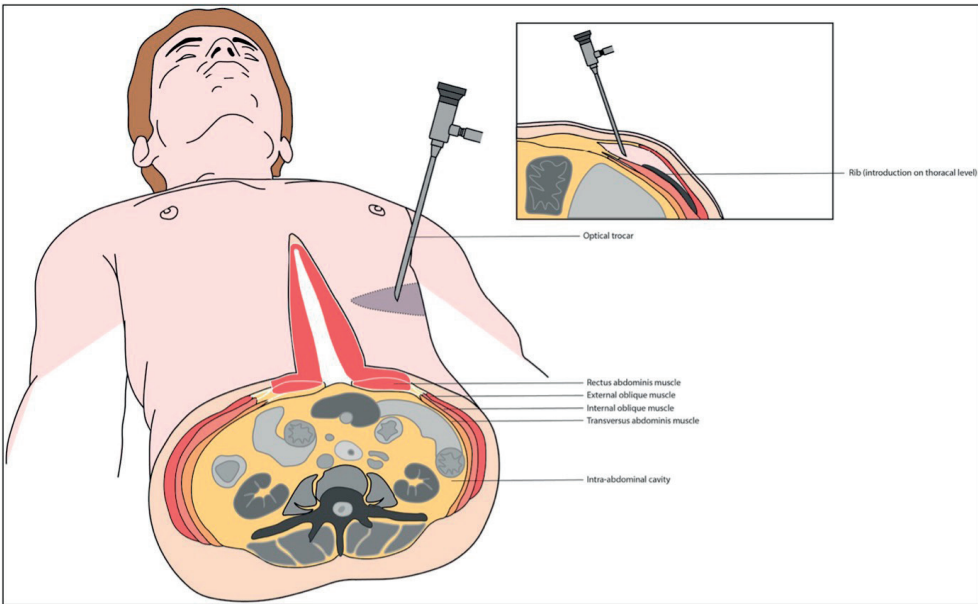


Figure 3: Trocar position eCST following Jorgenson



Step 6) 'Primary fascia closure'

The newly created compound flap consisting of the rectus muscle, internal oblique muscle, and transverse abdominal muscle (see enlargement in (Figure 4)) can now be advanced approximately 6–8 cm toward the midline on either side. Closing gaps between 10 and 15 cm in width. The posterior rectus fascia is opened and dissected following Rives–Stoppa for xyfoid until the pubic bone [20]. The fatty triangle must be fully opened. Care not to damage the neurovascular bundles on the lateral side of posterior rectus sheath.

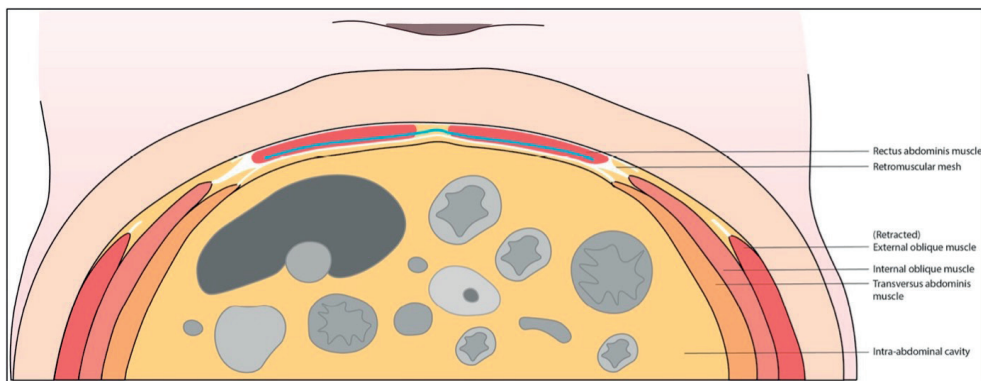


Figure 4: Retromuscular mesh placing after eCST

The posterior rectus abdominis fascia is in most patients of good quality and can be closed in the midline using a continuous slowly resorbable running 2/0 suture with small steps, small bites principle. A sublay position of the prosthetic lightweight mesh (underneath the rectus abdominis muscle, on top of the posterior rectus fascia) is preferred due to the reduced risk of bowel adhesions. In our opinion, it is not necessary to fixate the mesh. It diminishes the changes of bowel lesions or postoperative pain. The anterior rectus abdominis fascia is closed using a continuous slowly resorbable running 2/0 suture with small steps, small bites principle. The subcutaneous plane is always closed using resorbable 2/0 sutures. No drains are used. The skin is closed, and the wounds are dressed.

TIPS AND TRICKS

Tip 1) 'Presence of a uro- or enterostomy'

The presence of a uro- or enterostomy limits the surgical techniques that can be used for ventral hernia repair. However, eCST can be used in these patients if a "sublay" position of the mesh is feasible. Most important is the location of uro- or enterostomy in relation to the lateral border of the rectus (located in the center of the rectus muscle) in order to have sufficient mesh overlap. An ECST should not be used if the uro- or enterostomy must be

replaced or if a parastomal hernia is present. In these situations, a myofascial release using transversus abdominal release (TAR) should be recommended [21].

Tip 2 ‘Monitor position’

During eCST orientation inside the endoscopic pocket may be difficult for the performing surgeon. In order to assist the surgeon with orientation during the endoscopic release two endoscopic video monitors are used, one at the head of the operating table and one at the bottom end of the operating table. If the surgeon points the endoscope toward the head of the patient, the monitor located at that side of the table is used and vice versa if the endoscope is pointed towards the feet of the patient.

Tip 3 ‘Creating the endoscopic pocket’

The “space” between the external and internal oblique muscle may be difficult to identify due to its resemblance to the “space” between the transverse and the internal oblique muscle. However, after placement of the balloon trocar and insufflation of the “endoscopic pocket,” the surgeon can quickly check if he is creating the endoscopic pocket between the external and internal oblique muscle or (by mistake) in between the internal oblique and the transverse abdominal muscle since the first is an avascular plane and shouldn’t be accompanied by any bleeding during dissection of the connective tissue and the latter is not.

Tip 4 ‘Postoperative care’

The patient is advised to wear an abdominal binder for at least 4 weeks and avoid heavy lifting for 6 weeks, although there is a lack of evidence to support this [22].

EXPERIENCE

Our current practice is a single-center (regional referral center for abdominal wall surgery), retrospective series of patients who underwent elective incisional hernia repair through an eCST ($n=36$) with retro-rectus mesh position between September 2014 and December 2018 with a follow-up of at least 2 years. Data are collected prospectively in a hospital-based database. All patients received standard preoperative workup and are discussed preoperatively in a multidisciplinary setting with several hernia-specialized surgeons, pulmonologist, anesthetist, intensive care physician, and specialized abdominal wall case manager. Together, they set up a patient-tailored treatment plan and discuss the most suitable surgery.

Patients are included if they met the following criteria: age >18 years, hernia size confirmed by abdominal computed tomography (CT) scan; hernia repair with a sublay mesh; use of a lightweight polypropylene mesh or poly-4-hydroxybutyrate mesh in a contaminated situation (since 2016).

Table 3 summarizes their demographics, which are assessed preoperatively.

Table 3. Per- and postoperative data

	eCST (n=36)
Mesh type	
Synthetic	30 (83%)
Bio-synthetic	7 (19%)
Operative time	167 (120-290)
SSO	9 (25%)
SSE	4 (11%)
pulmonary complications	8 (22%)
Length of stay >14d	4 (11%)
Re-operation	1 (3%)
Recurrence	3 (8%)

Table 4 describes the operative and postoperative characteristics. A postoperative SSO rate of 25%, some patients had multiple SSOs. However, a small amount was clinically relevant surgical site events. Eight patients (22%) had postoperative seroma in the dissection plan between external and internal rectus muscle, 3 (8%) had a hematoma, 1 (3%) had wound dehiscence. Clinically relevant SSEs were present in 4 patients (11%) and consisted of 3 (8%) punctures in seroma, 1 (3%) patient needed blood transfusion due to large hematoma. One patient was re-operated within 90 days; however, this was the placement of a surgical tracheostomy.

Three patients had a recurrence in a mean follow-up length of 24 months. One patient was diabetic, smoked, and had a previous hernia repair and was classified as HPW stage 2; one patient smoked and had a previous hernia repair; one was obese and had a stoma.

Table 4. Patient demographics and hernia characteristics

	eCST (n=36)
sex	
male	19 (53%)
female	17 (47%)
Age (y)	61 (31-84)
BMI (kg/m ²)	28 (21-37)
obesity BMI >30	13 (36%)
hernia size (cm ²)	173 (31-436)
comorbidities	
DM	4 (11%)
COPD >Gold II	3 (8%)
immunosuppression	1 (3%)

Table 4. Continued

eCST (n=36)	
ASA score	
1	3 (8%)
2	23 (64%)
3	10 (28%)
HPW	
2	30 (83%)
3	6 (17%)
4	0
VHWG 2012	
1	6 (17%)
2	23 (64%)
3	7 (19%)
midline	36 (100%)
CDC	1 (3%)
1	12 (33%)
2	20 (56%)
3	2 (6%)
stoma in situ	1 (3%)

Table 5. Indications for eCST and PCS-TAR

	indications for eCST	indications for PCS-TAR
Location	Midline hernia (M2,3,4)	Hernia near bony structure (M1, M5)
	Parastomal hernia with border >2 cm medial from semilunar line	Lateral hernia (L1-L4)
Size	Hernia width 10-20 cm	Parastomal hernia with border <2cm medial from semilunar line or passing semilunar line
History	Hernia width 10-25 cm	Hernia width 10-25 cm
	Previous repair with intraperitoneal mesh	Previous repair with anterior component separation

DISCUSSION

e CST can be used to reconstruct midline abdominal wall hernias with a defect of 7–15 cm at the waistline even in patients with a uro- or enterostomy. If an anterior myofascial release is used to reconstruct a large abdominal wall defect the endoscopic assisted CST seems superior to the classical open anterior CST with respect to SSO [19].

Our technique to perform the endoscopic release differs from previously published methods such as those performed by Lowe *et al* [16]. In our opinion using a distension balloon to create a subcutaneous space has little advantage over the original technique described by Ramirez *et al.* because of trauma to the skin vascularization [3]. Rosen *et al.* and Fox *et al.* described an endoscopic method using the plane between the internal and external oblique muscles, though they lack full endoscopic control since a dissection balloon is used and the external oblique fascia is incised in three places because an extra trocar is needed to complete transection of the external oblique muscle [9,23-25]. The use of full video-endoscopic guidance to create a space in the avascular plane between the internal and external oblique muscle and transect the external oblique aponeurosis is a safe-operative technique and causes less trauma to the skin vascularization. Although the dissection in the technique described by Jorgenson is quite elegant, especially for the ergonomics of the surgeon, it is not that controlled because the balloon can easily damage small vessels. These small bleedings can be difficult to control by coagulation.

As the complexity of the abdominal hernias increases, the discussion about surgical techniques evolves.

A systematic review by Cornette *et al.* compared the SSO rates in eCST and PCSTAR surgery [26]. They found a SSO rate of 23.7% ($n = 761$) for PCSTAR and 20.3% ($n = 193$) for eCST which did not differ significantly. It is hard to compare our study outcomes with these outcomes because of the large heterogeneity in baseline patient characteristics in the studies used in the systematic review. Several of the included studies showed patients' age, contaminated wound status, and hernia width to be possible predictors of a surgical site infection and thus SSO [26].

Recent systematic review of Balla *et al.* about eCST + laparotomy (hybrid) vs. complete eCST (endoscopy in combination with laparoscopy) vs. Robot PCS-TAR shows some superiority of de-PCS-TAR considering SSO, the main difference between the techniques is the midline laparotomy which is necessary for the eCST. This midline laparotomy is sometimes unavoidable, which makes the groups not completely comparable [27].

In hernia surgery, one size does not seem to fit all. The eCST is well suitable in defects smaller than 15 cm because of the limited dissection. Therefore, the endoscopic approach is primarily

for midline hernia defects that reach up to a maximum of 2 cm medial from the semilunar line [14]. For hernias located <2 cm of the semilunar line or passing it, the PCS-TAR has been shown to be an excellent option for abdominal wall repair. Large lateral and flank hernias should have a mesh overlap of at least 5–7 cm, which only can be achieved by a PCS-TAR procedure [21]. Besides, hernias near bony structures, like subxyphoid or suprapubic, do not benefit from anterior component release but are suited for PCS-TAR (Table 5) [21].

The trocar position and number of trocars depend on the surgeons' preference. In our opinion, two lateral trocars give the best exposure to perform the dissection. Trocar position at the costal margin probably has better ergonomics.

In conclusion, reconstruction in complex abdominal wall defects is tailored surgery and demands skills of several techniques to reconstruct the abdominal wall. The choice of which techniques should be performed depends on hernia and patient characteristics. eCST can be useful in selected patients. The surgeons in any centre of excellence for hernia surgery should be familiar with the endoscopic assisted CST.

DECLARATION OF PATIENT CONSENT

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published, and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed

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9

Assessing Textbook Outcome After Implementation of Transversus Abdominis Release in a Regional Hospital

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Background

The posterior component separation technique with transversus abdominis release (TAR) was introduced in 2012 as an alternative to the classic anterior component separation technique (Ramirez). This study describes outcome and learning curve of TAR, five years after implementation of this new technique in a regional hospital in the Netherlands.

Methods

A standardized work up protocol, based on the Plan-Do-Check-Act cycle, was used to implement the TAR. The TAR technique as described by Novitsky was performed. After each 20 procedures, outcome parameters were evaluated and new quality measurements implemented. Primary outcome measure was Textbook Outcome, the rate of patients with an uneventful clinical postoperative course after TAR. Textbook Outcome is defined by a maximum of 7 days hospitalization without any complication (wound or systemic), reoperation or readmittance, within the first 90 postoperative days, and without a recurrence during follow up. The number of patients with a Textbook Outcome compared to the total number of consecutively performed TARs is depicted as the institutional learning curve. Secondary outcome measures were the details and incidences of the surgical site and systemic complications within 90 days, as well as long-term recurrences.

Results

From 2016, sixty-nine consecutive patients underwent a TAR. Textbook Outcome was 35% and the institutional learning curve did not flatten after 69 procedures. Systemic complications occurred in 48%, wound complications in 41%, and recurrences in 4%. Separate analyses of three successive cohorts of each 20 TARs demonstrated that both Textbook Outcome (10%, 30% and 55%, respectively) and the rate of surgical site events (45%, 15%, and 10%) significantly ($p < 0.05$) improved with more experience.

Conclusion

Implementation of the open transversus abdominis release demonstrated that outcome was positively correlated to an increasing number of TARs performed. TAR has a long learning curve, only partially determined by the technical aspects of the operation. Implementation of the TAR requires a solid plan. Building, and maintaining, an adequate setting for patients with complex ventral hernias is the real challenge and driving force to improve outcome.

INTRODUCTION

Major surgeries in an aging population maintain the surgical epidemic of incisional hernias [1, 2]. Repairing these hernias remains fraught with complications, especially if a patient needs a component separation technique (CST) for primary fascial closure [3–6]. Such complex abdominal wall repair procedures can be challenging, require well-organized peri-operative multidisciplinary guidance and a team which should be able to adopt new techniques [7].

Latest alteration in component separation techniques is the transversus abdominis release (TAR) [8–15]. This posterior CST was introduced in 2012 as an alternative to the classic anterior component separation technique (Ramirez) [8, 16]. The TAR is also a myofascial release intended to decrease midline tension but has an improved overlap of large defects and hernias near bony structures. The safe plane in which the mesh is positioned and lack of extended subcutaneous dissection are also assets [17, 18]. Because TAR seemed to have less surgical site occurrences and recurrences than Ramirez, TAR became popular in many hernia centers over the world [10, 11, 19, 20].

The operation itself is described as technically difficult, requiring an intimate understanding of pertinent anatomy to avoid TAR pitfalls [12, 14, 21] (Supplementary Table S1). Division of incorrect layers lead to neurovascular lesions, semilunar hernias, interparietal herniation, and recurrences. Multiple authors mentioned a learning curve of the TAR and advised implementation only after adequate training and proctoring of the first 5–15 cases, depending on the experience in open Rives-Stoppa repair [9–15].

In 2016, a team of surgeons from a regional hospital in the Netherlands commenced with the TAR after attending a TAR workshop with hands-on cadaveric dissections. This study aims to describe the outcome and learning curve of TAR, after implementation of this new technique in a dedicated hernia center.

METHODS

Setting

The Elkerliek Hospital in Helmond, the Netherlands, is a non-teaching regional hospital with three experienced hernia surgeons performing 75 complex ventral hernia repairs per year. Before the TAR was implemented, endoscopic anterior CST and open Ramirez were standard techniques for complex hernia patients.

Study Design

The Plan-Do-Check-Act (PDCA) cycle, or *Demming* cycle, was used to implement TAR and repeatedly evaluate outcome [22]. PDCA is a four-step problem-solving process involving *plan* (establishing the processes needed to deliver results according to the desired outcome), *do* (implement the new process on a small scale), *check* (measure the new process and observe any differences between that and the desired outcome), and *act* (analyze the difference between observed and expected to determine the cause). The iterative nature of repeated PDCA cycles is critical prerequisite of value-based healthcare [23, 24]. In this study, *plan* compromised a standardized work up protocol for each complex hernia patient and continuous registration of at least 200 characteristics per patient in a database. *Do* was implementation of the TAR. Outcome was *checked* after each episode of 20 procedures. Specific measurements to improve outcome were defined and subsequently implemented (*act*). The effect of these measurements was checked again after the next 20 procedures, new measurements were developed and the cycle repeated itself (Supplementary Table S2). All patients consented with the TAR and postoperative data analysis. The Institutional Review Board approved this review.

Standardized Work-Up Protocol

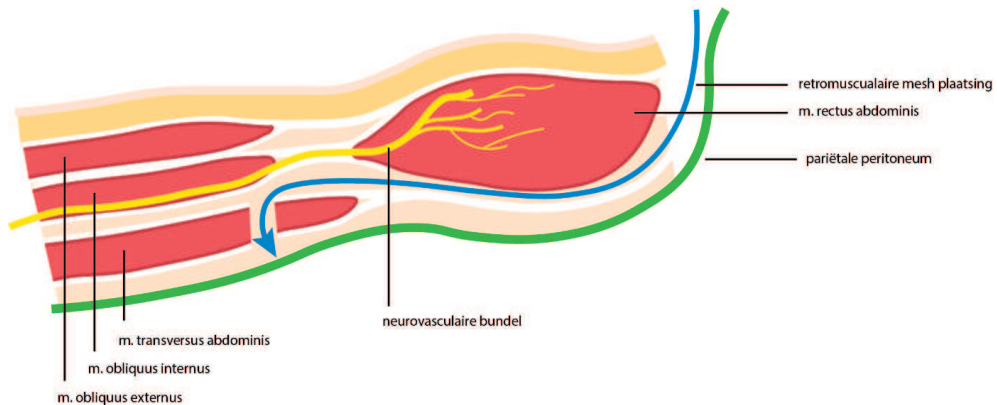
All eligible patients were informed, both orally and digitally by the patient journey app. After consent, each patient with a symptomatic complex ventral hernia was presented at a monthly multidisciplinary team (MDT) meeting, involving experienced hernia surgeons, anesthetist, ICU physician, pulmonologist, physical therapist and case manager. Patients were discussed according a four-step protocol: (I) hernia was graded according the EHS and the Hernia Patient Wound staging system [25–27]. According the Dutch guideline for incisional hernias, a complex ventral hernia is any hernia HPW stage II-IV [28, 29]. Hernias <10 cm width were also included if a primary fascial closure could not be achieved without an additional component separation technique, like hernias located against a bony structure or hernias with a significant loss of domain (LOD) > 20% [25, 26, 28, 30]. LOD was assessed by the Sabbagh method [30, 31]. Parastomal hernias were classified by the EHS parastomal hernia classification [32]; (II) surgical options were discussed. Patients with a lateral hernia or midline hernia that passed the semilunar line were initially selected; (III) potential modifiable factors for prehabilitation were identified and feasible goals that had to be achieved for the patient were assessed. Active counseling was provided to ensure a BMI <30 kg/m², smoking cessation

more than 4 weeks prior to surgery, glycemic control for diabetics and an optimal mental, physical, cardiopulmonary and nutritional status [5, 33]. Pre-operative Botulinum was not applied [34].; (IV) the *decision* was made to plan an operation, postpone surgery until the prehabilitation goals were met or waive any operation.

