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ORIGINAL SCIENTIFIC REPORT

Intraoperative Surgical Strategy in Abdominal Emergency Surgery

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Abstract

Background Emergency abdominal surgery is associated with a high rate of postoperative complications and death. Pre- and immediate postoperative bundle-care strategies have improved outcome, but so far, no standardized intraoperative strategies have been proposed. We introduced a quality improvement model of specific intra- and postoperative strategies for the heterogenous group of patients undergoing emergency abdominal surgery. The objective was to evaluate a quality improvement strategy, using an intraoperative, multidisciplinary time-out model in emergency abdominal surgery to apply one of three surgical strategies; definitive–palliative–or damage control surgery.

Methods All patients scheduled for any gastrointestinal emergency procedure were stratified dynamically according to standardized criteria for performing definitive–palliative–or damage control surgery. Pre- intra- and postoperative data were collected according to the intraoperative strategy applied. Postoperative complications were displayed according to the Clavien-Dindo-score and the CCI (Comprehensive Complication Index). 30–90-day- and 1-year mortality was presented.

Results We included 436 consecutive patients undergoing emergency laparotomy or laparoscopy in 2019. Intraoperative strategy was definitive in 326(75%)–palliative in 90(21%) and damage control approach in 20(4%) patients. CCI was 21(0,45), 30(17,54) and 78(54,100) in the definitive–, the palliative–, and the damage control group, respectively. 30-day mortality was; 11.7%, 26.7% and 30%, and the 1-year mortality was 16.9%, 56.7% and 40% in the definitive– the palliative– and the damage control group, respectively.

Conclusions We present a multidisciplinary, intraoperative decision-making standard as a potential quality improvement tool of ensuring individualized intra- and postoperative treatment for every emergency surgical patient and for future research-protocols.

Introduction

Abdominal emergency surgery is a high-risk procedure associated with increased morbidity and a 15% 90-day mortality [1]. Advanced age and perioperative conditions like sepsis and dependent functional status increase the mortality rate to more than 20% [2–4]. This heterogeneous group of patients suffer from various conditions and comorbidities and undergo a wide range of surgical procedures, most frequently laparoscopy or laparotomy for

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bowel obstruction, perforation, ischemia and hemorrhage [1]. Some patients have additional malignant disease. Through the last decade international research suggests a bundle-care strategy of pre- and immediate postoperative evidence-based interventions (early administration of antibiotics, reduced time to diagnostic computerized tomography and surgery, administration of goal-directed fluid therapy and enhanced perioperative care the first postoperative days) [5, 6] to substantially improve patient outcomes. Mortality after emergency laparotomy has improved over the last decade [7], probably reflecting the multidisciplinary initiatives applied.

Patients undergoing abdominal emergency surgery are usually presented without discrimination of the underlying intraoperative pathology. The intraoperative surgical standards and postoperative regimes are not clear, and the overall mortality is usually presented without taking into consideration the type of surgical strategy applied, the patients age, frailty, sepsis, or co-existing malignancies [8, 9]. Pre- and immediate postoperative standardized strategies have been introduced to improve outcomes [6, 10, 11], but so far, no intraoperative standardized surgical strategies have been suggested.

The preoperative and immediate postoperative bundle-care treatment for abdominal emergency surgery was standardized and introduced in 2017 at our institution. As an additional quality improvement model of specific intra- and postoperative strategies, an intraoperative multidisciplinary team (MDT) approach was developed and implemented between the emergency surgeons and anesthesiologists in 2018.

The objective was to evaluate the strategy using an intraoperative, multidisciplinary, time-out model and present the results at the level of cohort description and outcomes according to the intraoperative strategy applied: definitive, palliative, and damage control surgery.

Material and methods

The study was conducted between January 1, 2019 and December 31, 2019 at Copenhagen University Hospital Herlev, Denmark. The hospital is a trauma level II facility, serving a population of 432,000. The hospital treats single-compartment abdominal trauma, but the main cohort of emergency surgical patients is non-trauma abdominal emergencies.

