Technical Evidence Review for Emergency Major Abdominal Operation Conducted for the AHRQ Safety Program for Improving Surgical Care and Recovery

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Enhanced recovery pathways (ERPs), initially developed more than 2 decades ago for colorectal operations, have been shown to improve patient outcomes for many elective procedures.[1-4] They apply standardized, evidence-based, and multidisciplinary approaches to reduce surgical stress and modify physiologic responses.[5-9] As these pathways evolve, it is evident that the key principles, including multimodal analgesia, early mobilization, patient and family engagement, and best practices for preventable harms, can benefit surgical patients broadly, including those undergoing emergency operations.

Emergency general surgery (EGS) represents a growing public health burden in the US, with more than 3 million patients admitted annually for these conditions and nearly 30% requiring operation.[10] EGS patients are complex; 35% are older than 70 years and 50% have at least 1 medical comorbidity and are at higher risk for morbidity (15%) and mortality (1.2%).[10,11] Rates are even higher for complex emergency procedures, including 46.9% morbidity for bowel resections and 23.8% mortality for laparotomies.[11] Quality improvement work in EGS is challenging, limited by the urgent nature and heterogeneity in disease and patient characteristics. However, given that the success of ERPs lies in reducing perioperative stress through transdisciplinary teamwork and standardization, the benefits of ERPs might be even more pronounced in this high-risk population.

The Safety Program for Improving Surgical Care and Recovery (ISCR) is a national ERP initiative implemented in 2017 through a collaboration among AHRQ (funder), American College of Surgeons, and Johns Hopkins Medicine Armstrong Institute for Patient Safety and Quality. The ISCR program has been implemented across colorectal, orthopaedic, and gynecologic surgery services. Building on the lessons learned from earlier cohorts, the final cohort of the program will expand into EGS and include appendectomy; cholecystectomy; and emergency, nontrauma, and nonvascular major abdominal operations. The objective of this study was to evaluate the evidence for ERPs for emergency major abdominal operations and to provide a framework for developing and implementing ERPs in this patient population.

METHODS

Seven common EGS procedures, including appendectomy, cholecystectomy, perforated peptic ulcer repair, colectomy,

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Abbreviations and Acronyms

EGS	= emergency general surgery
ERP	= enhanced recovery pathway
ISCR	= improving surgical care and recovery
LMWH	= low-molecular-weight heparin
LOS	= length of stay
MA	= meta-analysis
NGT	= nasogastric tube
RCT	= randomized controlled trial
RR	= risk ratio
SBO	= small bowel obstruction
SR	= systematic review
SSI	= surgical site infection
VTE	= venous thromboembolism

lysis of adhesions, small bowel resection, and exploratory laparotomy, account for 80% of morbidity, mortality, and costs associated with EGS.[11] This review focused on the last 5 procedures (ie excluding appendectomy and cholecystectomy), which we defined as emergency major abdominal operations. The evidence for appendectomy and cholecystectomy was reviewed in parallel and reported separately.[12,13]

The published ISCR project review protocol was followed.[14] Briefly, candidate components for the emergency major abdominal operation ERP were identified from existing ERPs; evidence was extrapolated from colorectal operations and hip fracture operations; and a technical expert panel of national leaders in EGS, anesthesiology, and implementation science was consulted. Using search terms generated by a research librarian (QEW), individual searches were performed for each candidate component in MEDLINE for English-language articles published before December 1, 2018 (eTable 1). Additional studies were identified through reference mining. Because EGS literature often focused on disease processes rather than procedures, search terms also captured common causes necessitating emergency laparotomy or bowel resection, such as incarcerated or strangulated hernias. We excluded studies solely evaluating appendectomy, cholecystectomy, or trauma. However, studies evaluating the broader spectrum of EGS were included, even if an excluded procedure was addressed. Other exclusions included nonsystematic reviews, editorials, and case reports.

A Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram was recorded for each candidate component (eFig. 1). After title and abstract screening, full texts were assessed for inclusion. Given the heterogeneous nature of the data, meta-analysis was not performed. Results are reported narratively in a hierarchical manner, in which we preferentially synthesized data from contemporary, well-conducted systematic reviews (SRs) with or without meta-analysis (MA) and then supplemented with randomized controlled trials (RCTs) or observational studies published after the SR/MA, when available. Finally, we incorporated clinical guidelines from national and international professional societies and the US Department of Health and Human Services.

RESULTS

Seventeen candidate components for the emergency major abdominal operation ERP were identified (Table 1). Components span the continuum of care (preoperative to hospital discharge). For each component, we report the rationale, primary evidence, summary of guidelines if applicable, and recommendations. Table 2 provides the evidence for each component, the strength and consistency of the evidence, and the level of guideline support. Table 3 summarizes guideline recommendations for each component and the strength of evidence.

PREOPERATIVE SETTING

Patient education and counseling

Rationale

Preoperative education and counseling can improve patient outcomes by setting expectations and increasing adherence to postoperative protocols.