Standardized TAR Technique

Each patient was operated by two surgeons. Prophylactic antibiotics were administered. Midline laparotomy with excision of the scar was followed by resection of the hernia sac and complete reduction of bioburden, including formerly implanted meshes. A complete enterolysis between bowels and parietal peritoneum was performed. The rectus sheath was then incised approximately 0.5–1 cm from its medial border exposing the rectus muscle and posterior rectus sheet. This retromuscular plane was extended to the retroxyphoidal space superior and the space of Retzius inferior. Laterally, the plane was extended to the linea semilunaris until the neurovascular bundles were visualized medially. To preserve these perforators, 0.5–1 cm medial from the neurovascular bundles, the posterior lamel of the musculus obliquus internus (MOI) was incised exposing the transverse muscle (TM) in the upper abdomen and the inserting fascia of the TM in the lower abdomen. The transversus abdominis fascia and muscle were then subsequently transected exposing the underlying peritoneum/transversalis fascia (PTF). The next step was dissecting the TM from the PTF by sharp and blunt dissection, creating a large plane bordered by the lateral edges of the psoas muscle, retroxyphoidal space and Retzius' space (Figure 1A). Defects in the PTF that could not be closed, were managed with omentum or an inlay dual layer mesh (Ventralite ST™, BD). After complete posterior CST, the medialized posterior rectus sheaths were then re-approximated with a running slowly resorbable 2/0 monofilament (small bites and steps). A large mesh was placed in retromuscular position between the fasciae and selectively secured anteriorly with two slowly absorbing 2/0 monofilament stitches. The preferred mesh was a permanent large pore monofilament polypropylene mesh (30 × 30 cm Soft Mesh™, BD) in CDC wound class 1-2 or a long-term bioresorbable monofilament Poly-4-hydroxybutyrate mesh (40 × 20 cm or 30 × 25 cm Phasix™, BD) in case of contaminated surgical fields (CDC wound class 3-4), at the surgeons discretion [35]. Closed-suction drains were placed laterally on the mesh [8, 21, 36]. The anterior rectus sheaths were reapproximated with a running slowly resorbable 2/0 monofilament. Subcutaneous tissue was closed with an absorbable polyfilament running suture (Figure 1B). A subcutaneous drain was placed at the surgeon's discretion. Skin was closed intracutaneously with rapid absorbable monofilament and a sterile adhesive plaster and abdominal binder were applied. After 6 weeks of wearing a binder day and night in combination with reduced activities, a protocolized rehabilitation program under guidance of a physical therapist was commenced.

A

Posteriore componentseparatietechniek (TAR)

B

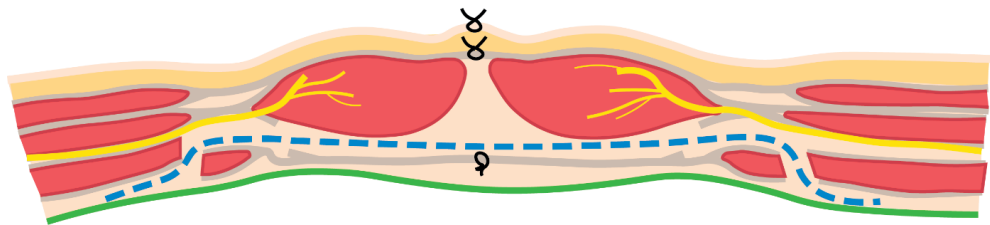
Eindsituatie na TAR met retromusculaire mesh

Image 1: (A) Schematic overview of posterior component separation technique with transversus abdominis release. (B) Final situation after TAR with retromuscular, preperitoneal mesh in place.

Outcome Measures

Primary outcome measure is Textbook Outcome (TO): the rate of patients with an uneventful clinical postoperative course after TAR. Textbook Outcome is defined in this study by a maximum of 7 days hospitalization without any complication (wound or systemic), reoperation or readmittance, within the first 90 postoperative days, and without a recurrence during follow up. While comparison of complication rates between hernia studies is biased by registration and interpretation issues, Textbook Outcome enables a comprehensive summary of simple and unambiguous clinical care parameters. Textbook Outcome is used in other surgical specialties for both internal quality improvement and comparison with other studies [37, 38]. The number of patients with a Textbook Outcome compared to the total number of consecutively performed TARs is depicted as the institutional learning curve. The institutional learning curve of applying TAR for complex abdominal wall hernias is not equivalent to the surgical

TAR learning curve, defined by a minimum number of operations needed for a surgeon to master TAR.

Secondary outcome measures were the details and incidences of the surgical site and systemic complications within 90 days, as well as long-term recurrence and bulging rates. Wound complications were grouped under surgical site occurrences (SSO) and surgical site events (SSE) [39]. SSE are all SSIs and clinically relevant SSO. SSOPI are SSO requiring a Procedural Intervention, like percutaneous drainage, wound opening, debridement, negative pressure wound therapy (NPWT) or mesh removal. Seromas and hematomas were subcategorized according the Morales-Conde classification into incidental seromas/hematomas (present max 6 months) or complicated seromas/hematomas (>6 months with discomfort or complications that needed intervention) [40]. Complications were graded by the Clavien-Dindo classification system (I-V): severe complications are type IIIb, IVa, IVb and V[41]. A recurrence was defined as any new protrusion of the contents of the abdominal cavity or preperitoneal fat through a defect in the abdominal wall at the site of a previous repair of an abdominal wall hernia [42]. Postoperative bulging is a bulge in the area of previously repaired hernia. In case of a suspected recurrence, clinical evaluation and CT were always performed.

Statistics

Continuous variables are presented as mean (SD) and categorical variables by number (proportion). To evaluate the differences between the two independent groups, for continuous variables the Mann-Whitney U Test was used and for categorical variables the Fisher's exact test. A $p < 0.05$ (two-tailed) was considered statistically significant. Statistical analysis was performed using Microsoft Excel and IBM SPSS Statistics 27.

RESULTS

During five and a half years (1 January 2016 to 1 July 2021), 491 consecutive complex hernia patients were discussed at the MDT meetings, of whom 289 patients (59%) were ultimately operated. A total of 132 (46%) patients underwent an elective CST: 69 TAR, 57 endoscopic anterior CST (ECST) and 6 Ramirez. Over the years, the rate of anterior CST decreased gradually to zero and TARs increased to 100%.

The baseline characteristics and HPW stages of the 69 TAR patients were distributed per group of 20 consecutive patients and demonstrated no relevant differences between these groups (Table 1). Comorbidity according the HPW classification (P1) was present in 29% of all patients. Pre-operative contamination of the surgical field (W1) was present in 33% of the patients, due to a stoma ($n = 21$), an ulcerated skin ($n = 1$) or open mesh ($n = 1$). Two-third (61%) of the patients were first referred for prehabilitation. Ten (14%) patients had stage I (HPW “non-complex,” <10 cm) hernias, but still needed TAR because of location against the xiphoid or iliac crest, and/or a $\text{LOD} > 20\%$. Over the years, patients tended to be older ($p = 0.07$) but had less diabetes ($p = 0.06$) and less stoma-related procedures ($p = 0.14$).

Table 1. Demographics of patients that underwent a TAR

Episode	I	II	III	IV	Total	
n	20	20	20	9	69	p-value
Hernia factors						
Previous incisional hernia repair, n (%)	5 (25)	6 (30)	7 (35)	2 (22)	20 (29)	0.788
Previous wound infection, n (%)	13 (65)	6 (30)	10 (50)	3 (33)	32 (46)	0.932
Hernia location						
Midline (EHS M1-4,L0), n (%)	10 (50)	13 (65)	15 (75)	5 (56)	43 (62)	0.823
Lateral (EHS M0,L1-4), n (%)	1 (5)	2 (10)	0 (0)	3 (33)	6 (9)	
Mixed (EHS M1-4,L1-4), n (%)	9 (45)	5 (25)	5 (25)	1 (11)	20 (29)	
Stoma present (including Bricker), n (%)	7 (35)	5 (25)	6 (30)	3 (33)	21 (30)	0.490
Presence of a concomitant parastomal hernia	4 (20)	2 (10)	5 (25)	3 (33)	14 (20)	0.391
Parastomal hernia with concomittant midline hernia (EHS type III/IV)	4 (20)	1 (5)	4 (20)	1 (11)	10 (14)	0.472

Table 1. Continued

Episode	I	II	III	IV	Total	
n	20	20	20	9	69	p-value
Planned concurrent abd. procedure	7 (35)	4 (20)	2 (10)	3 (33)	16 (23)	0.245
Hernia width on CT (cm), mean (SD)	12.3 (4.9)	12.7 (5.6)	13.3 (4.2)	11.0 (4.2)	12.5 (4.8)	0.698
H1: 0-9.9 cm, n (%)	5 (25)	6 (30)	2 (10)	3 (33)	16 (23)	
H2: 10-19.9 cm, n (%)	13 (65)	11 (55)	17 (85)	6 (67)	47 (68)	0.238
H3: >20.0 cm, n (%)	2 (10)	3 (15)	1 (5)	0 (0)	6 (9)	
Area of hernia ^a (cm ²), mean (SD)	153.0 (112.0)	140.3 (120.8)	157 (105.0)	98.0 (85.8)	143.3 (109.0)	0.267
Loss of domain > 20%, n (%)	7 (35)	3 (15)	4 (20)	2 (22)	16 (23)	0.503
Loss of substance, n (%)	9 (45)	7 (35)	8 (40)	3 (33)	27 (39)	0.122
Patient factors						
Age (years), mean (SD)	62.6 (11.6)	58.5 (8.5)	62.5 (11.0)	69.6 (6.3)	62.3 (10.5)	0.073
Males, n (%)	11 (55)	11 (55)	11 (55)	4 (44)	37 (54)	0.819
Oncological history, n (%)	5 (25)	5 (25)	12 (60)	3 (33)	25 (36)	0.090
ASA class III, n (%)	6 (30)	4 (20)	1 (5)	2 (22)	13 (19)	0.364
COPD GOLD I-IV, n (%)	4 (20)	4 (20)	7 (35)	1 (11)	16 (23)	0.851
Cardiovascular disease	7 (35)	5 (25)	7 (35)	2 (22)	21 (30)	0.811
Use of oral anticoagulants, n (%)	9 (45)	7 (35)	6 (30)	4 (44)	26 (38)	0.921
BMI (kg/m ²), median (SD)	29.5 (3.2)	27.3 (3.1)	27.6 (3.8)	28.9 (4.9)	28.2 (3.6)	0.200
Obesity (BMI>30 kg/m ²), n (%)	9 (45)	3 (15)	4 (20)	2 (22)	18 (26)	0.198
Patient factors						
P1: Morbid obesity (BMI>35 kg/m ²)	1 (5)	0 (0)	0 (0)	2 (22)	3 (4)	
P1: Current smoker past 4 weeks, n (%)	0 (0)	0 (0)	4 (20)	1 (11)	5 (7)	
Former smoker	15 (75)	13 (65)	14 (70)	4 (44)	46 (67)	0.432
P1: Diabetes, n (%)	7 (35)	2 (10)	0 (0)	4 (44)	13 (19)	0.060
P1: Use of Immunosuppression, n (%)	1 (0)	0 (0)	3 (15)	0 (0)	4 (6)	
At least one P1 factor present, n (%)	8 (40)	2 (10)	5 (25)	5 (56)	20 (29)	0.189
Wound factors						
W1: CDC wound class 2-4, n (%)	7 (35)	5 (25)	7 (35)	4 (44)	23 (33)	0.367
Pre-operative HPW stage				(0)		
I H1P0W0	3 (15)	5 (25)	2 (10)	0 (0)	10 (14)	
II H1P1W0;H2P0-1W0	10 (50)	9 (45)	11 (55)	4 (44)	34 (49)	0.415 ^a
III H1-2P0-1W1;H3P0W0	5 (25)	4 (20)	6 (30)	5 (56)	20 (29)	
IV H3P1W0;H3P0-1W1	2 (10)	2 (10)	0 (0)	1 (11)	5 (7)	
Patients referred for prehabilitation						
	11 (55)	9 (45)	15 (75)	7 (78)	42 (61)	0.154

TAR (Posterior component separation technique with) Transversus Abdominis Release, EHS European Hernia Society, ASA American Society of Anesthesiologists, COPD Chronic obstructive pulmonary disease, BMI Body Mass Index, CDC Center of Disease Control, HPW Hernia Patient Wound classification (H1, H2 or H3;P0 or P1;W0 or W1). ^aStage I&II versus stage III&IV

Table 2 demonstrates the monthly caseload, partially influenced by the Covid pandemic in latter episodes. The rate of contaminated surgical fields increased during surgery from 33% to overall 42% of the patients, due to 6 (W0) patients that had unintended bowel lesions (4) or an unexpected infected mesh that was explanted (2). Other intra-operative characteristics demonstrated no significant differences, except for the application of topical microporous polysaccharide hemospheres (MPH) (Arista™, Absorbable Surgical Hemostat, BD) to prevent hematomas and seromas, which commenced after the 31st patient. Mean operation time reduced after 60 TARs by half an hour.

Table 2. Intra-operative characteristics of patients that underwent a TAR

Episode	I	II	III	IV	Total	
n	20	20	20	9	69	p-value
Time span (months)	31	11	13	11	66	
caseload per month	0.6	1.8	1.5	0.8	1.0	
Contaminated surgical field, n (%)	8 (40)	7 (35)	10 (50)	4 (44)	29 (42)	0.805
Planned concurrent abdominal procedure (stoma reversal or replacement), n (%)	7 (88)	4 (57)	2 (20)	3 (75)	16 (55)	
Unintended contamination of the surgical field (complete bowel lesions), n (%)	3 (15)	3 (43)	1 (10)	1 (25)	8 (28)	0.728
Extirpation of an infected mesh, n (%)		1 (14)	3 (30)	1 (25)	5 (17)	
Blood loss (ml), mean (SD)	103 (151)	240 (483)	184 (425)	184 (335)	176 (372)	0.718
Bilateral TAR performed, n (%)	17 (85)	15 (75)	14 (70)	5 (56)	51 (74)	0.389
Synthetic mesh, n (%)	16 (80)	17 (85)	18 (90)	8 (89)	59 (86)	0.825
Complete anterior fascial closure, n (%)	19 (95)	19 (95)	19 (95)	9 (100)	66 (96)	0.911
Use of topical MPH (powder)	0 (0)	10 (50)	16 (80)	6 (67)	32 (46)	0.005^a
Drain placement, n (%)	10 (50)	8 (40)	4 (20)	2 (22)	24 (35)	0.184
Operation time (min), mean (SD)	186 (84)	174 (56)	180 (42)	160 (52)	178 (61)	0.751

TAR (Posterior component separation technique with) Transversus Abdominis Release, MPH Microporous Polysaccharide Hemospheres, ^afor closure of posterior fascia defects, ^bPeriod I&II versus period III&IV

Table 3. Short (90-day) and long term complications of patients that underwent a TAR

Episode n	I 20	II 20	III 20	IV 9	Total 69	p-value
Wound morbidity						
Patients with any SSO, n (%)	12 (60)	9 (45)	4 (20)	3 (33)	28 (41)	0.072
Seroma type I-IV, n (%)	5 (25)	4 (20)	2 (10)	2 (22)	13 (19)	0.659
Surgical Site Infection (SSI), n (%)	7 (35)	3 (15)	1 (5)	1 (11)	12 (17)	0.079
Hematoma type I-IV, n (%)	5 (25)	2 (10)	2 (10)	1 (11)	10 (14)	0.494
Wound dehiscence, n (%)	6 (30)	1 (5)		1 (11)	8 (12)	
Enterocutaneous fistula, n (%)	1 (5)				1 (1)	
Patients with SSE, n (%)	9 (45)	3 (15)	2 (0)	2 (22)	16 (23)	0.045
Patients with SSOPI, n (%)	4 (20)	2 (10)	1 (5)	1 (11)	8 (12)	0.517
Systemic complications, n (%)	13 (65)	10 (50)	6 (30)	4 (44)	33 (48)	0.173
Pneumonia, n (%)	6 (30)	5 (25)	6 (30)	2 (22)	19 (28)	0.957
Paralytic ileus, n (%)	4 (20)	2 (10)	3 (15)	1 (11)	10 (14)	0.825
Anemia requiring blood trans- fusion, n (%)	5 (25)	3 (15)		2 (22)	10 (14)	0.127
Decompensatio cordis, n (%)	2 (10)	1 (5)			3 (4)	
Abdominal compartment syndrome, n (%)		1 (5)			1 (1)	
Maximal Clavin-Dindo classification						
IIIb	2 (10)	1 (5)			3 (4)	
Iva	2 (10)				2 (3)	
Ivb		1 (5)			1 (1)	
Reoperation < 90 days, n (%)	2 (10)	2 (10)	1 (5)		5 (7)	
Length of hospital stay (days), mean (SD)	11.2 (9.3)	8.5 (6.2)	7.5 (3.5)	7.2 (3.8)	8.9 (6.6)	0.164
Readmission, n (%)	1 (5)		1 (5)	2 (22)	4 (6)	0.169
Follow up (months), median (SD)	37.0 (12.0)	28.2 (4.8)	23.3 (3.5)	12.3 (3.7)	27.2 (10.7)	
Recurrence, n (%)	2 (10)	1 (5)			3 (4)	0.548
Bulging, n (%)	1 (5)	1 (5)		3 (33)	5 (7)	0.398

SSO Surgical Site Occurrence, SSE Surgical Site Event, SSOPI SSO requiring Procedural Intervention

The rate of patients with one, or more, systemic complication (48%) was higher than patients with any wound complication (41%). Pneumonia (28%), ileus (14%) and anemia (14%) were most frequent (Table 3). No mortality was noted. SSO and SSI demonstrated a tendency to decrease (respectively, $p = 0.07$ and 0.08) and SSE significantly decreased in the different episodes ($p < 0.05$). Two thirds of all seromas and half of all hematomas were complicated. Eight patients developed a SSOPI (12%) of whom four patients (7%) were reoperated. During the first episode, two patients needed wound debridement (one reoperation, one outpa-

tient), one patient underwent a mesh explant (reoperation) and one patient local excision of exposed synthetic mesh (outpatient, after 82 days). During the second episode one patient needed wound debridement (outpatient) secondary to an unnoticed bowel injury (that spontaneously healed) and one patient underwent mesh explant (reoperation) secondary to an abdominal compartment syndrome. In this patient the posterior fascia could be closed again and a biosynthetic mesh placed on top. The anterior rectus fascia was left open and negative pressure wound therapy was applied. In both the third, and in the fourth episode, one patient each needed wound debridement (one reoperation, one outpatient). Application of MPH did not reduce the rate of seromas ($p = 0.53$) or hematomas ($p = 0.14$) significantly. In none of the patients, intraparietal herniations or semilunar hernias were noted. Length of hospital stay decreased from twelve to 7 days ($p = 0.16$). Readmissions occurred due to wound problems in three patients or constipated stomas in two. Recurrence rate was 4%; all three cases were related to contaminated surgical fields and use of biosynthetic meshes. No iatrogenic semilunar hernias or intraparietal herniations were encountered. Bulging occurred in five patients (7%) and all were laterally located. Three of the six lateral hernias (one with a Bricker) bulged, one mixed hernia bulged laterally after a previous ipsilateral Ramirez and in one patient mixed hernia bulged due to a pre-existent absent unilateral rectus muscle. One year mortality rate was 1% (cerebrovascular attack 11 months after TAR) and two-year mortality rate 4% (another 2 patients died after 19 and 22 months due to oncological causes).