Senior emergency surgeons were present every day, at all times. All patients scheduled for any abdominal emergency laparotomy or laparoscopy were included. Patients < 18 years of age were excluded. Patients with appendicitis or cholecystitis were also excluded.

Data were collected from journal reviews. The preoperative data registered included: demographic data; American Society of Anesthesiologists score, (ASA); Performance status [12]; body mass index (BMI); former abdominal surgery performed; risk factors such as smoking and alcohol habits; pre-existing comorbidities, malignancies, medications; and preoperative chemotherapy within the last 8 weeks. Intraoperative data included: type of surgery performed (laparoscopy, laparotomy, or laparoscopy converted to laparotomy); intraabdominal pathology (perforation, bowel obstruction, ischemia, hemorrhage or various); and the degree of intraabdominal contamination (peritonitis = contaminated class 3 or dirty class 4[13]). The overall intraoperative surgical strategy (definitive, palliative, or damage control surgery) was extracted and classified in three groups (Fig. 1). In addition, the preoperative, and immediate postoperative bundle-care treatment for abdominal emergency surgery was standardized (Fig. 2).

Intraoperative surgical strategy and time-out The primary access to the abdomen, laparoscopy or laparotomy was chosen preoperatively according to the preference of the operating surgeon, and depending on the expected surgical intervention (intestinal resection or not), the physiological status of the patient (physiology deranged = hemodynamic instability due to septic or hemorrhagic shock with acidosis, coagulopathy, and/or hypothermia [14]), and whether former major open abdominal surgery had been performed.

The intraoperative time-out was a short, standardized conversation mainly between the anesthesiologist, and the surgeon to plan the overall surgical strategy, the number of expected procedures and the intention to treat (cure or relieve symptoms) during the operation at 30-and 60-min, and at the end of surgery. A specific surgical strategy was then chosen with attention to the patient's age, performance status, intraabdominal pathology and intraoperative hemodynamics (e.g., septic or hypovolemic shock):

	Procedure	Surgery	Intention to treat
Definitive Strategy	One-step	Laparoscopy or laparotomy	Cure
Palliative Strategy	One-step	Minimal surgical intervention	Relieve symptoms
Damage Control	Two-step	Laparotomy to control shock followed by definitive repair	Cure

A definitive surgical strategy was applied by default and defined as the single surgical procedure necessary to cure