Evidence

We did not find any studies evaluating preoperative patient education for emergency major abdominal

Table 1. Improving Surgical Care and Recovery: Emergency Major Abdominal Operation Components Reviewed

Component
Preoperative management
Education and counseling
Medical assessment and optimization
Preoperative multimodal analgesia
Venous thromboembolism prophylaxis
Intraoperative management
Antimicrobial prophylaxis
Skin antisepsis
Laparoscopic surgical technique
Regional analgesia
Wound protector use
Avoidance of routine nasogastric tube placement
Avoidance of routine intra-abdominal drain placement
Postoperative management
Early urinary catheter removal
Early oral alimentation
Early mobilization
Postoperative multimodal analgesia
Discharge evaluation
Perioperative management
Perioperative enhanced recovery protocol or pathway

operation. We identified 1 SR of 12 RCTs and 7 non-RCTs evaluating preoperative patient education for elective procedures, which expanded on an earlier SR in orthopaedic operation to include cardiothoracic and abdominal operations.[27,28] Education was in-person or written and/or visual and studies found improvements in perceived pain control, functional activities, objective and subjective knowledge, anxiety and emotional well-being, and length of stay (LOS). Objective knowledge demonstrated the most consistent improvement (7 of 9 studies) and LOS was reduced in 2 of 7 studies.

Summary and recommendations

Preoperative education appears to improve outcomes after elective operations, particularly objective knowledge. Although there is no evidence for the emergency setting and the optimal method and content of patient education are still unclear, there is no evident downside.

Medical assessment and optimization

Rationale

Medical assessment offers an opportunity to identify sepsis or other physiologic derangements and to optimize patient condition before emergency major abdominal operation.

Evidence

We identified 1 RCT in emergency abdominal operation and 3 prospective cohort studies in emergency laparotomy evaluating perioperative assessment and optimization.[29-32] An RCT of 101 patients with perforation peritonitis found that goal-directed optimization based on objective measures lowered APACHE II scores at 24 hours ($p = 0.02$), shortened LOS ($p = 0.007$), and lowered mortality ($p = 0.03$) compared with controls.[31] All 3 prospective cohort studies evaluated preoperative protocols, including early assessment of physiologic derangement, sepsis screening and early broad-spectrum antibiotics, goal-directed resuscitation, and short interval from decision to operate to procedure.[29,30,32] When compared with historical controls, all intervention groups had lower mortality after emergent laparotomy.

Summary and recommendations

Evidence supports assessment and optimization of preoperative sepsis and other physiologic derangements before emergency major abdominal operation. Sepsis guidelines and protocols should be followed.

Venous thromboembolism prophylaxis

Rationale

Emergency major abdominal operation increases the risk of venous thromboembolism (VTE). Perioperative pharmacologic and/or mechanical VTE prophylaxis is an important component of care.

Evidence

We identified 1 SR and 1 observational study assessing VTE prophylaxis in EGS patients.[33,34] The SR (1 RCT, 3 prospective and 1 retrospective observational studies, and clinical guidelines) found that nonelective surgical patients have an increased risk of VTE compared to elective patients (2.65% vs 0.94%; $p < 0.001$).[34,35] Despite a lack of guidelines or risk assessment tools specific to EGS, VTE risk stratification on hospital admission using a validated tool (eg Caprini Score, Rogers Score, Johns Hopkins Risk Factors) is recommended.[34,36-38]

For choice of pharmacologic prophylaxis, the RCT in emergency major abdominal operation found a nonsignificant reduction in VTE from 22% to 8% with low-molecular-weight heparin (LMWH) compared with placebo ($p = 0.12$),[39] but both unfractionated heparin and LMWH are effective in surgical and nonsurgical inpatients.[34,40] CHEST guidelines for nonorthopaedic operations recommend pharmacologic prophylaxis with mechanical sequential compression devices based on risk stratification unless contraindications exist.[17,34]

We did not identify evidence on timing of prophylaxis specific to emergency abdominal operation. However,

Table 2. Summary of Reviewed Emergency Major Abdominal Operation Components, Outcomes, and Guideline Support