Table 4. Textbook Outcome of patients that underwent a TAR

Episode n	I 20	II 20	III 20	IV 9	Total 69	p-value
1. Hospital stay $\leq$ 1 week, n (%)	7 (35)	11 (55)	13 (65)	6 (67)	37 (54)	
2. No Surgical Site Occurrences < 90 days, n (%)	8 (40)	11 (55)	16 (80)	6 (67)	41 (59)	
3. No systemic complications < 90 days, n (%)	7 (35)	10 (50)	14 (70)	5 (56)	36 (52)	
4. No reoperations < 90 days, n (%)	18 (90)	18 (90)	19 (95)	9 (100)	64 (93)	
5. No readmission < 90 days, n (%)	19 (95)	20 (100)	19 (95)	7 (78)	65 (94)	
6. No recurrence during follow up, n (%)	18 (90)	19 (95)	20 (100)	9 (100)	66 (96)	
Textbook outcome (all 6 items present), n (%)	2 (10)	6 (30)	11 (55)	5 (56)	24 (35)	0.012

Contamination of the surgical field was positively correlated to the development of SSOPI ($p = 0.01$). Pre-operative HPW stage was not significantly correlated with any of the outcome parameters. A significant ($p = 0.01$) increase in patients with a Textbook Outcome was found over time (Table 4). After the second episode (40 TARs), Textbook Outcome increased to 55%. The institutional learning curve of TAR demonstrated a gradient of 0.5 and was still rising after 69 procedures (Figure 2).

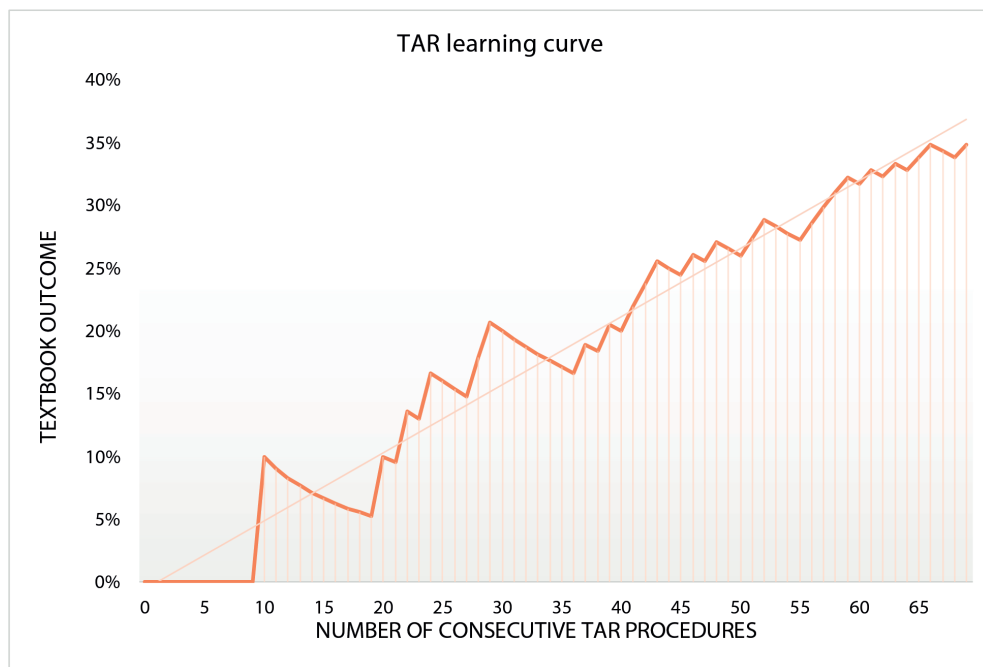


Figure 2. TAR learning curve

Check and Act: Evaluation of Outcome (TO, SSO, SSE, SSOPI) and Quality Measurements Implemented

Outcome Evaluation After the First Episode of 20 Patients

Textbook Outcome was 10% and the rate of wound complications twice compared to other TAR studies. TAR implementation developed slowly, and rate of contaminated fields was high (40%).

Measurements: 1) decreasing contaminated surgical fields by expanding the indication for TAR to include more midline hernias and hernias near bony structures, 2) decreasing SSO by improving prehabilitation (sticking more tight to the predetermined goals, in particular the requirement to have a BMI <30), 3) increasing the number of monthly complex hernia repair slots and, 4) decreasing hematomas and seromas by increased attention for meticulous dissection in combination with the application of MPH in flanks, on the mesh and subcutaneously.

Outcome Evaluation After the Second Episode of 20 Patients

Textbook Outcome increased to 30%, SSE rate decreased from 45% to 15% ($p = 0.04$), SSO and SSOPI rates also decreased (n.s.). The rate of systemic complications (50%), especially

pneumonias, remained high. Although more midline hernias were included, contaminated surgical fields did not decrease (35%). Median BMI decreased, monthly case load tripled, and MPH was applied. ACS developed in one patient. Measurements: 1) Reevaluation of the operative protocol: consultation with anesthesiologists led to measuring of the pulmonary plateau pressures under deep neuromuscular block (confirmed by post-tetanic-count stimulation), just before and immediately after midline closure. An arbitrary increase of ≥ 6 mm Hg may increase the risk of postoperative pulmonary failure or ACS and could alter the operative strategy from midline closure with an augmenting mesh to a bridging procedure. 2) Reduce drain placement while using MPH application.

Outcome Evaluation After the Third Episode of 20 Patients

Textbook Outcome increased to 55% and rate and severity of both wound and systemic and complications was further reduced: SSO to 20% ($p = 0.03$), SSE 10% ($p = 0.02$), SSOPI 5% ($p = 0.07$), despite contaminated fields in 50%. Referrals for prehabilitation increased to 75%. Lack of ICU-capacity due the Covid pandemic severely decreased caseload. Drain placement minimized from 50% to 20%. Rate of systemic complications decreased from 65% to 50%–30% in the third cohort ($p = 0.08$). Severe complications (Dindo > IIIa) did not occur. Measuring the pulmonary plateau pressures did not alter any operative strategy, nor did it reduce the rate of pulmonary infections (30%). Measurement: 1) decrease the rate of patients that need a postoperative ICU bed. The respiratory risk score, developed by Fischer, predicts the risk of postoperative respiratory failure after CAWR (43). This score was implemented to enhance the MDT decision for the need of ICU beds after CAWR. 2) Expand the indication for TAR to giant isolated flank hernias.

DISCUSSION

Five years after implementing the TAR in our hospital, Textbook Outcome occurred in 35% of 69 consecutive TAR patients. More patients (47%) developed systemic complications, than wound complications (41%). Separate analyses of three comparable cohorts of each 20 consecutive TAR patients demonstrated that both Textbook Outcome (10-30-55%) and clinically relevant wound complications (45-15-10%) significantly improved over time. After 69 TARs, the institutional learning curve of performing TARs for complex abdominal wall hernias still did not flatten.

Strength and Limitations

The strength of this conclusion is based on the “real world” design of this study: all consecutive TAR patients were included, and peri-operative characteristics and complications were recorded meticulously. A strict protocol to select and prehabilitate complex hernia patients was used, a dedicated multidisciplinary team was present, and the hospital was equipped with three experienced hernia surgeons. Repeated evaluations (PDCA cycle) generated a deeper insight in the dynamics of different outcome parameters during the course of this study, which helped in defining and implementing new quality measurements.

This study is limited by its retrospective nature. Also, quality of life, perhaps the most important outcome parameter in complex hernia surgery, was yet not evaluated in our patients [15]. Pre-operative Botulinum, which might have increased the rate of primary fascial closures or reduced the overall rate of CST, was still not standardized within our protocol [34, 44]. This study was not powered to demonstrate that HPW stratification would lead to significant differences in outcome per stage, or to detect variables (like MPH) that may improve outcome independently.

Evaluation of Outcomes

Our results were compared to similar publications from single institutions, that also reported on their initial TARs (maximum 100 patients) [8, 11, 13, 15, 20, 45–49]. Three studies described the rate of patients without any *wound* complications during hospitalization, which was 61–76% [45–47]. After the initial 40 TARs in this study, Textbook Outcome increased to 55% in the next 20 patients. This approaches these rates, although those studies did not take a 90-day inclusion period, systemic complications, re-admissions or recurrences into account. Wound complications reported in comparable studies (SSO 3-39%, SSE 3-14%, SSOPI 3-12%) resemble the results reported here, except for SSE (23%), which was high in the first episode [8, 11, 13, 15, 18, 20, 45–49]. While SSE is underreported in most studies, and no specific cause can be designated, this may be related to the TAR learning curve [8, 13, 15, 48, 49]. The rate of patients without any systemic complication cannot be deduced in any other study, nor can it be adequately compared with our results. Reported rates of recurrences (0–6%) parallel our results (4%).

Larger cohort studies or data from national registries, varying from 184 to 3109 TAR cases, demonstrated slightly better outcomes than the smaller series: SSO 18–31%, SSE 19%, SSOPI 5–9% and recurrence 3–4% [6, 10, 18, 19, 50, 51], which may be due to some learning curve effect.

The finding that more systemic, than wound, complications were noted in our series is interesting, especially in the light of 42% contaminated surgical fields. Increased attention for prehabilitation may have positively affected the SSO rate. The high rate of former smokers (67%) and COPD (23%), a higher rate of forced primary midline closure after TAR that leads to intraabdominal hypertension, a low threshold to register complications, or the fact that underreporting of systemic complications is common in TAR publications, may also have played a role in this high rate of systemic complications [11, 20, 45].

Learning Curve

The previously reported learning curve to master TAR (around ten) correlates with our SSE rate being the highest in our first episode, more specifically, in the first ten patients [9, 12]. However, TAR-specific complications, like damage to the perforating neurovascular bundles, non-closable peritoneal defects, extreme lateral (paracolic) enterolysis leading to unintended bowel injuries with fecal spillage, or primary closure under too much tension leading to an abdominal compartment syndrome, occurred mainly in our first 40 patients. In our experience, mastering the TAR technique may indeed require 5–10 procedures, but understanding for whom the TAR is the best solution, requires more than 10 TARs, and an extensive experience in mastering other component separation techniques as well.

Several authors have emphasized that the real challenge in complex hernia surgery is adequate patient selection [10, 12, 52, 53]. Maloney demonstrated in 775 CST patients, that 168 ‘ideal’ patients (BMI <35, not diabetic, no history of smoking, synthetic mesh used, complete fascia closure and a noncontaminated field) had a SSO rate of 21%, compared to 39% in 607 ‘non-ideal’ patients ($p < 0.05$) [10]. This not only demonstrates that CST has a high SSO rate and that the institutional learning curve will never be 100%, but also that outcome may be improved by converting “non-ideal” patients into “ideal” patients, possibly by effective prehabilitation [54]. Centralization of hernia surgery [52, 53, 55], prehabilitation of modifiable factors like BMI, smoking behavior or physical condition [54, 56–58], building multidisciplinary teams [7], assessing the quality of life by analyzing short- and long term patient-reported outcomes [13, 15, 49], are all quality measurements that improve patient selection and outcome. Thus, the continuous inclination of our straight-lined institutional learning curve, even after 69 TARs, does not only reflect our technical development, but also the improved capabilities in patient preparation and selection.

Future

There seems a commendable trend in hernia literature to present peri-operative data more precisely [11, 13, 15]. Still, interpreting outcome between hernia studies remains comparing “apples to oranges” [42, 59]. This can be improved by the unambiguous variable “Textbook Outcome.” Textbook Outcome is easy to understand for patient and health care workers and proved to be a valuable and simple tool to monitor the learning curve. To the best of our knowledge, this study is the first in hernia literature using Textbook Outcome, a simple, powerful and positive parameter. Therefore, future studies describing (new) operative techniques might consider using Textbook Outcome as a function of the learning curve, to put a technique in a broader perspective and make results more comparable. ‘Significantly improved quality of life’ should also become an important element in a new definition of Textbook Outcome.

CONCLUSION

The five-year results after implementing the open transversus abdominis release in a regional hospital are presented. Outcome was positively correlated to an increasing number of TARs performed. TAR demonstrated to have a long learning curve, only partially determined by the technical aspects of the operation. Implementation of the TAR in a regional hospital is feasible but requires a solid plan. Building, and maintaining, the adequate setting for patients with these complex ventral hernias is the real challenge and driving force to improve outcome.

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Perineal Hernia Repair: Multicenter Comparative Analysis of Synthetic Mesh versus Mesh combined with Tissue Flap

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Background

Surgical techniques for perineal hernia repair after abdominoperineal resection have evolved over time. Synthetic mesh repair is currently the preferred technique, but recurrence rates are high. This study aimed to compare the outcomes of mesh-only with combined mesh and tissue flap repair.

Method

Between 2006 and 2022, patients who underwent perineal hernia repair with synthetic mesh or any mesh combined with tissue flap were retrospectively identified from three referral centres. Primary endpoint was recurrent perineal hernia.

Results

Seventy-two patients with primary perineal hernia were included, of which 58 patients underwent mesh-only repair and 14 patients mesh with flap repair. Postoperative perineal wound complications occurred in 21% in both groups. Meshes were explanted solely within the mesh-only group ($n=3$). There were no technical flap failures. Recurrence of perineal hernia occurred in 34% ($n=20/58$) of mesh-only patients and in 14% ($n=2/14$) of mesh with flap patients ($p=0.12$), during a median follow up of 53 months (IQR 20-81) and 24 months (IQR 14-58), respectively. Time to recurrent hernia was median 16 months (IQR 3-31). Crossover to mesh with flap after failed mesh-only repair was successful in 4/4 patients.

Conclusion

Mesh combined with tissue flap repair of a perineal hernia seems more effective than synthetic mesh-only repair, based on an absolute 20% difference in recurrence rate. There was a lack of statistical power due to the low-volume type of surgery, even in this largest published series so far.

INTRODUCTION

Perineal hernia can develop following an abdominoperineal resection (APR), and usually occurs after a median of eight to eleven months [1-3]. A perineal hernia can have a significant impact on a patient's quality of life due to discomfort during sitting and walking, urogenital dysfunction, and small bowel obstruction [4-7].

The reported incidence of a perineal hernia after primary perineal wound closure varies widely, ranging up to 30% [1, 2]. It is important to note that the true incidence of a perineal hernia might be even higher due to the underreporting of asymptomatic patients. The development of a perineal hernia is influenced by several risk factors, including preoperative radiotherapy, extralevator resection (which leads to a broader perineal defect at the pelvic floor level), wound infection, and technique used for perineal wound closure [1, 2].

Treatment of a perineal hernia ranges from a non-surgical approach, such as utilizing supportive garments, to perineal reconstruction. It remains uncertain which technique of perineal hernia repair yields the most favourable outcome, based on scarcity of relevant literature. A systematic review from 2023 revealed 29 studies, which in total reported on 325 patients who underwent 347 repairs [8]. Synthetic meshes were preferred over biological meshes for their suggested superior success rates and lower costs [9]. Nevertheless, both types of meshes still exhibit significant recurrence rates [10].

Promising outcomes were observed with a novel surgical approach combining mesh repair with a tissue flap based on initial experience in a small series [9]. This comparative multicentre cohort study aimed to evaluate perineal hernia repair using synthetic mesh-only or mesh combined with a tissue flap, with recurrence rate as primary outcome.

METHODS

Patients

This study describes an extended experience in perineal hernia repair with follow-up update following previous publications [9, 11, 12]. Furthermore, we combined the experiences from three institutes which enabled a direct comparative analysis at an individual patient level between two surgical techniques.

Consecutive patients who underwent a perineal hernia repair were included from 2006 (Catharina Hospital, Eindhoven) or 2014 (Amsterdam University Medical Centre (UMC)) until 2022. A third cohort (2021-2022) from the Erasmus Medical Centre (MC) comprises an extension of the Amsterdam UMC cohort after a consultant surgeon switched clinics.

Patients with a symptomatic primary perineal hernia who underwent surgery at one of these three institutes with either a synthetic mesh or a mesh (synthetic or biological) combined with a tissue flap were included in the main comparative analysis. A symptomatic perineal hernia was defined as recognizable perineal complaints along with perineal bulging found during physical examination and/or descent of abdominal contents below the line between the coccyx (or distal sacrum) and the perineal body on radiological imaging. Asymptomatic hernias, detected incidentally on imaging, were not considered as an indication for surgical repair. Patients who were referred with recurrent perineal hernia after failed primary repair in another hospital were separately analysed. Patients were included irrespective of the type of APR and irrespective of underlying disease. Those who underwent pelvic exenteration as index surgery or perineal hernia repair using a biological mesh-only repair were excluded. We have previously published on this technique, and stopped performing biomes mesh repairs thereafter [11]. The medical ethics board was consulted in all three hospitals, and if deemed necessary an opt-out letter was sent.

Surgical technique

Type of hernia repair was almost exclusively determined by the institution and year of surgery. Synthetic mesh-only repair has been standard of care in the Catharina Hospital Eindhoven during the whole study period. Before the study period (2003-2006), a partially absorbable mesh and Prolene 2.0 sutures were used in eight cases, which all failed. Since 2006, standard approach was transperineal in prone position with fixation of a large nonabsorbable propylene mesh with sufficient overlap under high tension to the sacrotuberal ligaments lateral, to the urogenital diaphragm ventral, and to the gluteus maximus muscle and coccygeal bone lateral. A suction drain was placed according to surgeon's preference. Finally, layered closure of subcutaneous fat and skin was performed. Videos showing this technique have been provided in a previous publication [12]. Technique of synthetic mesh-only repair since 2014 in Amsterdam UMC was similar to the Eindhoven technique, except for a more inward fixation of the mesh to the remnants of the levator muscle laterally.

Combined mesh with tissue flap repair in Amsterdam UMC and Erasmus MC was also performed using a perineal approach in prone position. Several types of fasciocutaneous tissue flaps were initially performed on indication if tensionless closure over the mesh was not possible, and gluteal turnover flap has become standard technique since 2019. After fixation of the mesh, a gluteal turnover flap can be performed with one of the buttocks as donor site. A half-moon-shaped skin island with a maximum width of 2.5 cm is created by making an additional curved incision on one side of the wound. Subsequently, the subcutaneous fat is divided in a 45 degree angle towards the gluteus fascia. The skin is deepithelialised. A redon suction drain is routinely placed. The flap is then positioned on top of the mesh and the dermis of the flap is stitched to the opposite fixation line of the mesh laterally. The perineal subcutaneous fat of the opposite site as where the flap is harvested is mobilized from the gluteus fascia if indicated for tensionless closure over the flap, followed by layered closure of fat and skin. This technique has previously been described and illustrated with pictures [9, 13].