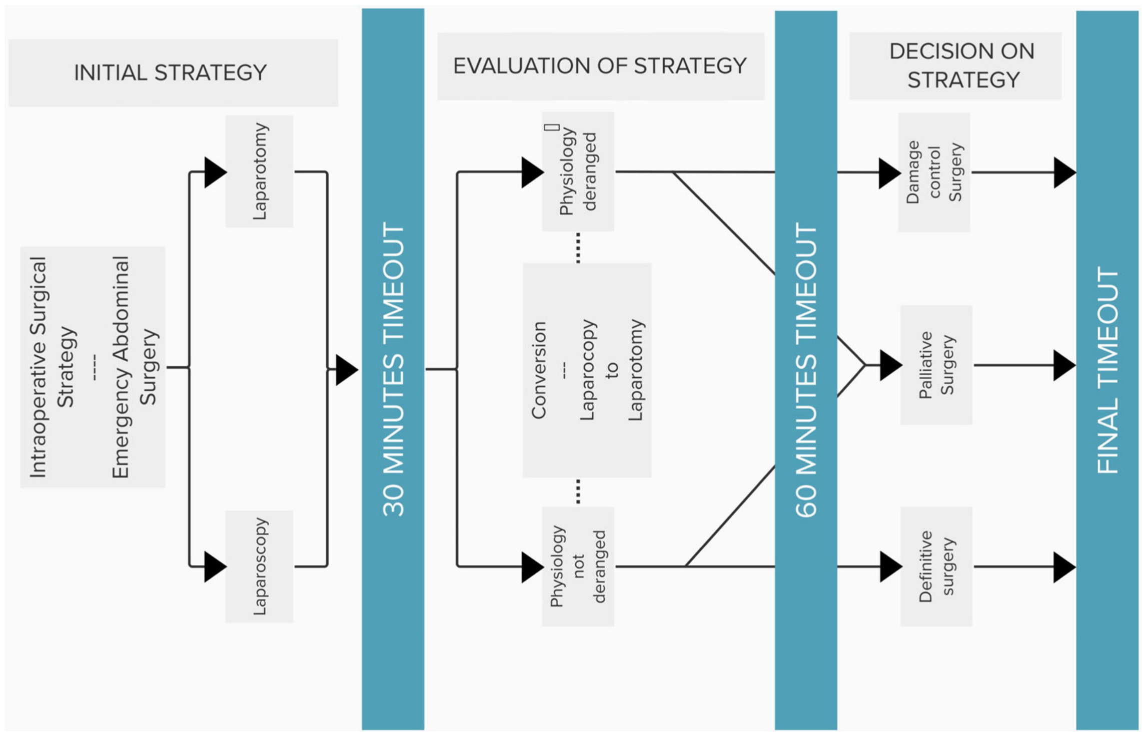

Fig. 1 Intraoperative surgical strategy

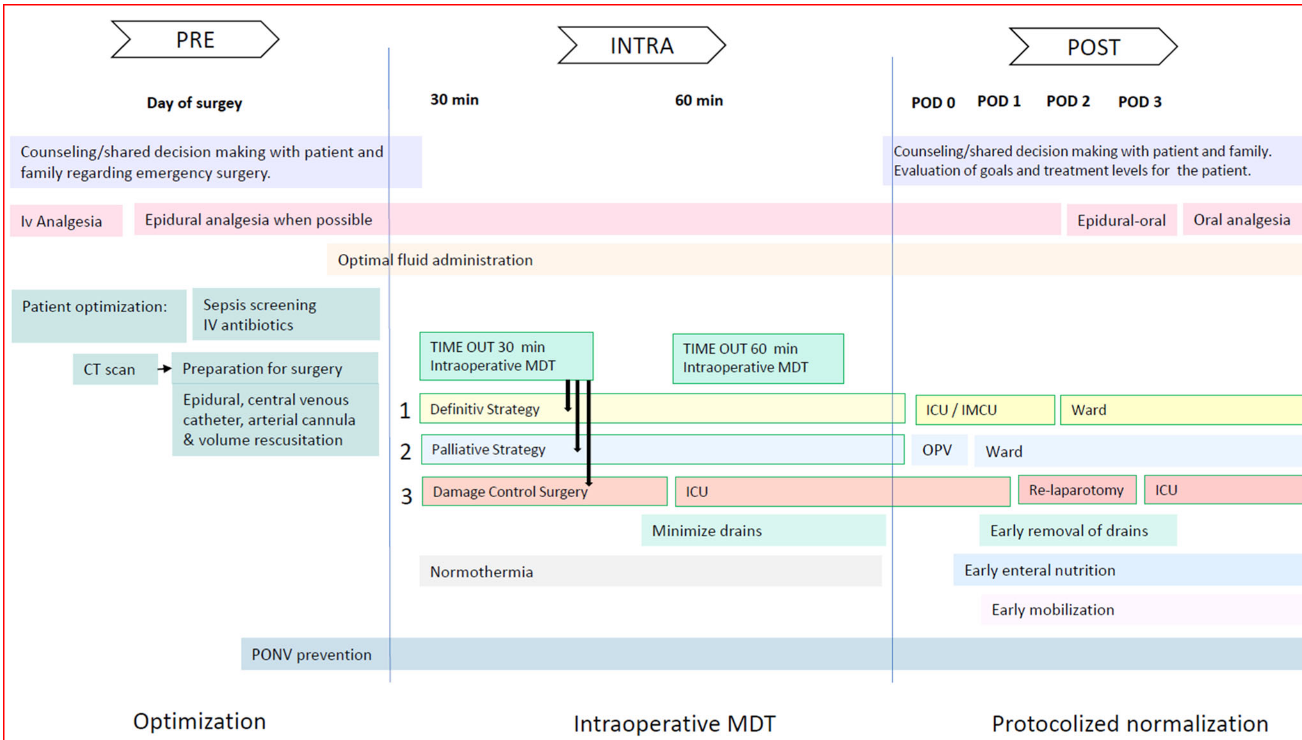

Fig. 2 Pre-, intra-, and postoperative strategies in emergency abdominal surgery (Inspired by C Peden. [29])

the intraabdominal pathology (obstruction, perforation, ischemia or bleeding).