Component, outcomes	Study	Study population	Evidence grade*	Guideline support†
Preoperative management				
Education and counseling, ↓ LOS, ↑ pain control, knowledge	1 SR	Elective operation	+	None
Medical assessment and optimization, ↓ LOS, APACHE II scores, mortality	1 RCT, 3 OS	Emergency abdominal operation	++	√√
Preoperative multimodal analgesia, ↓ pain	1 SR	Elective colorectal operation	+	None
VTE prophylaxis, ↓ VTE	1 SR, 1 RCT, 1 OS	Emergency general operation	+	√
Intraoperative management				
Antimicrobial prophylaxis				
↓ SSI	1 SR	All colorectal operation	++	√√
↓ SSI	1 SR/MA	All hernia operation	++	√√
↓ Complication and mortality, LOS	1 OS	Emergency abdominal operation	+	√√
Skin antisepsis, ↓ SSI	1 SR	Elective operation	++	√√
Laparoscopic surgical technique				
↓ Mortality, complication, LOS	2 SR, 2 RCT, 7 OS	Perforated peptic ulcer repair	++	√√
↓ Complication, LOS	2 SR, 2 SR/MA, 8 OS	Emergency colorectal operation	++	√√
↓ Complication, LOS	1 SR, 3 OS	Emergency operation for SBO	+	√√
↓ Reoperation	5 OS	All femoral hernia repair	+	√√
↓ Mortality, LOS	10 OS	Emergency abdominal operation	+	√√
Regional analgesia				
↓ Mortality (epidural analgesia)	1 OS	Emergency abdominal operation	+	None
↓ Pain score, rescue analgesic (truncal nerve block)	1 RCT	Emergency abdominal operation	+	None
Wound protector use, ↓ SSI	1 SR/MA	Elective and emergent abdominal operation	+	None
No routine nasogastric tube placement, ↓ time to ROBF; no difference in complication	1 SR, 1 RCT, 1 OS	Elective and emergent abdominal operation	++	None
No routine intra-abdominal drain placement				
No difference in complication	2 OS	Perforated peptic ulcer repair	+	None
No difference in complication	4 SR/MAs	Elective colorectal operation	++	None
Postoperative management				
Early urinary catheter removal, ↓ urinary tract infection	1 SR, 2 MAs	Elective colorectal operation	+	√√
Early oral alimentation, ↓ LOS	1 RCT, 2 OS	Emergency abdominal operation	+	None
Early mobilization				
↓ LOS, ↑ mobility	1 RCT	Surgical ICU patients	+	None
↓ LOS, no difference in complication	1 SR	Elective abdominal operation	+	None
Postoperative multimodal analgesia, ↓ pain	1 SR	Elective colorectal operation	+	None
Discharge evaluation, ↑ knowledge, ↑ functional ability	2 RCT, 1 OS	Emergency hip fracture operation	+	None
Perioperative management				
Perioperative enhanced recovery protocol or pathway, ↓ LOS	2 RCT, 6 OS	Emergency abdominal operation	++	None

*Evidence grading: ++, consistent evidence across studies showed benefit (intervention) or impact (risk assessment); +, evidence was either mixed with the majority favoring benefit/impact or little evidence existed in only 1 direction.
†Consistency with clinical guidelines: √√, all guidelines supported a given practice or the guidelines cited strong evidence of support; √, guidelines cited weak evidence or expert opinion.
LOS, length of stay; MA, meta-analysis; OS, observational study; RCT, randomized controlled trial; ROBF, return of bowel function; SBO, small bowel resection; SR, systematic review; SSI, surgical site infection; VTE, venous thromboembolism.

Table 3. Summary of Guidelines Supporting the Reviewed Emergency Major Abdominal Operation Components

Component, patient population, society	Year	Recommendation/statement
Preoperative management		
Education and counseling	NA	NA
Medical assessment and optimization		
SBO, WSES	2017	Initial evaluation should be complemented with assessment of nutritional status and laboratory tests evaluating at least blood count, lactate, electrolytes, and BUN/creatinine (level 2D).[15]
Intra-abdominal infection, WSES	2017	Early recognition of the patient with ongoing abdominal sepsis is an essential step for an effective treatment. Prompt administration of IV fluids for resuscitation is critical in patients with ongoing sepsis. This initial resuscitation should be titrated to the clinical response and not solely guided by a predetermined protocol. Vasopressor agents can serve to augment and assist fluid resuscitation, particularly where this therapy alone is failing (level 1A).[16]
Preoperative multimodal analgesia	NA	NA
VTE prophylaxis, general, American College of Chest Physicians	2012	For general and abdominal-pelvic operation patients at very low risk for VTE (<0.5%; Rogers score, < 7; Caprini score, 0), we recommend that no specific pharmacologic (grade 1B) or mechanical (grade 2C) prophylaxis be used other than early ambulation.[17] For general and abdominal-pelvic operation patients at low risk for VTE (approximately 1.5%; Rogers score, 7−10; Caprini score, 1−2), we suggest mechanical prophylaxis, preferably with IPC, over no prophylaxis (grade 2C).[17] For general and abdominal-pelvic operation patients at moderate risk for VTE (approximately 3.0%; Rogers score, >10; Caprini score, 3−4) who are not at high risk for major bleeding complication, we suggest LMWH (grade 2B), LDUH (grade 2B), or mechanical prophylaxis, preferably with IPC (grade 2C), over no prophylaxis[17]; for general and abdominal-pelvic operation patients at moderate risk for VTE (3.0%; Rogers score, > 10; Caprini score, 3−4) who are at high risk for major bleeding complications or those in whom the consequences of bleeding are thought to be particularly severe, we suggest mechanical prophylaxis, preferably with IPC, over no prophylaxis (grade 2C)[17]; for general and abdominal-pelvic operation patients at high risk for VTE (approximately 6.0%; Caprini score ≥5) who are not at high risk for major bleeding complication, we recommend pharmacologic prophylaxis with LMWH (grade 1B) or LDUH (grade 1B) over no prophylaxis. We suggest that mechanical prophylaxis with elastic stockings or IPC should be added to pharmacologic prophylaxis (grade 2C)[17]; for high VTE risk patients undergoing abdominal or pelvic operation for cancer who are not otherwise at high risk for major bleeding complications, we recommend extended-duration pharmacologic prophylaxis (4 wk) with LMWH over limited-duration prophylaxis (grade 1B)[17]; for high VTE risk general and abdominal-pelvic operation patients who are at high risk for major bleeding complications or those in whom the consequences of bleeding are thought to be particularly severe, we suggest use of mechanical prophylaxis, preferably with IPC, over no prophylaxis until the risk of bleeding diminishes and pharmacologic prophylaxis can be initiated (grade 2C)[17]; for general and abdominal-pelvic operation patients at high risk for VTE (6%; Caprini score ≥5) in whom both LMWH and unfractionated heparin are contraindicated or unavailable and who are not at high risk for major bleeding complications, we suggest low-dose aspirin (grade 2C), fondaparinux (grade 2C), or mechanical prophylaxis, preferably with IPC (grade 2C), over no prophylaxis.[17]
Intraoperative management		
Antimicrobial prophylaxis		
General		
SIS	2013	The optimal time for administration of preoperative doses is within 60 min before surgical incision. Some agents, such as fluoroquinolones and vancomycin, require administration over 1−2 h; therefore, the administration of these agents should begin within 120 min before surgical incision[18,19]; shortened postoperative course of antimicrobials involving a single dose or continuation for < 24 h.[18,19]