Data collection

Patient records were retrospectively reviewed for baseline characteristics. Regarding intraoperative details, surgical approach, type of mesh, type of flap, and operative time were collected. Also, data were retrieved on hospital stay, perineal wound complications, and recurrent perineal hernia. In the event of a recurrence, data were collected regarding date of diagnosis, radiological imaging, and re-repair. Missing data were handled using a pairwise deletion strategy.

Outcome

The primary outcome was recurrent perineal hernia, which was defined as recognizable perineal complaints along with perineal bulging found during physical examination and/or descent of abdominal contents below the line between the coccyx (or distal sacrum) and the perineal body on radiological imaging. Secondary outcomes were intra-operative complications, length of hospital stay, postoperative perineal wound complications and reinterventions, long-term complications related to the mesh (i.e. explantation, fistula, small bowel obstruction), and treatment of recurrent perineal hernia.

Statistical analysis

Categorical data were compared using the Chi-Squared test, and numerical data with the independent t-test or Mann-Whitney U test according to distribution. Kaplan Meier curves including log-rank test were constructed to estimate the cumulative proportion of recurrent perineal hernia rates. The statistical significance level was set at a P value of <0.05. Statistical analysis was performed using SPSS software for Windows version 28 (IBM Corp, Armonk, NY).

RESULTS

Patients

Between 2006 and 2022, 107 consecutive patients underwent a perineal hernia repair. Patients were excluded because of biological mesh closure (n=19), primary closure (n=2), exenteration as index surgery (n=6), and refused consent (n=1). In total, 79 patients were included, seven of whom had undergone initial perineal hernia repair at a referring hospital. Of the 72 patients who underwent primary perineal hernia repair at one of our three centres, 58 had mesh-only perineal hernia repair and 14 had mesh with flap repair. Included patients underwent APR for rectal cancer in 88% (63/72) (Table 1). In the mesh with flap group, patients had undergone more often previous pelvic surgery ($p=0.04$), had more often anal cancer ($p=0.01$), and underwent more often extralevator APR ($p=0.01$), which was performed more often by laparoscopy ($p<0.001$) and involved more additional resections ($p=0.04$). Mesh-only patients were more frequently treated with any type of radiotherapy ($p=0.03$). Perineal wound complication rate after index APR was significantly higher in the mesh with flap group (64% vs. 22%, $p=0.009$).

Table 1: baseline characteristics

	Mesh-only n=58 (%)	Mesh + Flap n=14 (%)	p-value
Referral	11/58 (19)	5/14 (36)	
Gender, women	31/58 (53)	10/14 (71)	0.22
Age, years (mean $\pm$ SD)	68 $\pm$ 9	66 $\pm$ 9	0.38
BMI, kg/m ² (mean $\pm$ SD)	26 $\pm$ 3	27 $\pm$ 5	0.30
ASA $\geq$ 3	7/58 (7)	3/14 (21)	0.71
Active or previous smoking	21/58 (36)	7/14 (50)	0.27
Medical history, yes*	15/58 (26)	6/14 (43)	0.18
Diabetes	6/58 (10)	3/14 (21)	
COPD	3/58 (5)	3/14 (21)	
Cardiac disease	12/58 (21)	3/14 (21)	
Previous pelvic surgery (other than APR)	20/58 (35)	9/14 (64)	0.04
Neoadjuvant radiotherapy			0.03
None	3/56 (5)	3/14 (21)	
Short-course radiotherapy	11/56 (20)	1/14 (7)	
Chemoradiotherapy~	40/56 (71)	7/14 (50)	
Radiotherapy for anal cancer	2/56 (4)	3/14 (21)	
Missing	2/58 (3)	0/14 (0)	

Table 1: Continued

	Mesh-only n=58 (%)	Mesh + Flap n=14 (%)	p-value
Primary disease			0.01
Rectal cancer	54/58 (94)	9/14 (64)	
Anal cancer	2/58 (3)	3/14 (22)	
Other [#]	2/58 (3)	2/14 (14)	
Type of APR			0.01
Extralevator	15/47 (32)	6/7 (86)	
Conventional	27/47 (57)	0/7 (0)	
Intersphincteric	5/47 (11)	1/7 (14)	
Missing	11/58 (19)	7/14 (50)	
Abdominal approach APR			<0.001
Open	46/53 (87)	1/9 (11)	
Laparoscopic	7/53 (13)	8/9 (89)	
Missing	5/58 (9)	5/14 (36)	
Additional resection during APR*	14/52 (27)	7/11 (64)	0.04
Coccygectomy or sacrectomy	4/52 (8)	0/11 (0)	
(Partial) vagina wall resection	5/25 (20)	3/8 (38)	
Uterus extirpation	3/25 (12)	0/6 (0)	
Adnex extirpation	4/25 (16)	0/8 (0)	
Other	2/52 (4) [^]	5/11 (45) ⁺	
Missing	6/58 (10)	3/14 (21)	
Omentoplasty	47/54 (87)	8/12 (67)	0.17
Missing	4/58 (7)	2/14 (14)	
Perineal closure after APR			0.75
Primary closure	53/58 (92)	13/14 (93)	
Biological mesh	2/58 (3)	0/14 (0)	
Flap closure	3/58 (5) [§]	1/14 (7) [@]	
Uterus extirpation before or during APR	8/31 (26)	4/10 (40)	0.35
Perineal wound complication <30 days after APR	12/54 (22)	7/11 (64)	0.009
Missing	4/58 (7)	3/14 (21)	

Data are presented as absolute numbers (proportions), unless stated otherwise.

SD: Standard Deviation; BMI: Body Mass Index; ASA: American Society of Anaesthesiologists;

COPD: Chronic Obstructive Pulmonary Disease; APR: Abdominoperineal resection

*more than one of the variables below may be applicable to the same patient

~of which two patients did not receive chemotherapy

[#] Crohn's disease (n=2), vulvar cancer, pararectal synovial sarcoma

[^]partial prostate, pelvic rim and seminal vesicles

⁺lateral lymph node dissection (n=2), proctocolectomy, vulvectomy, seminale vesicles

[§]Vertical Rectus Abdominis Muscle (VRAM) flap (n=2), gracilis flap

[@]gluteal turnover flap

Perineal hernia repair

Only a perineal approach was carried out in 97% (56/58) of the mesh-only group and in 100% (14/14) of the mesh with flap group. The performed flaps included the gluteal turnover flap (n=7), unilateral VY plasty (n=3), bilateral VY plasty (n=2), and both inferior (n=1) and superior (n=1) gluteal artery perforator flap. In one patient with VY plasty, a gluteal turnover flap was used to close the perineum after APR. In the mesh with flap group, every patient had at least one perineal vacuum drain, while this was done in 26% (15/58) of mesh-only patients ($p<0.001$). Duration of surgery was a median of 56 minutes (IQR 44-70) for mesh-only reconstruction, which was significantly shorter than 167 minutes (IQR 103-240) for mesh with flap reconstruction ($p<0.001$) (Table 2).

An intra-operative complication occurred in one patient within the mesh-only group, involving minor injuries to the serosa during extensive adhesiolysis, which were sutured. In the mesh with flap group, also one intra-operative complication occurred, consisting of a ureteral injury for which a nephrostomy was placed.

Table 2. Details of primary perineal hernia repair

	Mesh-only n=58 (%)	Mesh + Flap n=14 (%)	p-value
Time between APR and diagnosis PH, months (median, IQR)	13 (8-39)	5 (2-14)	0.03
Missing	8/58 (14)	2/14 (14)	
Time between APR and primary PH repair, months (median, IQR)	20 (12-49)	17 (8-34)	0.34
Approach to PH repair			0.65
Transperineal	56/58 (97)	14/14 (100)	
Abdominal, open	3/58 (3)	0/14 (0)	
Type of synthetic permanent mesh			
Polypropylene	35/58 (60)	-	
Composite	22/58 (38)	-	
Not specified	1/58 (2)	-	
Type of mesh			
Synthetic*	-	8/14 (57)	
Biological^	-	6/14 (43)	
Perineal vacuum drain	15/58 (26)	14/14 (100)	<0.001
≥ 2 drains	1/58 (2)	4/14 (29)	
Intraoperative complication~	1/58 (2)	1/14 (0)	0.35
Duration of surgery, minutes (median, IQR)	56 (44-70)	167 (103-241)	<0.001

Data are presented as absolute numbers (proportions), unless stated otherwise.

APR: Abdominal Perineal Resection; PH: perineal hernia; IQR: Inter Quartile Range;

*Polypropylene (n=5), Composite (n=3)

^Strattice (n=5), not specified

~Mesh-only: extensive adhesiolysis along with serosa injury requiring suturing; Mesh + Flap: injury to the ureter occurred because of disturbed anatomy with the bladder herniated through the pelvic floor.

Outcome after perineal hernia repair

A postoperative perineal wound complication occurred in 21% (12/58) of the mesh-only patients and in 21% (3/14) of the mesh with flap patients ($p=0.60$). The infectious complications of mesh-only repairs were wound infection ($n=6$) and presacral abscess ($n=4$), and non-infectious complications were seroma ($n=4$) and dehiscence ($n=1$). In mesh with flap patients, no infectious complications were reported, three patients however developed a perineal wound dehiscence.

In the mesh-only group, infectious postoperative complications required antibiotic therapy ($n=7$), radiological abscess drainage ($n=4$) and surgical abscess drainage ($n=3$), which are grade 2, 3a and 3b complications according to Clavien Dindo, respectively. Regarding the mesh with flap group, all three perineal wound dehiscences closed by secondary wound healing without any reintervention (Claviend Dindo grade 1). The postoperative perineal complications required readmission in four mesh-only patients, whereas this was not indicated in mesh with flap patients. Finally, no flap failures or donor site complications were observed. The median length of hospital stay was two days (IQR 1-3) and seven days (IQR 3-8) in mesh-only and mesh with flap patients, respectively ($p=0.003$).

Table 3. Outcome after primary perineal hernia repair

	Mesh-only n=58 (%)	Mesh + Flap n=14 (%)	p-value
Length of hospital stay, days (median, IQR)	2 (1-3)	7 (3-8)	0.003
Perineal wound complication ≤ 30 days*	12/58 (21)	3/14 (21)	0.60
Infectious*	9/58 (16)	0/14 (0)	0.13
Wound infection	6/58 (10)	0/14 (0)	
Presacral abscess	4/58 (7)	0/14 (0)	
Non-infectious	5/58 (9)	3/14 (21)	0.18
Seroma	4/58 (7)	0/14 (0)	
Dehiscence	1/58 (2)	3/14 (21)	
Flap failure	-	0/14 (0)	
Reintervention due to perineal wound complication ≤ 30 days*	11/58 (19)	0/14 (0)	0.08
Antibiotic therapy	7/58 (12)	0/14 (0)	
Radiological abscess drainage	4/58 (7)	0/14 (0)	
Surgical abscess drainage	3/58 (5)	0/14 (0)	
Other~	1/58 (2)	0/14 (0)	
Readmission	4/58 (7)	0/14 (0)	

Table 3. Continued.

	Mesh-only n=58 (%)	Mesh + Flap n=14 (%)	p-value
Pelvic complication >30 days*	5/58 (9)	2/14 (14)	0.41
Infection of mesh	3/58 (5)	0/14 (0)	
Fistula formation	3/58 (5)	1/14 (7)	
Seroma	1/58 (2)	0/14 (0)	
Small bowel obstruction^	1/58 (2)	0/14 (0)	
Vaginal wall defect, exposing mesh	0/58 (0)	1/14 (7)	
Requiring surgical reintervention	4/58 (7)	1/14 (7)	
Explantation of mesh	3/58 (5)	0/14 (0)	

Data are presented as absolute numbers (proportions), unless stated otherwise.

*More than one of the variables below may be applicable to the same patient

~Approximating the perineal wound dehiscence using skin staplers

^Only small bowel obstruction that is related to the mesh of recurrent perineal hernia

Most of the long-term complications in the mesh-only group comprised infection of the mesh (n=3), along with fistula formation between the perineal skin and the mesh in two patients, and an isolated fistula between perineal skin and the gluteal region (n=1) (Table 3). All infected meshes were explanted (n=3), and the fistula trajectory (perineum to gluteal region) was incised followed by filling with gentamycin impregnated mesh and beads (n=1).

In the mesh with flap group, one patient with Crohn's disease suffered from a recurrent fistula between the posterior vaginal wall and presacral space, for which a resection was performed while the bilateral VY plasty remained sufficient. In another mesh with flap patient, there appeared to be a small defect of the posterior vaginal wall where the mesh was immediately palpable, which was treated conservatively.

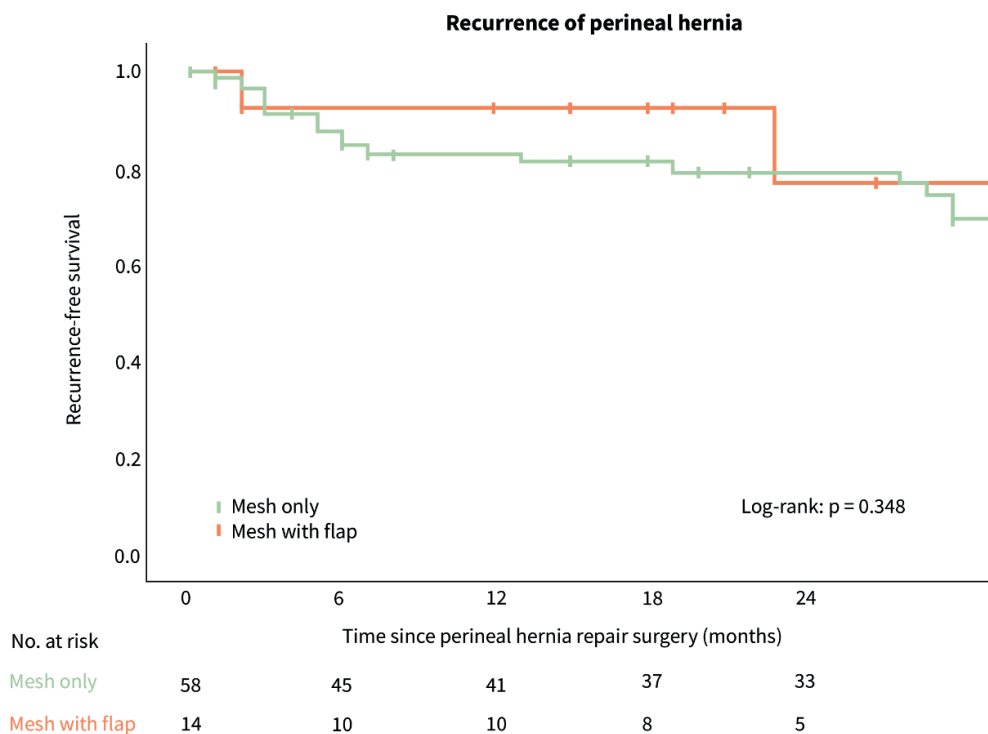


Figure 1. Recurrence of perineal hernia, Kaplan Meier analysis

Recurrence of perineal hernia

The median duration of follow-up was 53 months (IQR 20-81) after mesh-only repair, and 24 months (IQR 14-58) after mesh with flap repair ($p=0.11$) (Table 4). A recurrent symptomatic perineal hernia occurred in 34% ($n=20/58$) of the mesh-only patients and in 14% ($n=2/14$) of the mesh with flap patients ($p=0.12$). Overall median interval to recurrent perineal hernia was 16 months (IQR 3-31). Using Kaplan Meier analysis, recurrence-free survival rate at 30 months was 69% and 77%, respectively ($p=0.348$) (Figure 1).

In the mesh-only group, 14 of 20 patients with a symptomatic recurrent perineal hernia underwent a second repair. These secondary repairs consisted of mesh-only in 12 patients (by adding another synthetic permanent mesh or a refixation of the previous mesh), and mesh with flap in two patients, resulting in 8/12 and 0/2 re-recurrent perineal hernia, respectively (Supplementary Figure 1). Success rates of a third and fourth hernia repair, which were all mesh-only, were 4/8 and 0/2, respectively.

Regarding the mesh with flap group, both patients with a symptomatic recurrence underwent a second perineal hernia repair. In the first patient, a new biological mesh was placed because of contamination in the presence of a fistula, after which the previously performed bilateral VY plasty was resutured to the mesh. The other patient was treated with replacement of the

synthetic permanent mesh. Only this patient developed a re-recurrent perineal hernia for which not another surgical intervention has been performed.

All referred patients with recurrent perineal hernia after failed repair in another hospital (n=7) underwent mesh-only secondary hernia repair at Amsterdam UMC or Catharina Hospital, which were successful in 3/7 patients (Supplementary Figure 2). Success rate of a third hernia repair was 1/3 for mesh-only and 1/1 for mesh with flap, and corresponding success rates were 1/2 and 1/1 for a fourth hernia repair, respectively.

Overall, crossover from mesh-only to mesh with flap repair was successful in all four patients (two crossovers in the comparative cohort of primary repairs (n=72), and two crossovers in the referred patients with recurrent perineal hernia (n=7)).

DISCUSSION

This multicentre comparative cohort study demonstrates a lower recurrence rate after primary perineal hernia repair using a mesh and flap as compared to synthetic mesh-only repair (14% vs. 34%). Despite this is the largest documented cohort of perineal hernia repair so far, this difference did not reach statistical significance due to the low-volume type of surgery. Furthermore, crossover from mesh-only repair to mesh with flap re-repair in case of a recurrent perineal hernia was successful in all four patients. Infectious postoperative perineal wound complications exclusively occurred in the mesh-only group, resulting in radiological and surgical reinterventions, along with three mesh explantations in the long-term. Within the mesh with flap repairs, only perineal wound dehiscences were seen so far, which were all closed by secondary wound healing. Furthermore, no flap failures nor donor site morbidity was observed. These are promising results that warrant evaluation in larger series.

In literature, several perineal hernia reconstruction methods are described. A systematic review with literature search until December 2021 revealed 19 studies that reported on 172 patients [10]. The following pooled recurrence rates for three different techniques were found: 39% (95% CI: 27%–52%) after biological mesh closure (n=60), 29% (95% CI: 21%–39%) after synthetic mesh closure (n=93), 37% (95% CI: 14%–67%) after tissue flap reconstruction only (n=9), and 9% (95% CI: 1%–45%) after tissue flap reconstruction combined with mesh (n=10). The highest recurrence rate after biological mesh closure might be related to the resorbable mesh. But synthetic meshes still have high recurrence rates, indicating that fixation of the mesh is probably the Achilles heel of the technique. The present study revealed even a 34% crude recurrence rate using synthetic mesh. The study with the highest weight in pooled analysis (n=29) was the prior publication from one of our centres, the Catharina Hospital Eindhoven. The adapted technique since 2006 appeared to be successful in 20 of 21 patients (95%) at that time with relatively short follow-up [12]. These 21 patients have been updated and included in the present series. This update revealed another six recurrences, emphasizing the importance of adequate length of follow-up.

The systematic review also showed that tissue flap-only repair is similarly ineffective as mesh-only repair, while combined mesh with flap repair revealed the lowest failure rate (9%) [10]. Eight of the 10 patients who underwent mesh with flap repair in the review are also included in the present study, with follow-up update. The findings are still promising, and in addition, we now demonstrate that mesh with flap repair can be also effectively applied after failed mesh-only technique.