A palliative strategy was applied to patients suffering from disseminated malignant disease or very low performance status, defined as the minimal surgical intervention needed to relieve severe abdominal symptoms and improve the quality of life [15, 16], for example, a diverting stoma or bypass anastomosis to relieve disseminated malignant obstruction.

Damage control surgery (DCS), a two-step procedure, was applied (in non-definitive/palliative cases) to initially control bleeding, ischemia and/or intestinal perforation in patients with septic and/or hypovolemic shock, followed by resuscitation in the ICU (Intensive Care Unit) prior to definitive repair within the next 24 h. DCS was originally a surgical strategy in multisystem trauma but has since been adapted to emergency surgery in general [14, 17].

Time-out At 30-min, a multidisciplinary time-out was performed intraoperatively (Figs. 1, 2 and 3) as a standardized discussion between the anesthesiologist, the surgeon and the OR staff:

The circulating nurse called the time-out and moderated the dialog through defined steps from the standardized chart (Fig. 3).

The anesthetist reported the hemodynamic state and development of the patient. Was the current physiological status a deterioration or improvement? The need for vasopressors (shock or sedation related) was stated as well as the temperature (°C) and whether metabolic acidosis was present (pH < 7.35).

The surgeon announced the intraoperative findings (for example, small bowel perforation due to strangulation) and presented the expected proceeding intervention: the technical surgical strategy (for example, conversion to open surgery) and the overall surgical procedure and strategy (for example, definitive surgical strategy applied: one-step procedure with intestinal resection of 30 cm proximal jejunal bowel and primary end-to-end anastomosis). The approximate/expected time to finish the surgical intervention (minutes) was called.

At 60 min, the intraoperative time-out was repeated and the potential need for changes in the surgical strategy was decided upon. At the end of the procedure a final time-out was completed, summing up a postoperative strategy of care (enteral/parenteral nutrition, antibiotics, drains placed, level of observation).

Postoperative data consisted of complications according to Clavien-Dindo classification [18] (CD). Complications were considered minor if CD score was 1–2 (any complication handled in the surgical ward, for example correction of electrolytes, antibiotic treatment or superficial wound infections). Complications were considered severe if the CD score was 3–5 (any complication demanding surgical, radiological, or endoscopic interventions and/or any complication requiring intensive care management, with grade 5 being the death of the patient). The CCI (Comprehensive Complication Index) was calculated as the sum of all

INTRAOPERATIVE TIMEOUT						
Time	+30 minutes		+60 minutes		Final Timeout	
Cardiovascular	Status	Stable □ Unstable □	Status	Stable □ Unstable □	Status	Stable □ Unstable □
	Development	Better □ Same □ Worse □	Development	Better □ Same □ Worse □	Development	Better □ Same □ Worse □
Need Inotropic support?	No □ Yes, procedure related □ Yes, hemodynamic shock □		No □ Yes, procedure related □ Yes, hemodynamic shock □		No □ Yes, procedure related □ Yes, hemodynamic shock □	
Bleeding	None/discrete□ Yes, amount □ (mL) Yes, + signs of coagulopathy □		None/discrete□ Yes, amount □ (mL) Yes, + signs of coagulopathy □		Intraoperative blood loss_________(mL)	
Temperature	°C		°C		°C	
pH						
Surgical Strategy	Definite □ Palliative □ Damage Control □		Definite □ Palliative □ Damage Control □		Definite □ Palliative □ Damage Control □	
Conversion	No □ Yes □ Not relevant □		No □ Yes □ Not relevant □			
Expected surgical intervention	Minutes		Minutes		Postoperative strategy discussed	

Fig. 3 Intraoperative TIME-OUT

complications that are weighted for their severity using a validated online access [19]. The CCI was presented in median (25,75 percentiles). Data regarding the anesthetic care were epidural blockade (yes/no) and postoperative intensive care (yes/no). Postoperative primary outcome data consisted of 30-day, 90-day, and 1-year mortality presented in relation to the intraoperative surgical strategy.