(Continued)

Table 3. Continued

Component, patient population, society	Year	Recommendation/statement
SIPGWW	2005	The optimal time for administration of preoperative doses is within 60 min before surgical incision. Some agents, such as fluoroquinolones and vancomycin, require administration over 1−2 h; therefore, the administration of these agents should begin within 120 min before surgical incision[18,19] shortened postoperative course of antimicrobials involving a single dose or continuation for < 24 h.[18,19]
Intra-abdominal infection, WSES	2017	Knowledge of regional/local rates of resistance, when it is available, should always be an essential component of the clinical decision-making process when deciding the empirical treatment of infection (level 1C)[16]; for patients with CA-IAI, agents with a narrower spectrum of activity are preferred. However, in CA-IAI patients at risk for ESBLs producing *Enterobacteriaceae* infections, anti-ESBL-producer coverage might be warranted. For patients with HA-IAI, antibiotic regimens with broader spectra of activity are preferred (level 1B)[16]; in critically ill patients, antimicrobial therapy should be started as soon as possible. In these patients, to ensure timely and effective administration of antibiotics, clinicians should always consider the pathophysiologic status of the patient as well as the pharmacokinetic properties of the antibiotics used (level 1B)[16]; in patients with complicated intra-abdominal infection undergoing an adequate source-control procedure, a short course of antibiotic therapy (3−5 d) is always recommended (level 1A)[16]; patients who have ongoing signs of peritonitis or systemic illness (ongoing infection) beyond 5−7 d of antibiotic treatment warrant a diagnostic investigation (level 1C).[16]
Gastroduodenal procedure, SIS	2013	A single dose of cefazolin is recommended in procedures during which the lumen of the intestinal tract is entered (A).[18]
SBO, SIS	2013	For small bowel operation with intestinal obstruction, the recommended regimen is a cephalosporin with anaerobic activity (cefoxitin or cefotetan) or the combination of a first-generation cephalosporin (cefazolin) plus metronidazole (C).[18]
Colorectal procedure, SIS	2013	A single dose of second-generation cephalosporin with both aerobic and anaerobic activities (cefoxitin or cefotetan), or cefazolin plus metronidazole is recommended for colon procedures (A).[18]
Perforated diverticulitis, WSES	2016	The empirically designed antimicrobial regimen depends on the underlying clinical condition of the patient, the pathogens presumed to be involved, and the risk factors indicative of major resistance patterns (level 1C)[20]; although discontinuation of antimicrobial treatment should be based on clinical and laboratory criteria, a 4- to 6-d period of postoperative antimicrobial therapy in complicated acute left-sided colonic diverticulitis is suggested if source control has been adequate (level 1A).[20]
Obstructed or perforated colorectal cancer, WSES	2017	In patients with colorectal carcinoma obstruction with no systemic signs of infection, antibiotic prophylaxis is recommended (level 1A)[21]; prophylactic antibiotics should be discontinued after 24 h (or 3 doses) (level 1A)[21]; in patients with intestinal obstruction, even without systemic signs of infection, antibiotic prophylaxis mainly targeting Gram-negative bacilli and anaerobic bacteria is suggested, because of the potential ongoing bacterial translocation (level 1B)[21]; in patients with colon carcinoma perforation, antibiotic therapy mainly targeting Gram-negative bacilli and anaerobic bacteria is always suggested. Furthermore, in critically ill patients with sepsis early, use of broader-spectrum antimicrobials is suggested (level 1A)[21]; in patients with perforated colorectal cancer, antibiotic therapy should consider bacterial resistance, and should be refined according to the microbiological findings, once available (level 1B).[21]
Hernia, SIS	2013	For hernioplasty and herniorrhaphy, the recommended regimen is a single dose of a first-generation cephalosporin (A).[18]
Incarcerated hernia, WSES	2017	In patients with intestinal incarceration with no evidence of ischemia and no bowel resection (CDC wound class I), short-term prophylaxis is recommended (level 2C)[22]; in patients with intestinal strangulation and/or concurrent bowel resection (wound classes II and III), 48-h antimicrobial prophylaxis is recommended (level 2C)[22]; intimicrobial therapy is recommended for patients with peritonitis (concurrent bowel resection wound class IV) (level 2C).[22]