Considering baseline differences, proportions of anal cancer, extralevator APR, and additional resection during APR in the mesh with flap group were larger. Also, more laparoscopic APRs were performed within this group, limiting adhesion formation that usually prevents the small bowel from descending [2]. Furthermore, mesh with flap patients had more prior

hysterectomies, which reduces pelvic support with increased risk of vaginal prolapse and development of a perineal hernia [9]. Lastly, significantly more postoperative perineal wound complications after index APR were observed in the mesh with flap group, which further increases the risk of perineal hernia in this patient group [14]. Given these findings, the initial characteristics of the mesh with flap patients were worse than those of the mesh-only patients. This strengthens our conclusion on potential superiority of mesh with tissue flap reconstruction over mesh-only repair.

Disadvantages of a combined technique are longer duration of surgery and prolonged length of hospital stay. The five additional days of admission may be attributed to the initial imposition of bedrest, a practice we have gradually abandoned. In contrast, postoperative complications seem to be mild after mesh with flap. Observed perineal dehiscences could be due to some traction on the midline after gluteal turnover flap, as there is less skin to close after harvesting the flap. However, these perineal wound dehiscences recovered without any reintervention or mesh explantation. It is imaginable a tissue flap covering the implanted mesh has some protective effect, as illustrated by the difference in postoperative infectious complications (16% after mesh-only versus 0% after mesh with flap). This might be explained by the fact that the tissue flap is sutured onto the mesh, filling up the dead-space between the mesh and the perineal skin and thereby preventing fluid accumulation with inherent risk of secondary infection. Routine placement of at least one perineal vacuum drain might also have contributed to the prevention of these complications, while this was done in only 26% of the mesh-only patients.

Regarding the suggested lower recurrence rate, we assume that the flap provides additional support to the mesh. Complete coverage of the bridging mesh by well vascularized tissue might also improve ingrowth of the mesh. A better wound healing process can strengthen the neo-pelvic floor with better support of the abdominal organs, thereby reducing the number of recurrent perineal hernias.

Our study has several limitations, mostly related to the retrospective cohort study design. The number of patients included in the mesh with flap group is still low. Duration of follow-up was still relatively short after mesh and flap repair, despite this is an update of a previously published initial experience. Nevertheless, median 24 months follow-up in this group was longer than median time to developing a recurrent perineal hernia repair. Because of rarity of a perineal hernia, it is difficult to substantially increase experience with a novel repair technique within a reasonable time frame. The inclusion of patients with multi-visceral resections introduces a potential bias, as these procedures are a known risk factor for perineal hernia development. Similarly, included patients underwent different types of perineal closure during index surgery. However, their inclusion ensures that the findings are representative for the diverse spectrum of patients encountered in clinical practice. Finally, there was also

heterogeneity among applied techniques, due to different gluteal flaps that were used for filling the dead space.

By multicentre collaboration, we have created the largest cohort on this topic to our best knowledge [10]. This enabled us to provide a clinically relevant advice on treatment for forthcoming perineal hernia patients. Based on the observed differences in recurrence rates between the two repair techniques, we advocate the use of a mesh with flap reconstruction as primary treatment principle for patients with a primary as well as those with a recurrent perineal hernia.

CONCLUSION

In patients with a perineal hernia, adding a tissue flap to the mesh repair of the pelvic outlet seems to result in a lower recurrence rate, as compared to synthetic mesh-only repair. This combined repair seems also effective as a salvage treatment after failed mesh-only technique. Furthermore, perineal wound complications in mesh with tissue flap patients were minor. These findings have to be confirmed in larger series.

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11

Significant increase of emergency hernia operation during COVID

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Hernia, 2024

Introduction

During the COVID-19 pandemic, elective surgeries including hernia repairs, were postponed, or cancelled completely. However, it has been stated previously that the volume of surgical emergency hernia repairs did not drop during this period. Due to the disruption in elective surgeries, waiting lists have increased rapidly, causing a suspected treatment delay. To gain improved insight in preoperative patient prioritization, the aim of this multicenter study was to track volumes of hernia surgery before, during and after the pandemic to investigate for a shift from elective towards emergency hernia surgery.

Methods

A retrospective study using hernia databases from four regional hospitals to account for altered referral patterns (elective versus emergent), capturing patients' admissions and surgery times for both groin and ventral hernia repair was conducted. Study period was predefined from March 2019 to March 2023. Data are presented as descriptive statistics.

Results

During the historic period, 106 of 2267 hernia surgeries (4.7%) performed were defined as emergency repairs. During the pandemic, 3864 elective surgeries were executed, of which 213(5.5%) emergencies. During the current period, the portion of emergencies dropped to 4.9% (110 emergency hernia repairs); ($p = 0.039$). A non-significant increase in emergent incisional hernia repair during the pandemic period was found chronologically 9.9%, 11.8% and 11.6% emergent repairs ($p = 0.75$). There were no statistically significant differences across the hernia types in elective versus urgent rate.

Conclusion

Regionwide data showed a 15% decline in hernia repairs during the pandemic compared to historical levels, with an 0.8% increase in emergent repairs. Surgery rates are still convalescent after the pandemic, with a persistent proportion of emergent surgeries. These numbers emphasize the challenges in selecting patient whose hernia repair should not be postponed.

INTRODUCTION

Hernia surgery is considered elective surgery and postponeable in most cases. Research has shown that watchful waiting tends to be a safe strategy in the treatment of incisional, umbilical, and epigastric hernias [1]. However, the possibility of incarceration remains present, with cumulative incidences of 1.2-2.6% reported in incisional hernias [2]. Delaying elective hernia surgeries raises concerns that the incidence of strangulated hernias could increase [3]. Patients with acute ventral hernias are often comorbid with multiple medical diagnosis and unmodifiable risk factors that, in an elective setting, are known to predict both post-operative complications and recurrence [4]. Furthermore, it has been demonstrated that emergency hernia repair is tormented with up to 15-fold higher mortality, reoperation, and readmission rates than elective repair [5].

The impact of the coronavirus disease 2019 (SARS-CoV-2, COVID-19) on the healthcare system has been significant. In the Netherlands, a lockdown was instigated on March 12th, 2020 [13]. From that moment on, the number of scheduled surgeries was reduced tremendously: in the UK an estimated 28 million elective surgeries were cancelled, equaling 72.3% of all elective surgery [6-9]. Elective surgeries, including hernia repairs, were cancelled completely, or postponed in most cases, due to the high mortality rate of surgical patients with SARS-CoV-2 infections and the high demand of medical care on the wards, particularly the intensive care [10]. The first period of complete surgical reduction in the Netherlands lasted until May 11th. From this period on, on-and-off cancellation of elective procedures occurred, based on governmental and clinical progressive insight in among other things intensive care unit (ICU) capacity, availability of OR staff (due to their employability on COVID-wards and in the ICU), and availability of personal protective measures (PPM) [14]. Some feared that, following the decrease in surgical volumes, an increase in emergency operations in the post-covid would be expected, including emergency hernia repairs worsening postoperative outcomes [5].

The aim of this multicenter study was to analyze volumes of elective and emergency hernia repairs before, during and after the pandemic in the South-East region the Netherlands, to investigate a potential shift from elective towards emergency hernia repairs.

METHODS

A retrospective database consisting of all hernia repairs (inguinal/femoral, epigastric/umbilical, and incisional) in four hospitals in the South-East Netherlands was established (figure 1). Consecutive patients were included from March 2020 to March 2023.

Patient characteristics were not collected for analysis, only number of patients and timing of operation were studied, as the aim of the study was to track volumes of elective and emergency repairs.



Figure 1. Distribution of hospital in South-East Netherlands

During the pandemic, rules for postponing were cancelling as much elective surgeries- amongst which hernia surgeries- to save capacities for COVID patients. From the first

COVID patient in the Netherlands on the 27th of February 2020, until the 11th of May and further on-and-off until March 2022, when the last COVID measures expired, surgeries were continuously cancelled or postponed, completely dependent on the availability of OR capacity, staff availability, and availability of PPM [14].

Eligibility criteria

The number of performed hernia repairs (inguinal/femoral, ventral, parastomal and incisional) were collected retrospectively in each individual hospital. Perineal and hiatal hernias were excluded. Data were dichotomized and surgeries were labelled either elective or emergent, based on the electronical surgery order created at the time of surgery.

If the admission was not planned, the hernia repair was considered an emergency procedure.

The historical control group (pre-pandemic) was defined as surgery between March 2019 to March 2020. The 'pandemic group' was defined as surgery performed between March 2020 to March 2022, as based on the period of the first two pandemic waves in the Netherlands [12]. A current group (post-pandemic) was defined as hernia repair between March 2022 to March 2023

Statistics

Statistical analyses were performed using SPSS (Statistical Package for the Social Sciences for Apple). Data were presented descriptive using proportions, as appropriate. Differences between the predefined time periods were tested using a Chi-squared test. A p value < 0.05 was considered statistically significant.

Data per hospital were analyzed separately, to demonstrate altered referral patterns and to find important differences between hospitals.

RESULTS

During the historic period, 106 of 2267 hernia surgeries (4.7%) were defined as emergency repairs. During the two-year pandemic, 3864 surgeries were performed, of which 213 (5.5%) were urgent repairs. A reduction of 15% in surgical volume was seen, whereas a proportional increase of 0.8% was seen in urgent surgeries when comparing the periods.

During the current period, the portion of emergent surgeries dropped to 4.9%, with 110 emergencies out of 2244 surgeries. This shows a relative decrease of 0.6% in emergencies when compared to the pandemic period, and an increase in surgical volumes of 16% (Table 1).

Table 1. Proportions of elective versus urgent hernia surgery in historic, pandemic, and current period

Center	Historic		Pandemic		Current		p
	Urgent/total	%	Urgent/total	%	Urgent/total	%	
A	9/506	1.8%	19/741	2.6%	8/561	1.4%	0.33
B	54/739	7.3%	98/841	11.7%	53/376	14.1%	0.003
C	19/461	4.1%	39/1256	3.1%	16/470	3.4%	0.61
D	24/561	4.3%	57/1026	5.6%	33/387	3.9%	0.26
Total	106/2267	4.7%	213/3864	5.5%	110/2244	4.9%	0.38

No significant differences were demonstrated comparing the different types of hernia (incisional, umbilical/epigastric, inguinal/femoral). However, trends were identical when splitting the groups as mentioned before: surgical volumes in the historic and current period were comparable and showed a relevant drop during the pandemic period. Urgent surgeries were still more persistent in the current period compared to the historic period (Table 2).

Table 2. Hernia surgery case breakdown by hernia type

	Historic		Pandemic		Current		p
	Urgent/total	%	Urgent/total	%	Urgent/total	%	
Inguinal/femoral	49/1538	3.2%	111/2720	4.1%	61/1707	3.6%	0.34
Epigastric/Umbilical	26/417	6.2%	53/644	8.2%	22/304	7.2%	0.53
Incisional	31/312	9.9%	59/500	11.8%	27/233	11.6%	0.75

Table 3. Proportions of hernia surgery, breakdown by center

	Historic		Pandemic		Current	
	Total (n)	%	Total (n)	%	Total (n)	%
A	506	22.3%	741	19.2%	561	25.0%
B	739	32.6%	841	21.8%	376	16.8%
C	461	20.3%	1256	32.5%	470	20.9%
D	561	24.8%	1026	26.6%	837	37.3%
Total	2267	100.0%	3864	100.0%	2244	100.0%

Nevertheless, when comparing hospitals individually, significant differences were found in two out of four hospitals, accounting for 48-57% of the surgery totals. The most important differences found were a drop in total surgical volumes in one of the hospitals, resulting in more urgent surgeries even in the current group (14.1%, $p=0.0029$), and an increase in total surgical volumes in another hospital, however not statistically significant, resulting in less urgent surgeries in the current group: 4.3% vs 5.6% vs 3.9% ($p=0.2594$). Nonetheless, in this same hospital, an enormous amount of urgent incisional hernia surgeries was performed during the pandemic (44.4%, $p=0.0271$). The data from other hospitals showed no significant altered referral patterns or other unexpected differences.

DISCUSSION

Given the impact of the pandemic on healthcare occupation, several instances recommended delaying or postponing elective surgeries [11]. There was a need for allocation of all resources to the most necessary areas, and furthermore a decreased ICU capacity.

According to data analyzed and published in this article, there was a decrease of 15% in the execution of hernia surgeries, when comparing the pandemic period to an historical control period of one year before. At the same time, an increase of 0.8% was seen in the execution of urgent hernia surgeries.

However, when analyzing the current numbers to both periods, an increase of 16% was seen compared to the pandemic period, and a decrease in urgent surgeries of 0.6% was seen. Conversely, compared to the historical period, surgery volumes seem to have rebounded to the initial level, but the proportion of urgent surgeries is still higher, suggesting that delaying surgeries might not always be favorable.

The first decrease in executed hernia surgeries can be explained by the recommendations to delay or postpone all elective surgeries. By postponing these surgeries, the risk for incarceration develops, possibly increasing the rate of urgent surgeries. The abovementioned trend of urgent surgery proportions is seen in all kinds of hernias; however, the persistent higher level of urgent surgeries is most importantly seen in incisional hernias, compared to the umbilical/epigastric hernia and inguinal/femoral hernia, however this observed difference was not statistically significant.

The abovementioned data and assertions underscore the pivotal role of clinical decision-making in the context of hernia surgery. It is imperative not to unduly delay surgical intervention for ventral hernias in the absence of significant risk factors, as previously demonstrated in the management of inguinal hernias. Evidence indicates that in cases of watchful waiting, there is a 70% likelihood of eventual surgery. Moreover, this underscores the significance of regional collaboration, as exemplified by the consolidation of inguinal hernia treatment to a single center in the post-pandemic period.

Upon scrutinizing the data, it is anticipated that the backlog resulting from the pandemic has been fully addressed. Surgical caseloads have rebounded; however, it is plausible to conjecture that not all surgical procedures need to be fully recuperated, given the heightened mortality rates and persistent apprehension regarding hospital visits due to COVID-19.

Limitations

This study has several limitations, such as the cut-off value for urgent versus elective surgeries. This might not be the same in all the hospitals since this is mostly based on clinical experience of the surgeon.

Furthermore, since no patient data was acquired and thus not used, patient demographics could have differed per hospital, leading to more urgent surgeries in hospitals with patients with worse baseline characteristics. Moreover, given the fact that no patient data was acquired, postoperative numbers on morbidity are also lacking. It was therefore impossible to analyze the effect of urgent surgery on convalescence. However, this should be constant, and should not have differed during the pandemic period. It would have been interesting to account for patient demographics and to perform a risk factor analysis to which patient characteristics lead to greater incarceration risks.

Lastly, even though there was a clinically high suspicion of persistent more urgent surgeries in the current period, this suspicion was not supported by the statistical data. A relatively distorted picture may have been outlined, due to the assumption that surgical volumes dropped during the two COVID-19 years, however in reality the period might have been only a few months during the first, second and third lockdown: catch-up care might have been initiated already in between these lockdowns.

However, the collection of data from distributed hospitals throughout one region, makes this study large in numbers, and reliable for this amount-only analysis. These numbers allow for description of the evolution of urgent and elective surgeries during different periods in the pandemic. Even so, this study reflects the assessment of surgical emergencies. Presuming that surgeons' clinical assessments remained consistent throughout the pandemic, it is evident that certain surgeries could not be deferred, as determined by professional judgment, even amidst mandated reductions in surgical volume. Despite the myriad factors to consider—including the pandemic's health ramifications, governmental regulations, and hospital policies—the enduring challenge lies in the clinical evaluation and prioritization of patients.

CONCLUSION

This study sought to show the impact of the pandemic on the proportion of elective vs urgent hernia surgeries.

Concluding, regionwide data from this multicenter study showed a 15% decrease in hernia repairs during the pandemic compared to historical levels, with an increased proportion of urgent surgeries. Surgical volumes have rebounded to the historic levels, however urgent surgery proportions remain higher compared to the historic period.

Based on this study, it is advised not to postpone elective hernia surgery, in particular incisional hernia surgery, as it might lead to urgent intervention with higher morbidity and mortality rates. The risk for urgent intervention increases while delaying these surgeries, so in times of a(n inter)national healthcare crisis, these risks should be carefully evaluated.

DECLARATIONS

This study was approved by the local medical research ethics committee united (MEC-U).

Informed consent was not applicable.

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12

Summary and general discussion

Complex abdominal wall hernias can have serious impact on patients' lives. Yet despite this impact, outcomes in abdominal wall surgery have long been measured in terms of recurrence and complication rates. A shift in focus is needed, a transitioning from 'treating the hernia' to 'treating the patient with a hernia'. Implementing a multidisciplinary team that carefully considers each patient appears promising for achieving meaningful outcomes. There is, however, little clarity about what such discussions should cover. Furthermore, the impact of preoperative optimization on outcomes is under debate. When it comes to psychological screening before surgery, this area is hardly explored at all. This thesis aims to show the added value of a multimodal approach to complex abdominal wall surgery by evaluating the structure, function, and challenges of the multidisciplinary team. It explores opportunities to expand the care pathway- broadening the MDT's ability and scope- to improve surgical outcomes and improve patients' quality of life.

SUMMARY

As said above, complex abdominal wall repair (CAWR) aims to enhance quality of life (QoL). However, current studies often rely on complication and recurrence rates, neglecting patients' subjective experiences or outcome concerning QoL. A multi-database systematic search on patients treated for complex hernias was performed, including studies evaluating outcome in terms of QoL at least three months postoperatively. Seven studies were included, encompassing 729 patients, all of whom underwent an open repair. Various QoL instruments were used, such as Short Form 36 and Carolinas Comfort Scale. A standardized mean difference of 0.70 when comparing pre- to postoperative values was found, highlighting the moderate to large effect of open CAWR on QoL outcomes (Chapter 2).

Current multimodal approaches of optimization prior to CAWH treatment mainly focus on prehabilitation of physical conditions like smoking, obesity or physical performance. However, enhancing mental health prior to surgery could mitigate stress reactions. (Chapter 3). To gain insight into the prevalence of psychological risk factors, we expanded our multidisciplinary approach by conducting a prospective study using multiple preoperative screening questionnaires. Postoperative data such as opioid use, length of stay, and complications were collected. We found that psychological comorbidities are highly prevalent among patients undergoing CAWR, with substantial proportions screening positive for anxiety, depression, PTSD, and low perceived control. Even though sample size was small, these findings underscore the psychological vulnerability of this patient population, which may be linked to longstanding functional impairment, repeated surgical interventions, and chronic lifestyle disruption. The need to recognize and address psychological risk factors as a part of routine preoperative assessment was emphasized by these findings (Chapter 4).

A critical function of the MDT is to find modifiable risk factors and to assess whether prehabilitation can successfully downstage patients, making them eligible for surgery. In our center, this MDT is thoroughly prepared: each involved specialist- including the pulmonologist, intensivist, anesthesiologist, cardiologist, physiotherapist and surgeon- has assessed the patient in an outpatient setting when relevant, with the surgeon, physiotherapist and anesthesiologist evaluating every patient as a standard part of the pathway. This structured, pre-assessed approach allows for a well-informed discussion on further optimization and surgical eligibility. Evaluating this process provides insight into its effectiveness in enhancing surgical outcomes.

A retrospective cohort study evaluated the impact of preoperative optimization on outcomes in complex hernia patients with modifiable risk factors undergoing CAWR. All 418 patients were discussed within an MDT framework and classified by risk: green (no risk factors), orange (modifiable risk factors, eligible after optimization), or red (ineligible due to unmodifiable risks). Among the orange group, 55% completed a preconditioning program, which normalized preoperative differences in BMI, HbA1c, smoking rates or improved physical performance. Postoperative complication rates were similar between green and orange groups, suggesting prehabilitation can downstage patients and refine outcomes (Chapter 5).