This research was approved by the Danish Data Protection Agency (31–1521-382). There was no requirement for approval by The National Committee on Health Research Ethics.

Table 1 Demography and comorbidity

Intraoperative strategy in emergency laparotomy		Definitive/final	Palliative	Damage control	Chi^2
N all 436	*n*	326	90	20	
Female	*n*(%)	174(53.4)	55(61.1)	10(50)	0.387
ASA	< 3	185(56.7)	26(28.9)	5(25)	
	≥ 3	141(43.3)	64(71.1)	15(75)	**0.000**
Performance WHO	< 3	277(85.0)	66(73.3)	13(65)	
	≥ 3	49(15.0)	24(26.7)	7(35)	**0.006**
BMI	< 30	260(79.8)	81(90.0)	17(85)	
	≥ 30	49(15.0)	7(7.8)	2(10)	
	Missing	17(5.2)	2(2.2)	1(5)	0.153
Age, years, *n*	< 20	5	0	0	
	21–40	26	0	0	
	41–60	82	16	2	
	61–80	140	57	14	
	> 80	73	17	4	
Age > 60	*n*(%)	213(65.3)	74(82.2)	18(90)	**0.001**
Tobacco use	*n*(%)	88(27)	26(28.9)	7(35)	
	Missing	10(3.1)	6(6.7)	0(0)	0.703
Alcohol intake > SST	*n*(%)	59(18.1)	10(11.1)	5(25)	
	Missing	10(3.1)	5(5.6)	0(0)	0.223
Cerebrovascular disease	*n*(%)	33(10.1)	4(4.4)	4(20)	0.066
Dementia		20(6.1)	5(5.6)	1(5)	0.962
Hypertension		140(42.9)	37(41.1)	13(65)	0.135
Atrial fibrillation		36(11.0)	9(10.0)	4(20)	0.430
IHD		53(16.3)	12(13.3)	7(35)	0.060
Heart failure		24(7.4)	8(8.9)	2(10)	0.831
COPD		54(16.6)	9(10.0)	1(5)	0.261
Cirrhosis		11(3.4)	0(0)	1(5)	0.183
Chronic kidney injury		23(7.1)	9(10.0)	1(5)	0.585
Diabetes		32(9.8)	7(7.8)	2(10)	0.838
Anticoagulation		95(29.1)	13(14.4)	7(35)	**0.013**
Beta blocker		43(13.2)	9(10.0)	5(25)	0.196
Steroids		29(8.9)	22(24.4)	1(5)	**0.000**
Statins		73(22.4)	15(16.7)	5(25)	0.462
Diuretica		62(19.0)	14(15.6)	2(10)	0.481
Immunotherapy		23(7.1)	9(10.0)	2(10)	0.609
Malignancy	None or former *n*(%)	306(93.9)	5(5.6)	17(85)	
	Local or disseminated *n*(%)	20(6.1)	85(94.4)	3(15)	**0.000**
Chemotherapy < 8 weeks	*n*(%)	11(3.4)	30(33.3)	0(0)	**0.000**

Table 2 Intraoperative results

Intraoperative strategy in emergency laparotomy		Definitive	Palliative	Damage control
N all 436	*n* (%)	326	90	20
Surgery	Laparoscopic	81(24.8)	22(24.4)	0(0)
	Converted to open	75(23)	12(13.3)	7(35)
	Laparotomy	170(52.1)	56(62.2)	13(65)
Procedure	Perforation	108(33.1)	21(23.3)	6(30)
	Bowel obstruction	163(50.0)	54(60.0)	2(10)
	Ischemia	16(4.9)	1(1.1)	9(45)
	Hemorrhage	23(7.1)	2(2.2)	3(15)
	Various	16(4.9)	12(13.3)	0(0)
Peritonitis		93(28.5)	15(16.7)	6(30)
Epidural		164(50.3)	52(57.8)	11(55)