(Continued)

Table 3. Continued

Component, patient population, society	Year	Recommendation/statement
Skin antisepsis, general		
ACS/SIS	2016	Alcohol-containing preparation should be used unless contraindication exists. No clear superior agent (chlorhexidine vs iodine) when combined with alcohol. If alcohol cannot be included in the preparation, chlorhexidine should be used instead of iodine unless contraindications exist.[23]
CDC	2017	Perform intraoperative skin preparation with an alcohol-based antiseptic agent unless contraindicated. (category 1A).[24]
Laparoscopic surgical technique		
Perforated peptic ulcer, WSES	2017	Laparoscopic repair of perforated peptic ulcer can be a safe and effective procedure for experienced surgeons (level 1A).[16]
SBO, WSES	2017	Laparoscopic operation reduces adhesion formation and might reduce subsequent incidence of ASBO (level 1B)[15]; laparoscopic adhesiolysis might reduce morbidity in selected cases of ASBO that require operation. Results of a randomized trial are awaited (level 2C).[15]
SBO, EAST	2012	Laparoscopic treatment of SBO is a viable alternative to laparotomy in selected cases. When successful, it can be associated with decreased morbidity and a shorter length of stay (level II).[25]
Perforated peptic ulcer, WSES	2017	Laparoscopic repair of perforated peptic ulcer can be a safe and effective procedure for experienced surgeons (level 1A).[16]
Perforated diverticulitis, WSES	2016	Emergency laparoscopic sigmoidectomy for the treatment of perforated diverticulitis with generalized peritonitis is feasible in selected patients provided they are handled by experienced hands (level 2C).[20]
Incarcerated hernia, WSES	2017	Repair of incarcerated hernia—both ventral and groin—can be performed with a laparoscopic approach in the absence of strangulation and suspicion of the need of bowel resection, where an open preperitoneal approach is preferable (level 2C).[22]
Regional analgesia	NA	NA
Wound protector use	NA	NA
Avoidance of routine nasogastric tube placement	NA	NA
Avoidance of routine intra-abdominal drain placement	NA	NA
Postoperative management		
Early urinary catheter removal, general, CDC	2009	For operative patients who have an indication for an indwelling catheter, remove the catheter as soon as possible postoperatively, preferably within 24 h, unless there are appropriate indications for continued use (category 1B).[26]
Early oral alimentation	NA	NA
Early mobilization	NA	NA
Postoperative multimodal analgesia	NA	NA
Discharge evaluation	NA	NA

ACS, American College of Surgeons; ASBO, adhesive small bowel obstruction; CA-IAI, community-acquired intra-abdominal infection; EAST, Eastern Association for the Surgery of Trauma; ESBL, extended-spectrum beta-lactamase; HA-IAI, healthcare-associated intra-abdominal infection; IPC, intermittent pneumatic compression; LDUH, low-dose unfractionated heparin; LMWH, low-molecular-weight heparin; NA, not available; SBO, small bowel obstruction; SIPGWW, Surgical Infection Prevention Guideline Writers Workgroup; SIS, Surgical Infection Society; VTE, venous thromboembolism; WSES, World Society of Emergency Surgery.

early mechanical and pharmacologic prophylaxis are safe and effective in elective surgical and hospitalized medical patients without contraindications.[34] Guidelines recommend extended prophylaxis (4 weeks with LMWH) for high-risk patients undergoing abdominal and pelvic operations, such as those with malignancy or inflammatory bowel disease.[17,34] A recent observational study found that 35% of VTEs in EGS occurred after discharge, with 70% requiring readmissions, and that high-risk (eg malignancy or postoperative complications) groups had 6 times

higher rates of postdischarge VTE, suggesting that extended prophylaxis should be considered in high-risk patients.[33]

Summary and recommendations

EGS patients are at higher risk for VTE complications but limited evidence exists guiding optimal prophylaxis. Extrapolating evidence and guidelines from elective operations and other hospitalized patients, mechanical and pharmacologic VTE prophylaxis are recommended in EGS patients based on risk stratification. VTE prophylaxis should be initiated on admission and continued throughout hospitalization without interruption, unless contraindications exist. In high-risk populations, postdischarge extended VTE prophylaxis should be considered.

Preoperative multimodal analgesia

Rationale

A preoperative multimodal medication bundle composed of a combination of oral nonopioid analgesia can be beneficial even in the emergent setting.

Evidence

We did not identify any studies examining use of preoperative acetaminophen, NSAIDS, or gabapentinoids for emergency major abdominal operations. Our earlier review for colorectal operations found that each class of agent reduced pain and opioid requirement compared with placebo in elective surgical procedures.[41]

Summary and recommendations

Due to the lack of evidence as well as concomitant contraindications (ie intolerance to oral intake and intestinal obstruction), pre-anesthetic oral analgesic medications are not recommended currently.

INTRAOPERATIVE SETTING

Antimicrobial prophylaxis

Rationale

Timely administration of prophylactic antibiotics reduces the incidence of infectious complications after emergency major abdominal operations.