Another aspect discussed in an MDT is the need for postoperative ICU admission in complex hernia cases. A retrospective review of 379 cases (232 surgeries) assessed the accuracy of this multidisciplinary decision-making process. The recommendation was ICU admission in 38% of cases, with a positive predictive value of 55%, negative predictive value of 90%, and area under the curve of 0.763. Intraoperative events led to changes in decision in 15% of cases, with ICU overestimation of 45% and underestimation in 10%. These findings emphasize the role of MDTs in risk stratification and their potential value in hernia care pathways (Chapter 6).

Refining surgical outcomes in CAWH repair extends beyond perioperative planning. Mid-line fascial closure in CAWH reconstruction is challenging, with myofascial techniques presenting high morbidity. Technical advancements such as Botulinum Toxin A (BTA) prehabilitation may enhance feasibility of primary fascial closure by lengthening the lateral abdominal wall muscles (LAWM). We conducted a study involving 13 patients who received BTA before CAWR, compared to 26 propensity-matched controls. BTA prehabilitation resulted in a 27% absolute risk reduction in the need for component separation techniques (CST) and significantly increased LAWM length and mass. Overall, BTA exhibited favorable effects, preventing CST in 50% of cases, supporting its role in improving abdominal wall reconstruction (Chapter 7).

Postoperative outcome could also be decreased by less dissection using endoscopic approach. We reviewed 36 patients who underwent an endoscopic CST (eCST) procedure. Postop-

erative complications included seroma in the dissection plane between external and internal rectus muscle in 22%, hematoma in 8%, and 3% had a wound dehiscence. Three patients experienced recurrence in an average follow-up length of 24 months. Reconstruction in CAWR is tailored surgery and demands skills of several techniques; the choice of which techniques should be performed depends on hernia and patient characteristics (Chapter 8).

Transversus abdominis release (TAR) was introduced in 2012 as an alternative to anterior CST, providing enhanced overlap for large defects and hernias next to bony structures. A retrospective analysis of TAR outcomes in a specialized center showed a 35% textbook outcome (TO) rate, with results improving over time. Among 69 patients, systemic complications were seen in 48%, wound complications in 41%, and recurrences in 4%. Analysis of three successive cohorts (20 TARs each) showed significant improvement in TO and surgical site events with increasing experience, highlighting the ongoing learning curve of this complex technique (Chapter 9).

Combining synthetic mesh with tissue flaps for perineal hernias after abdominoperineal resection (APR) shows lower recurrence rates than mesh-only repairs.

A retrospective analysis of a multicenter database examined patients who underwent perineal hernia repair with synthetic mesh or mesh combined with tissue flaps. Over a follow-up period of 54 months, hernias recurred in 42% of mesh-only repairs and 14% of mesh with flap repairs. This indicates that combining mesh with tissue flap repair approach significantly lowers recurrence rates compared to mesh-only repairs (Chapter 10).

Beyond surgical techniques, healthcare system constraints—such as delays in elective surgeries—may also change patient outcomes. A multicenter study examined elective and emergency hernia repair volumes before, during, and after the pandemic within a region. During the pandemic, hernia surgeries decreased by 15%, with a slight increase in urgent cases of 0.8%. Post-pandemic, volumes rebounded by 16%, yet urgency rates remained elevated. These findings show that delays in elective repairs may lead to more emergency interventions, stressing the need for careful prioritization during healthcare crises (Chapter 11).

GENERAL DISCUSSION

The critical role of a multidisciplinary approach is put forward in this thesis, where each specialist conducts their own outpatient assessment to ensure the patient is thoroughly evaluated prior to a multidisciplinary team meeting (MDT). The broad pre-MDT inventory conducted helps to shift the focus from solely hernia to the patients' physical, psychological and social well-being. During the MDT, a strategy is made, inducing physical and psychological optimization, in treating patients with complex abdominal wall hernias. It serves as a decision-making moment: to operate, delay, or refrain from surgery. This central role allows the MDT to optimize surgical outcomes through structured prehabilitation and perioperative planning [1, 2]. Prehabilitation aims to improve patients' physical and mental condition before surgery. By increasing fitness levels, it may enhance postoperative recovery and reduce complications [3-5]. In surgical oncology, multidisciplinary team meetings have been shown to improve survival, reduce healthcare costs, and facilitate the design of tailored, patient-centered care [6, 7]. However, challenges remain, including variability in implementation, limited surgeon knowledge, and financial barriers.

Prehabilitation driven by MDT

Prior evidence on this subject supports MDT-driven prehabilitation in high-risk surgical patients, also showing improved postoperative outcomes, a reduction in perioperative complications and hospital stays [8-10]. It fosters tailored strategies, particularly for patients with significant comorbidities or complex defects [11]. Furthermore, Ramshaw et al. highlights the value of prehabilitation as an essential component of complex abdominal wall reconstruction through a multidisciplinary, patient-centered approach [12]. Preconditioning programs can 'down-stage' patients with modifiable comorbidities, by weight loss, smoking cessation, opioid cessation, exercise, health nutrition and medical optimization [13]. These risk factors have been extensively identified in literature and form the basis for risk stratification in complex abdominal wall reconstruction [14].

To assess these comorbidities, our MDT evaluates each patient and assigns a risk-based color code, which subsequently guides the decision regarding prehabilitation. However, in addition to physical optimization, we propose placing greater emphasis on the inclusion of psychological support within the MDT. Mental preparation is often overlooked, despite the suggestion that CAWH patients may carry a greater psychological burden [15]. We provided some insights of a high prevalence of psychological comorbidities, and its association with postoperative outcomes [16]. Participation in the psychological screening was limited. This may reflect differences in motivation or health literacy among patients. Consequently, the actual prevalence of psychological morbidity in this population may be underestimated [16]. Nevertheless, it has been shown that stress reduction can lower perioperative complications: the integration of psychological support can reduce patient anxiety and improves engagement, leading to improved adherence to treatment protocols and recovery trajectories [17,

18]. In other pathways, such as the oncological, described by Tsimopoulou and Ramezenie et al., it is demonstrated that psychological prehabilitation enhances patient resilience and recovery [19, 20]. However, its application in CAWR remains novel, highlighting the innovative nature of this thesis in proposing a more comprehensive preparation strategy for these patients [15]. Recognizing stress as a modifiable risk factor opens new possibilities: rather than simply accepting poor baseline resilience, the MDT can actively intervene before surgery. Embedding such interventions with multidisciplinary care pathways may improve both clinical and psychosocial outcomes, potentially reducing complication-related healthcare use and improving patient-centered recovery [20].

While current surgical literature mainly focuses on recurrence and complications as primary endpoints, we propose structured evaluation of patient-reported outcomes (PROs) as a more patient-centered indicator for surgical success [11, 21-23]. The pivotal role of QoL improvements post CAWR has already been highlighted by Jensen et al. Our findings further demonstrate that QoL assessments can enrich preoperative counseling and guide shared decision-making [13]. Systematically integrating quality of life assessments both preoperatively and postoperatively could provide valuable insights into the impact of CAWR, helping to identify which patients genuinely benefit from surgery [8, 9]. Improved QoL after CAWR can result in increased productivity and decreased healthcare utilization [24]. Higher levels of patient satisfaction may reduce long-term costs due to fewer hospital visits.

Although most studies included in this thesis are retrospective in nature and therefore susceptible to selection bias, they still offer valuable insights into daily surgical practice. One such insight is the growing importance of MDTs in the perioperative management of CAWH patients.

Over time, the MDT process has been refined through targeted adjustments. For instance, a color-coded classification system based on surgical risk has been introduced, along with tailored prehabilitation recommendations. These practical changes have shown measurable clinical benefits, such as preoperative patient downstaging (chapter 5).

While these findings support the role of the MDTs in delivering structured and individualized care, the absence of randomized controlled trials highlights the need for future prospective studies to quantify the true impact of MDT-guided prehabilitation in CAWR.

While few institutions currently apply such comprehensive care pathways systematically, doing so could improve efficiency, reduce variability in patient outcomes, and optimize resource allocation [25].

Surgical planning by MDT

Beyond prehabilitation, the multidisciplinary team plays a crucial role in improving the entire care pathway. In addition to preparing patients physically and psychologically, the MDT can guide key decisions about patient allocation, including ICU admission and best surgical timing based on overall condition and comorbidities. Our combined application of the Hernia-Patient-Wound (HPW) score and Fischer score, supported by MDT input, represents a novel and more comprehensive approach to patient selection and risk management in CAWR [26]. This approach goes beyond traditional physical factors like comorbidities and wound healing potential, also integrating psychological and functional considerations. By considering these factors, the MDT can figure out the need for intensive postoperative monitoring, improving ICU resources and ensuring that each patient receives the right care based on their specific needs. It provides a clearer picture of each patient's overall risk. Prospective validation of this approach is lacking, and it is possible that other factors may independently reduce the need for ICU admission. For example, changes in perioperative management such as reduced use of epidural analgesia, enhanced recovery protocol, or stricter ICU admission criteria may also explain reductions in postoperative ICU stay. Moreover, while our methods aim to tailor care more precisely, it may not be generalizable to all settings, particularly where MDT resources or psychological screening tools are limited.

This integrated strategy – combining MDT decision-making on ICU allocation, tailored prehabilitation, and comprehensive risk assessment – proved especially useful during the COVID-19 pandemic, which presented unique challenges. The crisis stresses the importance of flexible healthcare systems capable of adapting to external pressures [10]. Estimates suggest that over 28 million elective procedures were canceled or delayed during the peak 12 weeks of the pandemic, creating a substantial backlog that could take nearly a year to address [14, 27, 28]. Overburdened healthcare systems lead to delayed treatments and increased morbidity [29]. Constraints within the healthcare system were common, such as delays in elective surgeries and the consequent need for re-Botulinum Toxin A (BTA) prehabilitation due to rescheduling beyond the effective window. Although this applied only to a subset of patients, it illustrates how fragile prehabilitation trajectories can be when external delays occur. It introduced more complexity by adding logistical burdens. Furthermore, the question arose whether postponement of CAWR was always justified, especially given the potential for hernia progression and incarceration. These epidemiological findings echo broader surgical literature, emphasizing the need for robust surgical prioritization strategies during healthcare planning [30][31-34]. Our findings support the notion that surgical prioritization should not rely solely on (oncological) urgency, but also consider functional and complication-related risks, such as those inherent to large abdominal wall defects. Future prioritization frameworks should therefore explicitly weigh functional deterioration and complication risk alongside classical oncological urgency. Timely CAWR is essential to prevent clinical deterioration and to avoid unnecessary escalation of care needs. This became clear in the backlog created during the COVID-19 pandemic, where rescheduling efforts led to extended

waiting lists and more urgent surgery (chapter 11). Even in times of strain, standardized care pathways can improve outcomes and reduce complications. The pandemic highlighted the urgent need for universal guidelines and broader adoption for best practices. To mitigate such risks in future healthcare crises, a shift towards robust, evidence-based prioritization tools is called for. We therefore advocate for the development of prospective registries that capture outcomes and timing of care, enabling more refined triage strategies and informing universal guidelines for elective surgical care continuity during periods of disruption [35].

Tailored technical approach by MDT

BTA prehabilitation has emerged as an effective adjunct to CAWR, improving lateral abdominal wall muscle (LAWM) compliance and reducing the need for (endoscopic) component separation techniques ((e)CST)[36-40]. Previous studies, such as those by Bueno-Lledó et al., reported a subjective reduction in the need for CST following BTA injection [41, 42]. Our results confirm this effect, showing a 50% reduction in CST usage, and contribute by providing goal, quantifiable data on lateral abdominal wall muscle elongation. This offers a clearer understanding of the physiological impact of BTA and further supports its use in complex cases. Although literature on BTA in CAWR is expanding, the optimal dosing and timing remain subjects of debate [43]. By reducing operative complexity and morbidity ('down-staging'), BTA prehabilitation may also help lower long-term healthcare risks and costs [44, 45]. The measurable impact of BTA on muscle lengthening strengthens our findings and may improve the feasibility of CAWR. However, the small sample size- though propensity matched, mimicking a small RCT- and lack of long-term functional outcomes is limiting. Future research should aim to refine BTA dosage and timing, specify pulmonary complications, and confirm long-term outcomes through multicenter RCTs. Showing which patient subgroups benefit most will further refine its clinical application.

Advancements in surgical techniques, including eCST and TAR significantly improves outcomes in patients with CAWH [46-48]. We specifically evaluated these two component separation techniques [49]. TAR is increasingly favored over anterior CST due to better defect coverage and lower recurrence rates, and reduced wound complications, as reported in multiple studies [50, 51]. Our findings support this trend, demonstrating favorable complication rates and durable outcomes with TAR, particularly in later cases as experience increased [52]. This aligns with existing evidence but also underscores the importance of procedural standardization and experience. However, our study did not directly compare eCST and TAR outcomes, limiting our ability to offer definitive guidance on technique selection. A direct head-to-head comparison, ideally in a prospective of randomized setting, could help tailor the surgical approach to patient-specific factors. Furthermore, our single-center design and absence of external validation limit generalizability. Still, the detailed complication analysis we offer offers valuable insight into real-world outcomes and can guide surgical planning and quality improvement.

The inclusion of multiple techniques, such as TAR, eCST and BTA prehabilitation, adds to the clinical relevance. However, the introduction of this heterogeneity makes direct comparisons more complex. Moreover, the long-term follow-up data, while extensive, remain subject to patient attrition and variability in postoperative adherence.

Advancements in techniques like eCST and TAR in abdominal wall repair highlight similar needs for structured perioperative pathways, which are equally relevant in perineal hernia repair. Perineal hernias after abdominoperineal resection (APR) remain a surgical challenge, with recurrence rates of 15–30% [53, 54]. Previous studies suggest that combining mesh with flap reconstruction may reduce recurrence by providing both structural support and soft tissue coverage, though most evidence stems from small case series and retrospective cohorts [55, 56]. Our findings align with this notion, showing lower recurrence rates when using a mesh combined with flap repair [55]. Although direct comparison groups were limited, this supports the hypothesis that hybrid approaches may offer more durable outcomes than mesh or flap alone. Given the relative rarity and limited exposure to perineal hernia repairs in many centers, centralization of treatment may be beneficial. Additionally, prophylactic mesh placement after APR, similar to strategies suggested for abdominal aortic aneurysm repairs, might reduce the incidence of perineal hernias, although evidence is needed to support widespread adoption [57].

Beyond technical considerations such as mesh choice or surgical approach, challenges like patient frailty, comorbidities, and variability in postoperative care emphasize the need for structured perioperative pathways in hernia surgery. These factors can significantly affect outcomes. Standardized protocols for patient selection, surgical planning, and postoperative monitoring could reduce recurrence and improve consistency.

Future research

To evaluate the true impact of a multidisciplinary team in CAWR, a multicenter stepped-wedge trial would be the most right study design. This model allows for the staggered implementation of structured MDTs across participating centers, enabling comparison between patients discussed and not discussed in MDT settings, while accounting for temporal and institutional variability. In addition to outcome comparison, the design offers the unique opportunity to assess the MDT learning curve and its effect on clinical decision-making and surgical outcomes over time. Moreover, this study design eases the broader adoption and implementation of MDTs for CAWR across multiple centers, promoting standardized care and collaboration. Standardization should compromise at smallest surgeons, anesthesiologists, geriatricians, cardiologists, pulmonologists, psychologists, and physiotherapists.

However, the question stays which type of study design is most workable to generate meaningful results. While randomized controlled trials provide the highest level of evidence, they are challenging in this setting due to ethical considerations, patient heterogeneity, and logisti-

cal barriers. High-quality prospective registries may therefore be a more realistic alternative, if data collection is comprehensive and standardized.

A critical prerequisite for both stepped-wedge trials and registries is the use of a common language to describe patients and procedures. This includes standardized scoring systems (HPW and Fischer), uniform definitions of complexity, and consistent reporting of techniques, perioperative adjuncts (such as BTA), and standardized use of questionnaires. Without this, heterogeneity across centers will obscure the true effect of MDT input. Indeed, even within the surgical part of CAWR, there is wide variability in mesh type, CST, use of prehabilitation, each of which may confound outcomes. Therefore, while a stepped-wedge trial may offer an elegant design, the foundation for any future study lies in harmonized definitions and robust registry infrastructure. This dual approach- building standardized registries and piloting pragmatic trials- has been highlighted during recent conferences and may provide the most balanced path forward.

Multimodal prehabilitation

Structured prehabilitation improves surgical readiness, but its long-term effects on outcomes and costs are still unclear. While a prospective randomized controlled trial (RCT) would provide the highest level of evidence, such a study may no longer be possible due to ethical challenges. Alternative approaches such as propensity score matching might also be considered to address ethical and practical challenges. Furthermore, the necessity to prove the value of prehabilitation specifically for CAWR is debatable, given that its benefits have already been demonstrated in other surgical fields, such as colorectal surgery [58]. However, it is important to emphasize that the effectiveness of prehabilitation may differ across patient populations and surgical procedures, since there is still limited high-quality evidence, which partly explains the lack of added funding from healthcare authorities. For example, in bariatric surgery, prehabilitation has not consistently shown cost-effectiveness or clinical benefit, indicating that a one-size-fits-all approach is unlikely [59]. Therefore, it is still relevant to investigate the specific impact of prehabilitation in the CAWR population. A more workable alternative would be prospective observational cohort studies or analyses of real-world data within existing care pathways, evaluating the impact of structured prehabilitation on outcomes and healthcare costs.

In this context, registry-based studies offer an efficient way to collect large-scale data on patient characteristics, prehabilitation protocols, surgical details, and postoperative outcomes. Establishing a national registry specifically for complex abdominal wall hernia surgery could enable systematic data capture and benchmarking across centers. Essential registry elements should include patient demographics, comorbidities, details of prehabilitation (nutritional, physical, psychological), surgical techniques, and standardized PROMs. Such a registry would be instrumental in finding best practices, refining care pathways and ultimately improving patient outcomes on a broader scale. Existing platforms like the European Hernia

Society (EHS) registry and the German Herniaweb already contribute to this regard. The EHS registry collects standardized data on surgical techniques, mesh use, and patient risk factors across Europe. Similarly, Herniaweb focuses on ventral abdominal wall hernia outcomes in Germany, providing an online platform for outcome measurement and quality improvement. Participation in these registries supports broader initiatives to develop standardized care pathways and implement best practices in complex hernia surgery.

Particularly, the role of psychological prehabilitation in CAWR stays underexplored. Psychological interventions have shown benefits in oncological surgery. However, the type of psychological stress experiences in CAWR differs- shifting from the emotional burden of a cancer diagnosis to the functional limitations and body image concerns associated with a physically compromised abdominal wall. Although a step-wedge cluster RCT incorporating psychological screening tools (e.g., HADS, PCL-5) and targeted interventions (such as cognitive-behavioral therapy and mindfulness-based stress reduction) would be valuable in determining the optimal structure, timing, and patient selection criteria for these programs, it may still face significant practical challenges in execution, such as recruitment difficulties, heterogeneity of psychological stress, and limited integration capacity within surgical care. Longitudinal follow-up with patient-reported outcome measures (PROMs) is essential to capture sustained benefits beyond the immediate perioperative period. The use of validated PROM questionnaires is accessible, inexpensive and facily integrated in existing preoperative pathways.

Integrating PROMs systematically into CAWR research is critical for a more patient-centered evaluation of surgical success. Future studies should aim for large-scale, prospective registry-based research, incorporating validated QoL instruments such as the Hernia-Related QoL Survey (HerQLes) and EQ-5D, to assess long-term patient satisfaction, pain resolution, mesh performances and functional outcomes. A questionnaire-based retrospective cohort study using national hernia registries could help show predictors of poor long-term QoL and inform personalized perioperative care strategies.