Table 3 Postoperative complications

Surgery		Definitive	Palliative	Damage control (non-trauma)	Chi^2
N all 436		326	90	20	
Surgical CD $\geq$ 3 n(%)	All	55(16.9)	21(23.3)	14(70)	< 0.001
	Laparoscopy	8(2.5)	5(5.6)		
	Laparotomy	47(14.4)	16(17.8)	14(70)	< 0.001
Medical CD $\geq$ 3 n(%)	All	65(19.9)	21(23.3)	13(65)	< 0.001
	Laparoscopy	4(1.2)	4(4.4)		
	Laparotomy	61(18.7)	17(18.9)	13(65)	< 0.001
CCI	Median (25,75 percentiles)	21(0,45)	30(17,54)	78(54,100)	

CD Clavien-Dindo Score, *CCI* Comprehensive Complication Index (www.assessurgery.com)

Results

During 2019, 436 patients underwent emergency laparotomy or laparoscopy. Table 1 outlines demography and comorbidity. The patients within each of the three main surgical strategies (definitive/palliative/DCS) were similar in sex, BMI, comorbidities and in tobacco and alcohol habits. Age, ASA, and performance score $\geq$ 3 was significantly higher in the palliative and damage control groups, compared to the definitive intraoperative strategy. Malignancy was present (local or disseminated) in 94.4% of the patients treated with a palliative strategy. Of these, 33.3% were in active oncological therapy. Compared to this, for patients undergoing any other surgical strategy (definitive strategy or DCS), malignancy was only present in 7.1%, with 3.2% in ongoing chemotherapeutic treatment.

The intraoperative strategy (Table 2) was definitive in 326 (75%) patients, palliative in 90 (21%) patients and damage control surgery in 20 (4%) patients. Laparoscopic strategy was the primary surgical approach in 156 (47.9%) of the definitive group of patients.

Seven patients in the DCS group were planned for definitive treatment preoperatively and the procedure initialized laparoscopically, but due to an intraoperative physiological deterioration, conversion was performed and the surgical strategy converted to DCS. Patients with physiological instability due to hemorrhage or ischemia were treated with primary damage control laparotomy.

Gastrointestinal perforation (31.0%, $n = 129$) and bowel obstruction (52.1%, $n = 217$) were the main reasons for emergency surgery in definitive and palliative strategies. Ischemia, hemorrhage and perforation were the primary intraabdominal emergencies in damage control surgery (90%, $n = 18$).

Epidural analgesia for pain management was applied in 227 (52.0%) of the patients with no significant difference between the overall treatment groups. Postoperative intensive care was given to 150 (46.0%) of the patients in the definitive group, 31 (34.4%) of the palliative patients and 18 (90%) of the patients in the damage control population.

Surgical complication rates (CD $\geq$ 3) were significantly higher among patients undergoing laparotomy (23.1%, 77/333) compared to laparoscopy (12.6%, 13/103) (p = 0.02). The overall postoperative medical complication rate (CD $\geq$ 3) was 7.8% (8/103) and 27.3% (91/333) in the laparoscopic versus the laparotomy group, $p < 0.01$. The