Evidence

We identified 2 SR/MAs and 1 retrospective observational study evaluating antimicrobial prophylaxis.[42-44] An SR/MA (260 RCTs) of elective and emergency colorectal operations found decreased postoperative surgical site infection (SSI) with prophylactic antibiotics covering aerobic and anaerobic bacteria (risk ratio [RR] 0.34; 95% CI, 0.28 to 0.41).[44] Another SR/MA (15 RCTs) on hernia repairs found β-lactam/β-lactamase inhibitors (RR 0.44; 95% CI, 0.25 to 0.75) and first-generation cephalosporins (RR 0.62; 95% CI, 0.42 to 0.92) superior to placebo for preventing SSIs.[42] A retrospective observational study of major emergency abdominal operations, including gastroduodenal operation, small bowel resection, colon resection, and exploratory laparotomy, found that antibiotics administered more than 12 hours after triage, compared with 6 or 12 hours, were associated with a greater odds of complications, reoperation, 30-day mortality, and prolonged LOS (all, $p < 0.05$).[43]

Recent joint guidelines by the American Society of Health-System Pharmacists, Infectious Diseases Society of America, Surgical Infection Society, and Society for Healthcare Epidemiology of America provide recommendations for antibiotic regimens. The World Society of Emergency Surgery also published procedure-specific guidelines for many emergency abdominal procedures. Antibiotics administered before incision should provide appropriate antimicrobial coverage for the anticipated operation (Table 3).[16,18-22] Prophylactic antibiotics should be administered within 60 minutes before incision, except fluoroquinolone or vancomycin (120 minutes), and discontinued within 24 hours.[18,19] For complicated intra-abdominal infection, the World Society of Emergency Surgery recommends a short 3- to 5-day course of antibiotics after source control.[16]

Summary and recommendations

Patients undergoing emergency major abdominal operations should receive antimicrobial prophylaxis; choice of antibiotics should be appropriate for bacterial spectrum of the disease condition and local antimicrobial resistance patterns. Anitbiotics should be dosed based on weight and pharmacokinetics. Local and national guidelines for antibiotic selection, dosage, and timing should be followed (Table 3).

Skin antisepsis

Rationale

Skin preparation with antiseptic agents used immediately before incision decreases SSIs.

Evidence

We did not identify any studies evaluating preoperative skin antisepsis specifically for emergency major abdominal operations. We identified 1 SR (13 RCTs) evaluating skin antiseptics before elective clean operations and 1 SR/MA (13 RCTs and 6 observational studies) on elective clean and clean-contaminated operations.[45,46] One study found chlorhexidine plus alcohol reduced SSIs compared with povidone-iodine plus alcohol (RR 0.47; 95% CI, 0.27 to 0.82), with mixed-treatment comparison analysis

suggesting that alcohol-containing products had the highest probability of effectiveness.[45] An SR/MA found moderate-quality evidence that chlorhexidine was superior to iodophor for SSIs (RR 0.7; 95% CI, 0.52 to 0.92) and bacterial skin colonization (RR 0.45; 95% CI, 0.36 to 0.55).[46] American College of Surgeons, Surgical Infection Society, and CDC guidelines recommend skin antisepsis with alcohol-based solutions, but there is no evidence supporting superiority of chlorhexidine or iodine combined with alcohol (Table 3).[23,24] When alcohol-based solutions are not available, chlorhexidine is recommended over iodine.[23]

Summary and recommendations

There is no evidence for skin antisepsis specific to emergency major abdominal operation. However, low-to-moderate-quality evidence from elective clean and clean-contaminated operations support preoperative skin antisepsis with alcohol-based solutions. Chlorhexidine should be used when an allergy to alcohol exists.

Regional analgesia

Rationale

Use of regional analgesic techniques, including epidural, spinal, and truncal nerve blocks (ie transversus abdominus plane blocks), improve analgesia and reduce opioid consumption and opioid-related adverse effects.

Evidence

We identified 1 prospective observational study of epidural analgesia and 1 RCT on transversus abdominus plane blocks. A recent population-based study (n = 4,920) in emergency abdominal operation found reduced risk of 30-day and 90-day mortality with perioperative epidural analgesia.[47] This finding is consistent with SR/MAs in elective abdominal procedures, which demonstrated accelerated return of bowel function and reduced pain with epidural analgesia in open abdominal operations, although benefits are less certain for laparoscopy.[48,49] A small RCT in emergency laparotomy found that transversus abdominus plane blocks lowered pain scores and postoperative need for rescue analgesia compared with placebo.[50] Findings are consistent with earlier MAs, which demonstrated benefits from truncal nerve blocks in open and laparoscopic elective abdominal operations.[51,52]

Summary and recommendations

Epidural analgesia and truncal regional blocks are potentially beneficial for emergency major abdominal operations and should be considered in the appropriate clinical setting.

Laparoscopic surgical technique

Rationale

Laparoscopic approaches can decrease surgical morbidity, reduce postoperative pain, and shorten LOS compared with open approaches and might be feasible and beneficial in the emergent setting.

Evidence

We identified 49 studies evaluating laparoscopy for emergency abdominal procedures. The evidence is summarized by procedure for perforated peptic ulcer, acute diverticulitis, obstructing colon cancer, small bowel obstruction (SBO), incarcerated hernia, and others (eTable 2).