To achieve this, a standardized framework is needed across centers, specialties and nations, including shared terminology, harmonized surgical strategies, consistent use of staging systems such as HPW, and agreement on perioperative protocols (e.g., BTA administration). A “shared hernia language” will be essential for comparability, reproducibility and quality across studies and clinical practice.

Future efforts in CAWR should focus on evidence-based, multidisciplinary strategies- ranging from integrated prehabilitation and standardized care pathways to surgical innovation and PROM-driven evaluation- to improve both patient outcomes and healthcare value.

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13

Impact paragraph

This chapter provides a reflection in the societal and scientific impact of this thesis, highlighting its relevance for clinical practice, healthcare systems, and future research direction.

SCOPE

Despite advances such as minimal invasive laparoscopic and robotic techniques, incisional hernias remain a common complication following abdominal surgery. These hernias develop in 10-30% of patients following laparotomy [1]. In the Netherlands, approximately 4200 ventral hernias are repaired annually, encompassing 600-800 complex abdominal wall reconstructions (CAWR) [2][3]. However, this subset of patients undergoing surgery represents only a portion of the total number of complex abdominal wall hernias (CAWH), as it is estimated that 15,000 patients develop an incisional hernias in the Netherlands every year [4]. A CAWH is characterized by large defects, comorbid patients, significant evisceration or infection, making treatment especially demanding due to increased risk of complications and a higher likelihood of recurrence [5]. Despite advancements in complex abdominal wall reconstruction techniques, recurrence rates remain high, with some studies reporting rates between 24% and 54% after the first repair [8]. This cycle of repair and recurrence can lead patients into a vicious circle, where each subsequent surgery increases the risk of complications and recurrence. Each additional repair carries higher failure risk due to tissue degeneration, scarring, and surgical complexity [6].

For some patients with CAWH, psychological challenges may arise in the context of a burdensome medical history, such as previous oncological procedures, surgical complications, or multiple treatment trajectories. These experiences can lead to feelings of uncertainty, anxiety or a sense of lost control over their body. Additionally, the cosmetic implications of CAWH can be distressing. For instance, some patients may avoid activities like swimming with their children due to self-consciousness, impacting their overall quality of life. Studies have shown that patients with CAWH report significantly lower scores in physical functioning and body image assessments, indicating a profound effect on their well-being [9]. These limitations are associated with higher rates of anxiety, depression, and post-traumatic stress symptoms, as well as reduced perceived control over health.

The implications of CAWH extend beyond the individual. The economic burden includes both direct healthcare costs and indirect societal costs. In the Netherlands, average hospital costs for CAWH repair range from €4,500 to €9,950, depending on complexity and materials used. In France, this ranges from €4,153 for simple repairs to nearly €16,000 for complex procedures in hospital care [7].

Indirect costs are also substantial. Some patients are unable to return to work, leading to long-term disability and productivity loss. One study reported that average sick leave-related

costs amounted to €5,376 per working patient after abdominal wall reconstruction. In addition, approximately 42% of patients require postoperative ICU admission, which further increases costs. A Dutch study showed that ICU patients generate €15 per day in healthcare costs over the year following admission, compared to €3 per day for the general population [10].

Finally, CAWR is often deprioritized in operating theatre planning, leading to frequent postponements, especially in favor of oncological cases. These delays may further increase societal costs by prolonging patient recovery, work absence, and psychological stress.

CAWHs could lead to a recurring cycle of pain and surgery, that not only affects patients their daily lives but also has significant consequences for the broader healthcare system and society, including costs.

MAIN AIM, RESULTS AND CONCLUSIONS

This thesis aimed to improve the quality of total care for patients with complex abdominal wall hernias by showing that optimal outcomes depend on management within a standard multidisciplinary care model. Such programs combine surgical expertise, risk stratification, psychological support, coordinated teamwork, and continuous outcome monitoring. As a result, improved patient selection and surgical results, and enhanced patient well-being can be expected. Ultimately, this approach raises the standard of care for patients, surgeons, and the healthcare system.

RELEVANCE

The application of a multidisciplinary team approach in managing patients with complex abdominal wall hernias is still relatively novel but rapidly evolving. This thesis contributes to expanding the MDT concept beyond standard clinical measures. By integrating strategies such as risk stratification, prehabilitation, and psychological assessment into routine care, the MDT not only improves patient outcomes but also reduces complications and recurrence rates, ultimately lowering both costs and the impact on quality of life, while reducing pressure on the healthcare system.

This work offers valuable scientific insights into effective components of CAWR care, including risk reduction, surgical innovation, and integrated patient support. Firstly, MDT-driven “down-staging” of hernias in high-risk patients can reduce complication rates to levels comparable with patients without risk factors.

Furthermore, prehabilitation (BMI reduction, smoking cessation, optimizing physical fitness) through physical conditioning- actively recommended within the MDT- demonstrates benefits like reducing complications, recurrences and length of stay. Additionally, medical interventions such as pre-operative Botulinum Toxin A (BTA) injections can aid in the management of CAWH by relaxing affected muscles and improving surgical outcomes. Technical innovations, such as transversus abdominis release (TAR) or (endoscopic) Component Separation Techniques ((e)CST), enhance the ability to repair complex abdominal wall defects and reduce recurrence rates. Moreover, advances in the management of perineal hernias have improved patient outcomes by reducing recurrences, ultimately leading to improved long-term results.

Furthermore, experience and the use of well-registered MDT discussions allow for more efficient ICU management, reducing unnecessary admissions and optimizing resource use, especially in times of limited healthcare resources, as seen for example during the COVID-19 pandemic. Regionally, the integration of MDTs and the development of centers of excellence in abdominal wall surgery can improve interdisciplinary collaboration.

Given the prevalence of psychological risk factors and their probable association with increased complication risks, further research into psychological prehabilitation is urgently needed, as it is not yet integrated into standardized programs. Another critical advancement promoted by the MDT is the standardization and systematic collection of outcome measures- “what gets measures, gets managed” - although this is not yet uniformly embedded in all hernia care pathways. Standardizing the use of PROMs improves the consistency of care, enhances targeted prehabilitation strategies, and ensures more informed patient selection by weighing psychological and physical symptoms against operative risks.

For patients, the impact is profound: beyond clinical outcomes valued by healthcare providers, this thesis explores approaches and tools that enhance quality of life and patient satisfaction. It empowers patients to return to work and activities they cherish, free from limitations or fear. Ultimately, this thesis centers care around the patient’s everyday well-being.

TARGET AUDIENCE

The target audience includes surgeons, multidisciplinary healthcare professionals like intensivists, pulmonologists, physical therapists, policymakers, and industry partners involved in the care and innovation of complex abdominal wall hernia management. Policymakers such as healthcare insurers, may find value in these findings to inform reimbursement policies for prehabilitation strategies. Researchers in surgical outcomes and prehabilitation also benefit from this work to further investigate best practices and optimize protocols. Findings have been shared through publications, presentations at congresses, and meetings to reach

clinicians, decision-makers, and developers to implement these insights in their practice. Increased awareness of the impact and complexity of CAWHs may also support allocation of research funding, ensuring that abdominal wall surgery receives appropriate attention.

CONCLUSION

This thesis urges the adoption of a surgical multidisciplinary approach for the treatment of complex abdominal wall hernias, emphasizing that this model leads to improved patient outcomes, reduced complications, and could ultimately lead to reduced healthcare costs. It highlights the importance of multidisciplinary collaboration and calls for the development of standardized protocols to integrate MDTs into clinical practice effectively.

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NEDERLANDSE SAMENVATTING

HOOFDSTUK 1

Complexe buikwandbreuken vormen een groeiend probleem binnen de chirurgische praktijk, met vaak onderschatte gevolgen voor het dagelijks functioneren van patiënten. Naast fysieke klachten zoals pijn en bewegingsbeperking, ervaren patiënten een afname in kwaliteit van leven. Chirurgisch herstel is technisch uitdagend en gaat gepaard met aanzienlijke risico's, wat een nauwgezette indicatiestelling vereist.

Steeds vaker verschuift de focus naar patiëntgerichte zorg, waarin niet alleen de anatomie, maar ook psychologische factoren zoals angst, depressie, post-traumatische stress stoornis (PTSS) en het gevoel van controle worden meegenomen. Prehabilitatie speelt hierbij ook een cruciale rol, door patiënten voor een ingreep te optimaliseren. Zorgvuldige patiëntselectie binnen een multidisciplinair overleg op basis van medische, functionele, en psychosociale factoren krijgt steeds vaker een rol in de buikwandchirurgie.

Dit proefschrift beschrijft hoe een reeks klinische kwaliteitsverbeteringen is ingezet om de zorg rondom patiënten met complexe buikwandproblematiek te verbeteren, met nadruk op kwaliteit van leven, psychologische factoren, en intensieve samenwerking binnen een multidisciplinair team.

HOOFDSTUK 2

Kwaliteit van leven is een complex begrip dat in de context van de buikwandchirurgie vaak onderbelicht blijft. De beschikbare studies tonen aan dat open buikwandreconstructies meestal leiden tot een duidelijke verbetering van pijnklachten, lichamelijk functioneren en de algehele gezondheidstoestand. Toch zijn er grote verschillen in hoe kwaliteit van leven wordt gemeten, waardoor het lastig is om de resultaten over verschillende onderzoeken heen te vergelijken. Bovendien wordt de invloed van psychologische factoren, zoals angst of depressie, maar beperkt meegenomen. Deze lacune maakt het moeilijk om een volledig beeld te krijgen van wat patiënten echt ervaren en nodig hebben. Het benadrukt de noodzaak van toekomstig onderzoek dat gebruikmaakt van gestandaardiseerde en uitgebreide meetinstrumenten, die niet alleen lichamelijke maar ook mentale aspecten omvatten.

HOOFDSTUK 3

Mentale gezondheid speelt een cruciale rol in het herstelproces na een complexe buikwandoperatie. Angst, depressie en posttraumatische stress zijn relatief veelvoorkomende problemen die het herstel kunnen belemmeren en de ervaren kwaliteit van leven negatief beïnvloeden. Toch is psychologische begeleiding bij deze patiënten vaak onderbelicht. Het opnemen van systematische psychologische screening en gerichte prehabilitatie kan helpen om deze problemen vroegtijdig te herkennen en aan te pakken. Het vergroten van het gevoel van controle en het aanleren van coping strategieën kunnen de mentale weerbaarheid versterken

en daarmee het herstel positief beïnvloeden. Dit pleidooi benadrukt dat een goede voorbereiding niet alleen fysiek, maar ook mentaal moet zijn om het beste resultaat te behalen.

HOOFDSTUK 4

Het is al lang bekend dat fysieke kwetsbaarheid het herstel na een operatie kan beïnvloeden, maar psychologische kwetsbaarheid wordt vaak onderschat. Uit onze PETTICOAT studie blijkt dat bijna driekwart van de patiënten die een complexe buikwandreconstructie ondergaan, psychologische risicofactoren vertoont zoals angst, depressie of een laag gevoel van controle over hun situatie. Deze studie vond dat 53% van de patiënten een verhoogde score had op de Hospital Anxiety and Depression (HAD)-schaal voor angst en/of depressie, wat aanzienlijk hoger is dan in de algemene populatie. Deze bevinding benadrukt dat het mentale welzijn van patiënten minstens zo belangrijk is als hun fysieke conditie. Door deze risico's tijdig te identificeren, kunnen behandelaars gerichte ondersteuning bieden en zo het herstelproces positief beïnvloeden. Uit de analyse kwam ook naar voren dat patiënten met één of meer psychologische risicofactoren tijdens hun ziekenhuisopname vaker langdurige pijnklachten ervaren. Dit inzicht maakt duidelijk dat prehabilitatieprogramma's met aandacht voor geestelijke gezondheid onmisbaar zouden kunnen zijn bij deze patiëntengroep.

HOOFDSTUK 5

Multidisciplinaire teams brengen specialisten samen om het behandeltraject van patiënten met complexe buikwanddefecten nauwkeurig te plannen. Uit ervaring en onderzoek blijkt dat patiënten die via een multidisciplinair traject gaan én deelnemen aan een prehabilitatieprogramma, betere uitkomsten behalen. Het aantal complicaties neemt af, het herstel verloopt soepeler en minder patiënten moeten opnieuw worden geopereerd. In onze cohortstudie werden 418 patiënten besproken in een multidisciplinair team (MDO), waarna ze werden ingedeeld in drie risicogroepen: groen (geen risicofactoren), oranje (één of meerdere modificeerbare risicofactoren) en rood (te veel, of niet modificeerbare, risicofactoren). Van de oranje groep doorliep 55% een prehabilitatieprogramma, waarmee preoperatief belangrijke verschillen in bijvoorbeeld body mass index (BMI), gemiddelde bloedsuikerwaarde (HbA1c) en rookgedrag konden worden genormaliseerd, ten opzichte van de groene groep. Na de operaties waren de complicatiepercentages tussen deze beide groepen vergelijkbaar, wat suggereert dat prehabilitatie succesvol is in het 'downstagen' van patiënten en optimaliseren van hun kansen op een goed resultaat. De MDO-beoordeling blijft cruciaal om te bepalen welke patiënten baat hebben bij prehabilitatie, en hoe deze interventies het beste kunnen worden ingezet.

HOOFDSTUK 6

Naast het bepalen van de noodzaak tot prehabilitatie, kan het MDO een cruciale rol spelen in het inschatten van postoperatieve behoeften, zoals de noodzaak tot intensive care (IC) opname. Dit blijkt namelijk lang niet altijd noodzakelijk te zijn na complexe buikwandreconstructie. Door zorgvuldige inschatting kunnen beschikbare middelen efficiënt worden

ingezet. In een studie werden 379 patiënten besproken in het MDO, waarvan uiteindelijk 232 patiënten werden geopereerd. De voorspelling van IC-behoefte bleek met een negatieve voorspellende waarde van 90% zeer betrouwbaar, wat betekent dat patiënten die niet als hoog risico werden ingeschat, ook zelden een IC-opname nodig hadden. In 15% van de gevallen werden perioperatief gemaakte plannen aangepast. Hoewel er een overschatting van de IC-behoefte was in 45% van de gevallen, en een onderschatting in 10%, toont dit aan dat het MDO een waardevol hulpmiddel is om patiënten goed te stratificeren op risico en de postoperatieve zorg beter te plannen. Hierdoor worden IC-capaciteit en zorgmiddelen op een verantwoorde manier ingezet, zonder onnodige overbelasting.

HOOFDSTUK 7

Niet alleen optimalisatie van modificeerbare patiëntrisicofactoren, maar ook de optimale conditie van de buikwand kan leiden tot verbeterde (postoperatieve) uitkomstmaten. Bij complexe buikwandbreuken is het soms nodig om de buikwandspieren te scheiden, een ingreep die bekend staat als component separatie (CST), om de breuk te kunnen sluiten. Deze techniek gaat echter gepaard met een hoger risico op complicaties en langere hersteltijden. Een relatief nieuwe benadering is het gebruik van Botulinum Toxine A (BTA) als prehabilitatie. Door 2-6 weken voor de operatie BTA te injecteren in de schuine buikwandspieren, ontspannen deze en wordt de spanning op de breuk kleiner. In een retrospectieve studie kregen 13 patiënten voorafgaand aan de operatie BTA geïnjecteerd. Deze groep werd vergeleken met 26 patiënten uit een historische controlegroep middels propensity matching. Er werd een significante verlenging van de schuine buikwandspieren gezien bij de patiënten die waren 'geprehabiliteerd' met BTA. Vergeleken met de historische controlegroep was dit gekoppeld aan een absolute risicoreductie van 27% op het toepassen van de componenten separatie techniek. Dit ondersteunt het idee dat BTA als prehabilitatie een waardevolle strategie kan zijn voor patiënten bij wie het sluiten van de fascie moeilijk is. Hierdoor kunnen minder invasieve operaties worden uitgevoerd met behoud van goede uitkomsten en mogelijk minder complicaties. Deze techniek biedt daarmee een veelbelovende aanvulling op het arsenaal in de complexe buikwandchirurgie.

HOOFDSTUK 8

Nieuwe technieken maken het mogelijk om complexe breuken te sluiten. Wanneer primair sluiten niet mogelijk is, blijft CST een belangrijk alternatief. In ons centrum werd een endoscopische CST (eCST) toegepast bij 36 patiënten, en werden de resultaten hiervan beschreven in een retrospectieve studie. Het aantal complicaties lag relatief laag, met 22% seroomvorming, 8% hematoomvorming, en 3% wonddehiscenties. Het recidiepercentage bleef beperkt tot 8% over een gemiddelde follow-upduur van 24 maanden. Deze resultaten benadrukken het belang van maatwerk in de keuze voor reconstructieve technieken.

HOOFDSTUK 9

Een andere relatief nieuwe techniek is de transversus abdominis release (TAR), welke vooral voordelen biedt bij grote buikwanddefecten of hernia's in de nabijheid van benige structuren, doordat het een betere overlap mogelijk maakt. In een gespecialiseerde kliniek werd onderzocht hoe de introductie van de TAR zich ontwikkelde in de tijd. Bij 69 geopereerde patiënten behaalde aanvankelijk slechts 35% een 'textbook outcome' (TO), een samengestelde maat voor optimaal herstel zonder complicaties, heropnames of langdurige opnames. Om het leereffect in kaart te brengen, werden de uitkomsten opgesplitst in drie cohorten van telkens 20 opeenvolgende ingrepen. Gedurende deze fasen nam het aantal patiënten met een TO geleidelijk toe, terwijl het aantal complicaties juist daalde. Met het vorderen van de leercurve nam het aantal klinisch relevante complicaties significant af, en verbeterden de totale behandeluitkomsten zichtbaar. Deze resultaten illustreren dat ook in niet-academische centra hoogwaardige zorg geleverd kan worden, mits de introductie van complexe technieken zorgvuldig en gefaseerd plaatsvindt, waarbij rekening gehouden moet worden met een leercurve.

HOOFDSTUK 10

Perineale hernia's, ontstaan na abdominoperineale resecties (APR), vormen een aparte groep binnen de herniachirurgie. Ze kunnen lastig te behandelen zijn en kennen een relatief hoog risico op terugkeer na operatie. In een multicenter studie werd aangetoond dat het combineren van mesh met weefselflappen leidt tot een significant lager recidiepercentage (14%) in vergelijking met alleen mesh gebruik (42%). Deze bevinding benadrukt het belang van de gecombineerde reconstructieve benaderingen bij complexe anatomieën.

HOOFDSTUK 11

Ook externe factoren zoals beschikbaarheid van OK-capaciteit blijken invloedrijk op behandeluitkomsten. Zo leidde de COVID-19 pandemie tot een daling van het aantal electieve herniaoperaties met 15%, mede door verminderde beschikbaarheid van operatiekamers, IC-capaciteit en zorgpersoneel. Opvallend was dat het aantal spoedindicaties in dezelfde periode juist toenam met 0,8%. Hoewel de operatieve volumes na de pandemie herstelden, bleef het aandeel spoedingrepen verhoogd. Deze trend wijst op de risico's van uitgestelde zorg en benadrukt hoe cruciaal het is om in crisistijd niet alleen de acute, maar ook de planbare zorg strategisch te blijven organiseren. Het illustreert dat chirurgische uitkomsten niet alleen afhankelijk zijn van technische expertise, maar ook van systeemfactoren buiten het operatiecomplex.