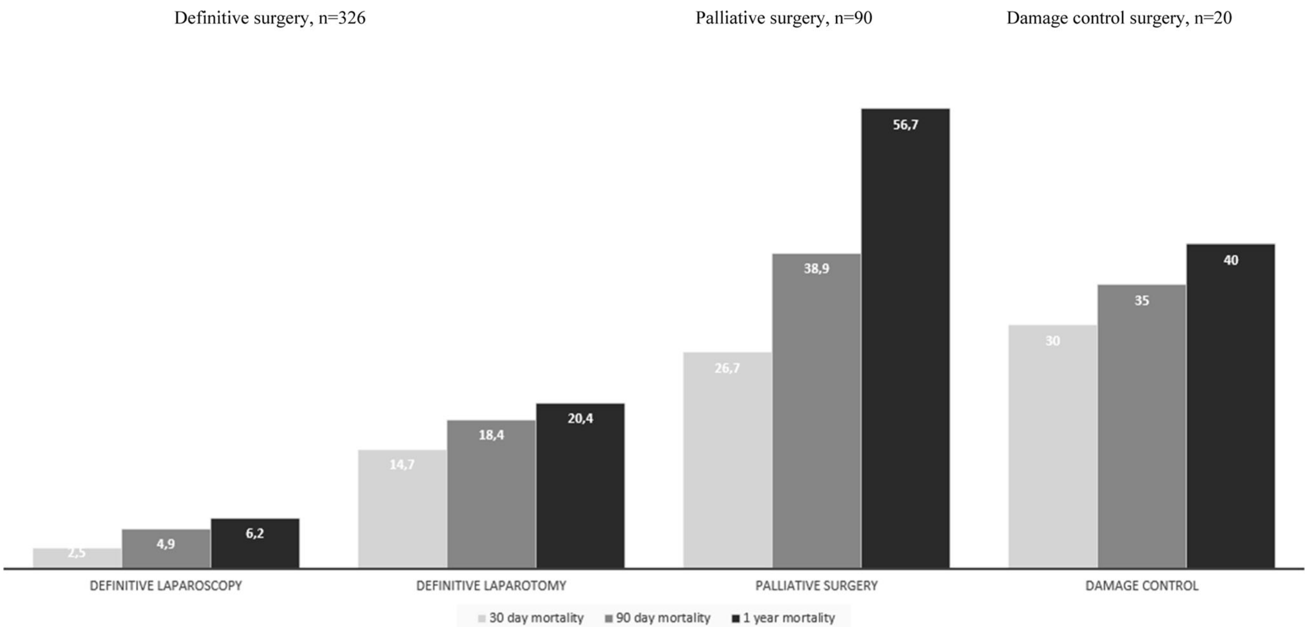

Fig. 4 Intraoperative Strategy, Mortality(%) $n = 436$

differences in postoperative complication rates between the definitive, the palliative and the DC groups are displayed in Table 3.

There was a significant difference in the amount of overall interventional surgical complications between the definitive, palliative and damage control groups, but no difference between the specific complication rates: wound infection 2.8% (2.2–5.0, $p = 0.79$), bleeding 3.9% (3.1–10, $p = 0.20$), intraabdominal abscess 5.0% (2.2–5.8, $p = 0.38$), dehiscence (laparotomy only) 3.3% (2.9–3.7, $p = 0.91$), and mechanical obstruction 2.5% (2.5–3.3, $p = 0.68$).

Likewise, there was a significant difference between the overall interventional medical complications between the groups, mainly because of the severity of complications in the damage control group (Table 3).

CCIs were 21(0,45), 30(17,54) and 78(54,100) in the definitive, palliative, and damage control groups, respectively.

The overall 30-day mortality was 15.6%, and significantly different between the definitive (laparoscopy 2.5% and laparotomy 14.7%), the palliative (26.7%), and the damage control groups (30%) ($p < 0.001$). The overall 90-day mortality was 20.9%, and the 1-year mortality, 26.1% (Fig. 4).

Discussion

The standardized time-out during surgery resulted in an individualized intra-, and postoperative treatment for every patient, by selecting a definitive, palliative or damage control surgical strategy. Remarkable differences in morbidity and mortality rates between the three groups were found and we believe this signifies the need for a differentiated intraoperative approach based on pathology, physiology and patient-related comorbidities.

The preoperative and immediate postoperative setting was standardized prior to this study and involved early administration of antibiotics, reduced time to diagnostic computerized tomography and to surgery, administration of goal-directed fluid therapy and enhanced care level in the first postoperative days. This organizational setting gave us the possibility to assess the abdominal emergencies intraoperatively in a standardized manner.

Previous reports on emergency laparotomy patients rarely comment on the intraoperative strategies applied and the surgical approach has not yet been clarified [1]. Comparable to international reports [21], we present 4 out of 5 abdominal emergency surgery patients suffering from perforation or bowel obstruction, but still with very different outcomes, when we address the intraoperative details further.