We identified 4 SRs (2 older SRs were excluded[53,54]), 2 RCTs, and 7 observational studies on laparoscopic repair of perforated peptic ulcers.[55-65] An SR (3 RCTs) found trends toward lower septic complications, SSI, ileus, and mortality with laparoscopy, and significantly shorter LOS in 1 RCT.[55,66-68] An older SR (56 articles) found that laparoscopy is associated with decreased LOS, postoperative pain, and morbidity and mortality, but increased operating time and recurrent leak.[56] Two recent RCTs found shorter operative time and LOS, decreased pain and analgesic requirement, fewer complications, and faster return to normal activities with laparoscopic repair.[57,58] Seven observational studies generally found shorter LOS and decreased morbidity and mortality.[59-65]

We identified 2 SRs, 2 MAs, and 13 observational studies (5 studies were in the SRs and were therefore excluded[69-71]) evaluating laparoscopic vs open emergent colon resections.[72-83] One MA (4 observational studies) on urgent or emergent sigmoidectomy for diverticulitis found that laparoscopy decreased complications (RR 0.62; 95% CI, 0.49 to 0.80; p = 0.0002).[73] A second MA (5 observational studies) on emergent colectomies for obstructing cancer found increased operative time, but decreased LOS and complications with laparoscopy.[72] An SR (3 RCTs) on sigmoidectomy for acute diverticulitis found insufficient evidence on the safety and effectiveness of laparoscopy.[71,84-86] Eight observational studies of emergent colectomies found longer operative times, but lower LOS, morbidity, and mortality.[75-82] We identified another SR of emergent laparoscopic sigmoidectomies for perforated diverticulitis, which concluded that laparoscopy was safe in the emergent setting but lacked open comparisons.[83]

We identified 1 SR and 3 observational studies examining surgical management of SBOs.[87-90] The SR found that 65% of laparoscopic cases (29 case series, n = 2,005 patients) were successful; however, no open comparisons were included.[87] The observational studies generally found shorter LOS and fewer complications with laparoscopy.[88-90]

We identified 5 observational studies examining hernia repairs.[91-95] One study on femoral hernia repairs (39.2% emergent) found a lower reoperation rate with laparoscopy.[91] Four case series demonstrated feasibility and safety of laparoscopic repairs of incarcerated hernias (incisional, femoral, and inguinal) and strangulated groin hernias without open comparisons.[92-95]

Finally, we identified 10 observational studies on emergency laparotomy.[96-105] One study compared emergency laparoscopy against laparotomy and found lower ICU LOS and mortality with laparoscopy.[96] Nine case series (n = 176 to 1,320 patients) demonstrated feasibility and safety of laparoscopy without open comparison groups.[97-105]

Summary and recommendations

There is evidence to suggest that laparoscopy is associated with shorter LOS and decreased morbidity and mortality and is feasible in the emergent setting, depending on available expertise and favorable pathophysiology.

Wound protector use

Rationale

Wound protectors are thought to decrease postoperative SSIs in abdominal operations.

Evidence

There is no literature evaluating use of wound protectors in emergency major abdominal operations. We identified 1 SR/MA (6 RCTs) using wound protectors for upper and lower gastrointestinal operations that found a reduction in SSIs (RR 0.55; 95% CI, 0.31 to 0.98; $p = 0.04$).[106] Univariate meta-regression analysis showed inclusion of emergent operations was a nonsignificant source of heterogeneity ($p > 0.12$), suggesting that the overall findings were likely applicable for emergency circumstances.[106] Of the 6 RCTS, 4 were on elective operations, 1 on elective and emergent abdominal operation, and 1 on emergent appendectomy.[107-112]

Summary and recommendations

Evidence from abdominal operations suggests that wound protectors can be beneficial, although few studies were specific to emergency operations. However, there is no evidence suggesting harm from wound protectors.

Routine nasogastric tube placement

Rationale

Routine nasogastric tube (NGT) placement is likely unnecessary and should be used selectively for appropriate clinical indications.

Evidence

We identified 3 SRs (2 older, overlapping SRs were excluded[113,114]), 1 RCT, and 1 observational study assessing NGT use.[115-117] The SRs (37 studies) comparing routine and selective/no NGT use after elective and emergent abdominal operations found earlier return of bowel function ($p < 0.00001$) and decreased pulmonary complications ($p = 0.09$) in the selective/no NGT group, but no differences in wound infection ($p = 0.39$), ventral hernia ($p = 0.09$), or anastomotic leak ($p = 0.70$).(110, 112) A recent RCT of emergency laparotomy found no differences in nausea, vomiting, or abdominal discomfort ($p = 0.38$); wound ($p = 0.30$); respiratory complications ($p = 0.30$); anastomotic leak ($p = 0.64$); return of bowel function ($p = 0.54$); or NGT reinsertion ($p = 0.43$) between NGT and no NGT groups, but longer LOS in NGT group (7.52 vs 6.53 days; $p < 0.05$).[116] Finally, an observational study evaluated immediate removal of NGT postoperatively as part of an ERP after emergency operations for malignant large bowel obstruction and found that reinsertion was not associated with either immediate NGT removal ($p = 0.87$) or ERP participation ($p = 0.75$).[117]

Summary and recommendations

Evidence suggests that routine NGT decompression is not needed after abdominal operation, even in the emergent setting. However, appropriate clinical judgment is required in this heterogeneous patient population based on disease pathophysiology.