CURRICULUM VITAE

Dite Louise Catharina was born on May 21st, 1999, in Woerden, the Netherlands, as the oldest of one younger brother and one younger (step)sister.

In 2016 she graduated from secondary school (VWO, supplemented with Latin) at RSG Lingecollege (Tiel, the Netherlands), where she completed a paper on the chemistry of death. This is where the curiosity for research started. Not much later, she started studying Medicine at Maastricht University.

During her master's degree and clinical rotations at the end of 2019, and beginning of 2020, the two interests were combined: she started doing research for the Department of General Surgery at the Elkerliek Hospital in Helmond, in collaboration with the Catharina Hospital in Eindhoven, where the first steps of this thesis were made.

After her graduation in 2022, she started as a surgical resident not in training (ANIOS) at the Elkerliek Hospital, continued her career as a resident not in training (ANIOS) at the Intensive Care of the Máxima Medisch Centrum Veldhoven, and continued working as a surgical resident not in training (ANIOS) at the Catharina Hospital in Eindhoven as of January 2024. In summer 2025, she decided to switch back to the Intensive Care of the Elkerliek Hospital in Helmond. It was here, she established the rest of her career pathway. As of October 2026, she will start her residency training to become an anesthesiologist. In the meantime, she will be working as resident not in training (ANIOS) at the anesthesiology department of Jeroen Bosch Ziekenhuis (JBZ).

Dite lives together with her fiancée in 's-Hertogenbosch.



DANKWOORD

Het zit erop. En als je tot hier bent gekomen met lezen, geldt dat voor ons beiden. Of misschien ben je achteraan begonnen- ook dat zou ik begrijpen- soms is het immers ook beter om met het dessert te beginnen. Die quote haalde ik ooit uit de film “Serendipity”. Serendipiteit, geluk bij toeval, het vinden van iets moois zonder echt te zoeken. Die serendipiteit, was er niet geweest zonder jouw bijdrage. Allemaal op je eigen manier. Maar iedereen hieronder, en waarschijnlijk nog veel meer, heeft bijgedragen aan mijn geluk bij toeval. Ik kan jullie niet genoeg bedanken. Alleen maar vereeuwigen.

Simon, ook wel de grote baas. Of de grote vriendelijke reus. Toen ik voor het eerst bij jou kwam in 2022, stapte ik als een klein onwetend meisje het grote Catharina Ziekenhuis binnen, op zoek naar de poli chirurgie. Ik wist niks van jou, jij weinig van mij (maar jou kennende had je vast al wat voorwerk gedaan). Wat ik kon verwachten van onze afspraak? Geen idee, maar 4 jaar later een promotieboekje, had ik in elk geval nooit gedacht. En ik weet dat ik (bijna) elke letter als eerste zelf op papier heb gezet, maar jij hebt ze allemaal, letter voor letter, omgedraaid. Op hun kop gezet. Achterstevoren en binnenstebuiten gekeerd. Je bekritiseerde elke letter, elk woord, en elke zin, zonder daarbij je geduld te verliezen. Niet alleen wetenschappelijk, maar later ook medisch inhoudelijk, heb je enorm bijgedragen in mijn ontwikkeling. Nadat ik besloot de chirurgie achter me te laten ben je me blijven helpen en steunen in mijn verdere loopbaanontwikkeling, waarvoor heel veel dank. Het was even spannend of je ook daadwerkelijk zou mogen optreden als promotor, maar ik ben ontzettend blij dat ik dit proefschrift uiteindelijk met jou als promotor mag verdedigen en vereeuwigen.

Tammo en Johannes. De geneeskunde, en de geneeskunst. Ook wel de reisleader en de jetset. Zonder jullie is er geen dag zonder feest. Geen dag zonder grappen en grollen, maar ook geen dag zonder “maar nu even serieus, hoe gaat het echt met je?”. Om dan snel weer door te gaan tot de orde van de dag: waar moeten we nu eten vanavond?

Johannes, in 2020 enthousiasmeerde jij mij in een verwilderde poging tot onderzoek. “Jij wil chirurg worden? Ik heb nog wel een leuk onderzoekje liggen hoor”. Maar koppig als ik was, ik was niet overtuigd. Gelukkig heb ik later nooit spijt gehad van het toch in zee gaan met dit idee: het bleek zelfs een van de betere ideeën van de afgelopen paar jaar. Jouw volhardendheid, kritische blik en prozaïsche schrijfwijze hebben me een hoop geleerd over het schrijven van artikelen, en het presenteren op congressen. Je creativiteit heeft onze onderzoeken meermaals de goede richting op geduwd. Op vrijdagmiddag na de overdracht, als er om 18:00u nog een A4tje bij werd gepakt, wist ik genoeg. Of als er een rode pen werd gepakt, bij het nakijken van mijn eerste manuscript. Bleef er dan nog iets zwarts staan op dat papier? Ik heb je uitgebreidheid vervloekt (bijvoorbeeld toen ik iets met een plectrum moest doen ;)), maar tegelijkertijd zó gewaardeerd. Gelukkig werd dit altijd goedgemaakt met een gin-tonic voor elke hand, valse noten in een karaokebar, ’s nachts om 03:00u op blote voeten door Manches-

ter lopen, in Praag naar de duplex, en in Parijs een dakterras onveilig maken. Om het over de Helmondse avonturen maar niet te hebben. Johannes, bedankt. The night is young.

Tammo, waar Johannes er niet in slaagde om mij te enthousiasmeren voor zijn onderzoek, had jij één zin of blik nodig: ik was overtuigd. We schudden elkaar de hand 2 dagen voor het uitbreken van de COVID-pandemie, op jullie oude werkkamer (die je toen nog deelde met Guido), en ik kon beginnen. Van co naar semi-arts. Van semi-arts naar ANIOS. En van ANIOS naar promovendus (en een hele hoop meer ANIOS-plekken). En hoe druk je ook bent, je bent er wel altijd. Wetenschappelijk, persoonlijk, en alles wat daar tussenin ligt. Met de moeilijkste (statistische, privé, tips-voor-restaurantjes) vraagstukken kan ik bij je terecht, en dat apprecieer ik. Ik ben blij dat dat was, is, en blijft. In ruil daarvoor heb ik altijd geprobeerd van de koffiedame een hartje in je cappuccino te krijgen, en hoop ik nog lang samen te mogen feesten. Je hebt me de belangrijke dingen in het leven geleerd en geleerd prioriteiten te stellen waarvan ik niet wist dat ik ze had.

Heren, jullie hebben voor mij een voorbeeldfunctie gedragen en allebei op je eigen manier vervuld.

Geachte leden van de beoordelingscommissie. Dank voor de moeite die jullie hebben genomen dit proefschrift te bestuderen. Prof. Dr. Laurents P.S. Stassen, prof. Dr. Frederik Berrevoet, dr. Eva B. Deerenberg, dr. Marc Buise. Dank voor het mogelijk maken van deze verdediging en daarmee deze promotie.

Aan alle medeateurs van alle stukken uit dit boek: bedankt. Zonder jullie had er geen letter op papier gestaan. Of in elk geval, geen zinnige letter. Elske en Renske, bedankt voor jullie begrip en ondersteuning, zowel mentaal als inhoudelijk, iets met hetzelfde schuitje. Ook Yindee, bedankt voor het meegaan in wederom een “goed” idee voor een studie, met heel heel veel mailtjes als gevolg. Sander, dank voor je radiologische expertise in het Botox stuk. Pim, dankjewel voor niet alleen de kans voor het stuk over perineale chirurgie, maar ook (het organiseren van) een legendarische WBS! Saskia, ook jij bedankt voor je geduld met mij als toen nog newbie promovendus in een groot ziekenhuis (met een AH in het ziekenhuis?!) in een grote stad.

Ellis, dank voor alle wijze woorden van een niet-gepromoveerd chirurg. Misschien zijn die nog wel waardevoller geweest dan veel inhoudelijks wat ik geleerd heb tijdens dit traject. En Imke, jou kan ik echt niet genoeg bedanken; niet alleen als collega, als mede-buikwandplichtige in het Elkerliek, als vriendin, als topmamma van twee topkids en als mega mega mega hulp in de PETTICOAT studie (en soms wat levensvraagstukken), jij hebt mijn tijd zo veel makkelijker, en zo veel leuker gemaakt.

Natuurlijk alle collega's van het Elkerliek ziekenhuis. Daar waar de eerste hand werd geschud, een zaadje werd geplant voor interesse in de chirurgie, en waar heel veel cappuccino werd gedronken (met hartjes). Jullie eindeloos geduld met mij als coassistent, later als semiarts (met nogal wat fratsen), en de inzet om mij te houden als ANIOS, blijft me zeker bij. Daarnaast natuurlijk de knipogen in de overdracht als Tammo of Johannes weer eens met een klusje kwam; een teken van herkenning of een moment van frustratie kon ik bij jullie altijd kwijt. Imke, Jony en Annemarie, dank voor de drie eenheid waarmee jullie mij van een opleiding hebben voorzien. Van traumabespreking bingo tot borrels in de assistentenkamer, gezamenlijk een koffie bestelling doen of BBQ'en, het roddelen niet te vergeten. Dankjulliewel voor al die steun.

Coen, Jessie, Roos, Johan, dank voor jullie tijd als mede-ANIOS in Helmond. Pascal, Bea, Wendy, Guido, Jan-Bernard, Christiaan, Marc, zoals ook hierboven al benoemd- bedankt voor de kansen en het vertrouwen, de wijze lessen, gezelligheid en borrels. Monique, Monique, Janneke, Dianne en Fenne, ook zonder jullie, had er nauwelijks een letter op papier gestaan. Zonder die koffiemomentjes, misschien wel iets sneller allemaal!). Dat ik later terug zou keren in andere hoedanigheid in jullie ziekenhuis had ik nooit verwacht, maar heeft wel het afmaken van mijn proefschrift vergemakkelijkt en daarvoor wil ik jullie nogmaals bedanken.

Vervolgens alle collega's van de Intensive Care in het Máxima Medisch Centrum. Maar in het bijzonder, Ad, als mentor (met jou ontdekte ik op een of andere manier meermaals om 4:00u 's nachts een tropische ziekte bij patiënten?). Klaas, als surrogaat-mentor, mede-liefhebber van een bijzondere muziekstijl, en favoriete vraagbaak voor niet-medische vragen over het leven. En Aart, ik weet niet hoe, maar je hebt me de grootste fan gemaakt van de hyponatriëmie, toen je me vroeg een uur lang onderwijs hierover te geven. Al weet ik nog steeds niet hoe blij ik daarmee ben.

Aan alle collega's in het Catharina Ziekenhuis; chirurgen, bedankt voor de 1,5 jaar ANIOS tijd waarin ik van jullie heb mogen leren. AIOS, dank voor alle wijze woorden en lessen. En ANIOS, dank voor het gedeelde leed. Natuurlijk ook alle verpleegkundigen, PA's en VS'en, dank voor alle ondersteuning in de afgelopen 1,5 jaar. Ook al ben ik niet (meer) blijven plakken binnen de wereld van de chirurgie, hebben jullie mijn jaren heel leerzaam gemaakt. In het bijzonder Iris en Alexander, samen in hetzelfde schuitje. Dankjulliewel voor al jullie hulp, voor alle koffietjes en dakterras sessies.

Opnieuw naar het Elkerliek, dit keer de Intensive Care. Toen ik afgelopen zomer de weg over mijn eigen loopbaan een beetje kwijt was, boden jullie allemaal het vangnet wat ik nodig had. En binnen twee weken zat ik weer op het "rechte" pad, waarvoor bedankt. Stephanie, bedankt voor dat inzicht. Één nachtdienst met een diepgaand gesprek om 03:30u was genoeg om opnieuw volledig in de ban te zijn van de IC en de bijbehorende specialisatie(s). Je hebt me

geholpen mijn verdere pad vorm te geven, en me geleerd mezelf te blijven uitdagen, plezier te blijven vinden in onwetendheid en altijd een uitdaging te zien in onkunde. Dat, en natuurlijk bedankt voor de sportieve uitdagingen. Ik weet zeker dat de laatste daarvan nog niet geweest is. Crétien, bedankt voor jouw vertrouwen in mij als arts en bedankt voor het elke keer opnieuw beantwoorden van mijn vragen met anekdotes en ervaringsverhalen. Je hebt me geleerd hoe het leven van een anesthesioloog-intensivist eruit ziet en daar zal ik altijd naar opkijken. Rens, dankjewel voor je grapjes, droge humor, maar ook voor je vertrouwen van het begin af aan. Door jou heb ik me echt een toevoeging aan jullie team gevoeld. Maxim, dankjewel voor je praktische hands-on tips op het leven, van advies over tupperware bakjes tot adviezen over juiste statusvoeringen of handige websites als anesthesioloog. Martijn, dankjewel voor de grapjes, gezelligheid, inzichten over hoe een loopbaan ook kan lopen, en elke nachtdienst weer samen dienst. Het leek een soort voorbestemd vanuit de roosters. Phu, dankjewel voor alle controversiële ideeën over de IC, maar ook over het leven. Wist ik veel dat je prima een hele kip op de markt kunt kopen en die samen met een bak rijst op de IC kunt opeten tijdens het ontbijt, lunch, en het avondeten. Eerlijk, heeft me wel op ideeën gebracht. Aan alle IC-verpleegkundigen, dankjulliewel voor de koffietjes in de nachtdiensten, voor de films die gekeken zijn, maar ook voor het nutteloze geklets om 04:00u; dat kan natuurlijk inhoudelijk weinig soeps zijn. Maar het was wel gezellig. I'll be back.

Last but not least in de klinische carrière volgt de afdeling Anesthesiologie van het Jeroen Bosch Ziekenhuis. Dames (en heren) van de POS, bij jullie heb ik mijn eerste echte stappen van het vak richting de anesthesiologie mogen zetten. Heel erg bedankt daarvoor. Aan alle anesthesiologen, bedankt voor het geduld en de passie waarmee jullie mij je vak hebben geprobeerd te leren, dit is waardevolle ervaring geweest waar ik enorm blij mee ben. Die gaat in de rugzak mee naar Rotterdam! En daarnaast, zijn jullie natuurlijk ook een geweldig gezellige en betrokken groep.

Dan volgt een bijzondere overgang. Van medici, naar alles wat me lief is of is geweest, naast het werken als ANIOS en aan een promotietraject. Had ik daar tijd voor? Zeker niet altijd, maar tijd maken voor wat je lief hebt, zorgt voor efficiëntie daarnaast. Daarom minstens net zo veel dank aan alle mensen hieronder, die inhoudelijk weinig hebben kunnen bijdragen, maar daar buiten o zo veel meer hebben gedaan.

Om maar te starten bij kickboksschool Ling Ho. Ik kwam bij jullie op een minder leuk moment, maar vond een passie en een langgekoesterd verlangen. Menno, jij ontving me met open armen in jullie (toen nog kleinere) sportschool, en gooide daarmee olie op het licht brandende vlammetje. Voor ik het wist stond ik in de ring! Helaas toen zonder succes, maar na adoptie in het team door coach Jano, heb ik inmiddels mijn eerste drie winsten binnen mogen slepen. Jano, bedankt voor het luisteren naar mijn eeuwig geklaag, mijn “het-is-nooit-goed-genoen”, het geduld met mijn ongeduld, en voor het precies weten wat ik wanneer nodig heb voor, tijdens en na een partij. En bedankt voor het luisteren naar al het gelul over

“fight like a physicist”, “je moet niet zo veel nadenken, gewoon doen”. Ben heel benieuwd waar de toekomst ons brengt.

Mijn allerliefste vrienden en vriendinnen. Ik weet niet eens waar ik moet beginnen.

Dichtbij huis dus maar. In Den Bosch, waar ik mede dankzij jullie, zo gelukkig ben geworden. Maureen, jouw eeuwige enthousiasme en puppy-gedrag (destijds) lokte mij naar Den Bosch dames 5, alwaar ik de afgelopen 3 jaar met enorm veel plezier met jou heb gehockeyd, en het aanvoerschap van je heb mogen overnemen. Maar vooral bedankt voor alle koffietjes op de momenten dat ik er doorheen zat, voor de logeerpartijtjes toen ik even geen onderkomen had, en voor alle feestjes en blikken. Lieke, mijn (ons) grote voorbeeld in de liefde, (dus eigenlijk is dit ook een beetje voor Duff), met een klein lief buurmeisje erbij (en Koos). Dankjewel voor alle wijsheden, alle wandelingetjes, de hockeydiscos en -wedstrijden, jouw eindeloze support in een eindeloze zoektocht, voor altijd buurvrouwtjes zijn, en het soms opvangen van Fleur als ik er weer eens niet ben. Dank jullie wel.

Zoek je wat ofso, de leukste vriendengroep uit de studentenstad Maastricht, jullie kan ik niet genoeg bedanken voor jullie geduld. Of compassie, als ik er weer eens niet bij kon zijn, omdat ik dienst had, aan mijn promotie moest werken, of moest trainen voor een kickboksgevecht. Barbara, Bjorn, Bram, Bram, Daan, Emma, Gijs, Joël, Marieke, Marie-Eline, en Lisa. Dank voor alle weekendjes met of zonder Yves.

Lisa, vriendinnen sinds jaar 1 van geneeskunde. Later bestuursgenootjes. En niet veel later huisgenootjes. Jij bent altijd degene geweest die me aan heeft gemoedigd vol voor mijn carrière te gaan, ook toen ik andere prioriteiten leek te hebben. Tijdens COVID zaten we samen aan onze doelen te werken, en het was ook daar waar dit idee van een promotie geboren werd. Tussen alle ochtenden Shaun T, bananen pannenkoekjes en koffie to go door, hier en daar soms een borrel plankje of een feestje, werden de eerste stappen van dit onderzoek gezet. Dankjewel voor jouw support en eindeloze liefde. Ik ben blij dat we elkaar blijven opzoeken, en enorm blij dat je mijn getuige bent op de bruiloft. You are my person.

Zachte kern, inmiddels eigenlijk ook allemaal weer harde kern. De afgelopen 15 jaar (en sommigen zelfs nog langer) hebben jullie altijd onvoorwaardelijk aan mijn zijde gestaan. Amy, dank voor je steun en het relativeren tijdens en na onze tijd op de Bogaardenstraat. Laura, dank voor het nuanceren van Remco zijn woorden. Diederik, bedankt voor het geluk wat je Pauline geeft, maar ook voor het eeuwige enthousiasme, het altijd overal bij zijn, en de forever golden retriever die je bent. Marleen, dankjewel voor onze vriendschap, onze ups en downs, en onze gezellige avondjes en sauna uitjes ter ontspanning. Milly, dankjewel dat jij onze groep bent komen vergezellen en Marleen altijd meesleurt naar een nieuw uitje met z'n allen. Eva, dankjewel voor de gezellige meidenavonden en het lekkere geroddel. Marieke, trainingsmaatje, dankjewel voor het leren incasseren en dankjewel dat jij altijd tijd maakt in

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Pauline, mijn oudste, beste vriendinnetje. Zonder jou was hier niks van mogelijk geweest. Elk idee wat ik heb juich jij toe alsof het je eigen is, en alles bekritiseer je met gepaste argwaan. Ik waardeer je eerlijkheid, je enthousiasme, je trouwheid en je eeuwige hartelijkheid. Alle duistere momenten die ik bij je heb mogen uithuilen, in Utrecht of bij je ouders (Marc en Manuela, bedankt). Alle eerste keren, alle moeilijke keuzes, en alle mooie momenten, ben je bij. Ik ben een gelukkig mens mede door de kennis dat jij altijd naast me staat, en nóg enthousiaster bent dan ikzelf.

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