Definitive surgery was applied in 75% of all cases, with an 11.7% 30-day mortality (2.5% in laparoscopies and 14.7% in laparotomies). The lower mortality rates in patients treated with a definitive laparoscopic approach might reflect less severe intraabdominal pathology in this group when compared to patients in need of open definitive surgery. The lower grade of surgical stress in a laparoscopic approach compared to open surgery is in general appraised, but the importance of this on mortality differences is still not settled [22].

A primary laparoscopic approach was chosen in 47.8% of the definitive surgical cases and 23% of these were converted to open surgery. Laparoscopy has become a standard procedure in two major abdominal emergencies in particular: bowel obstruction and perforated viscus. Besides convincingly lower mortality rates (2.5% 30-day, and 4.9% 90-day mortality), we found significantly fewer complications in the laparoscopy population compared to open procedures.

In the fifth patient report of the national emergency laparotomy audit 2019 [1], 9.5% of emergency bowel surgery was completed laparoscopically with a 30-day mortality of 3.5%, compared to 10% mortality in the open procedures. The mortality rate was similar to our results. We completed a higher rate of the emergency procedures laparoscopically. The distinction between laparoscopic and open emergency procedures provides the opportunity to identify possible surgical and anesthetic areas of improvement.

Palliative intraoperative strategies were mainly due to underlying malignant disease, which applied in 21% of the emergency cases with a 26.7% 30-day and a 56.7% 1-year mortality. A similar rate (18.6%) of malignant disease was reported by NELA [1].

The intraoperative classification of a palliative strategy provided the multidisciplinary team the immediate possibility to adjust the postoperative care with focus on palliation, early patient and family involvement and shared decision-making whenever applicable, to enhance patient recovery resources, respectfully [5].

Damage control surgery was rare in our population and applied in less than 5% of the emergency laparotomies. This particular anesthetic and surgical management is well-known in trauma patients (excluded from this population), but we addressed some non-trauma emergencies with similar staged procedures. DCS was mainly chosen to address the reversal of severe septic/hemorrhagic shock in the ICU prior to addressing the continuity of the alimentary tract when the patient stabilized, most often after a mesenteric ischemic insult or a major intraabdominal hemorrhage.

Internationally, the use of DCS in non-trauma emergencies has been reported as being used with great variety, but usually to a wider extent (8–25%) than we presented here [21, 23]. A recent meta-analysis found no difference in mortality in patients undergoing non-trauma DCS compared to conventional surgery [24]. The WSES guidelines [17] recommend considering open abdomen treatment following surgical management of acute mesenteric ischemia and abdominal compartment syndrome, but also urges caution when applying DCS on wider indications. In peritonitis the use of DCS is not clear, and the available evidence is in the form of retrospectively identified case series [25–27]. This correlates with the strategies applied in this setting.

There are several limitations to this study. This was a single-center study which might compromise the external validity. The study presented retrospective data and the results might therefore not be generalizable. The quality improvement strategy applied was a bundle-care strategy without explicitly reporting the compliance. Nevertheless, the specific strategy of choosing one of three pathways, presented the results of the MDT for all patients involved. The overall morbidity and mortality data were presented, reflecting the results of complex, detailed, intraoperative decision-making.

Pre- and immediate postoperative standardized strategies have been practiced during the last couple of years, to improve patient outcomes. We now propose the idea of specific intraoperative classification to allocate the emergency surgical patients to specific postoperative interventions and care pathways.

In an emergency surgical setting, the intraoperative intraabdominal findings sometimes differ from the expected diagnosis [28]. Similar intraabdominal pathologies are treated very differently depending on the age of the patient, frailty, sepsis or co-existing malignancies. We propose colleges to present outcomes related to the intraoperative standardized surgical strategy; definitive, palliative or damage control surgery to ensure a specific postoperative strategy, comparable between hospitals in different regions and countries, for this very broad population of different ages and clinical presentations.

Conclusion

There is still sparse evidence regarding interventions to enhance patient recovery in emergency abdominal surgery, and we propose an intraoperative quality improvement strategy to address the intraoperative surgical strategies and the postoperative rehabilitation.

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Declarations

Conflicts of interest The authors declare that they have no conflicts of interest.

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