Routine intra-abdominal drain placement

Rationale

Routine intra-abdominal drain placement is likely unnecessary and should be used based on clinical indication.

Evidence

We identified 2 observational studies evaluating routine drain placement after perforated peptic ulcer repairs.[118,119] One study prospectively compared 119 patients undergoing Graham patch repair for perforated duodenal ulcers and found no differences in wound infection (25% vs 24%), intra-abdominal fluid collection (34.1% vs 40%), return of bowel function (2.9 vs 3.2 days), or LOS (12.4 vs 12.0 days; all, $p > 0.05$).[119] In addition, 8 patients (10.7%) in the drain group experienced drain-related complications. The retrospective case-control study of 934 perforated peptic ulcer repairs found no differences in mortality, fasting duration, or LOS, but lower incidence of postoperative interventions with drains (1.9% vs 5.6%; RR 0.35; 95% CI, 0.16 to 0.73).[118]

There were no studies evaluating drain placement in other emergency major abdominal operations. Our earlier

review (4 SR/MAs) of elective colorectal operations found no differences in anastomotic and other complications with routine peritoneal and pelvic drains.[14,120-123]

Summary and recommendations

There is limited evidence suggesting benefit or harm from abdominal drainage in patients undergoing emergency major abdominal operations.

POSTOPERATIVE SETTING

Early urinary catheter removal

Rationale

Presence of a urinary bladder catheter is a risk factor for urinary tract infection and prompt removal reduces risk of catheter-associated urinary tract infection.

Evidence

There was no literature evaluating timing of urinary catheter removal after emergency major abdominal operation. Our earlier review for elective colorectal operation found 1 SR and 2 SR/MAs that demonstrated decreased urinary tract infections and LOS with early catheter removal.[14,124-126] Both SR/MAs evaluated colon operations and concluded that reduced use or duration lowered rates of catheter-associated urinary tract infection (53% reduction; $p < 0.001$).[125,126] The SR evaluated rectal operations and found that early removal decreased catheter-associated urinary tract infection (20% vs 42%, $p < 0.01$), although increased urinary retention (25% vs 10%; $p < 0.05$).[124,127] Finally, CDC guidelines recommend catheter removal soon after operation, preferably within 24 hours.[26]

Summary and recommendations

There was no evidence for emergency major abdominal operation, but evidence from elective colorectal operations supports early removal of urinary catheters, unless it is needed for hemodynamic assessment or procedure-specific indications (eg low rectal operations).

Early oral alimentation

Rationale

Early postoperative alimentation can speed gastrointestinal recovery after abdominal operations and can be safe and beneficial in emergent settings.

Evidence

We identified 1 RCT and 2 retrospective observational studies comparing early and traditional oral feeding after emergency operations.[128-130] An RCT in appendectomy, herniorrhaphy, bowel resection, and other abdominal operations found no differences in complications ($p = 0.1$) or LOS ($p = 0.2$) between early (within 24 hours) and traditional feeding.[128] There was a higher rate of vomiting with early feeding (13.5% vs 6.1%; $p = 0.03$), but no difference in NGT reinsertion. Patient surveys revealed more hunger with traditional care ($p < 0.01$). One small study of bowel resection found that early feeding (within 48 hours) shortened ICU LOS (1 vs 2 days; $p = 0.038$) and hospital LOS (9 vs 12 days; $p = 0.012$), and decreased pulmonary complications (13.6% vs 47.5%; $p = 0.001$).[129] Another propensity-matched, larger retrospective study of emergency bowel resection or repair for gastrointestinal perforation or strangulation associated early feeding with reduced mortality rates (4.5% vs 19.4%; $p = 0.008$; hazard ratio 0.03; 95% CI, 0.01 to 0.49; $p = 0.015$) and LOS (median 14, interquartile range 8 to 24 vs median 17, interquartile range 11 to 26; $p = 0.048$).[130]

Summary and recommendations

Evidence from emergency abdominal operations suggests that early alimentation is safe and beneficial.

Early mobilization

Rationale

Early ambulation can be feasible in emergent settings and improve patient outcomes, such as improved functional recovery and reduced LOS.

Evidence

No literature was found for emergency major abdominal operations. We identified 1 RCT evaluating early mobilization in the surgical ICU and 1 SR in elective abdominal operations.[131,132] The RCT compared standard treatment with early, goal-directed mobilization among critically ill patients after abdominal operations. Intention-to-treat analysis showed improved mobilization levels ($p < 0.001$), decreased surgical ICU LOS ($p = 0.005$), and better functional mobility at hospital discharge ($p < 0.001$).[132] The SR (3 RCTs and 1 observational study) evaluated early mobilization protocols involving supervised, mandatory exercises 12 to 24 hours postoperatively vs delayed ambulation or activity at the patient's discretion.[131] No differences were found in complications, but 1 study found reduced LOS and 1 study found improved gastrointestinal function. Studies were poor quality and there was no consistent evidence supporting a specific early mobilization protocol.

Summary and recommendations

There is no evidence for emergency major abdominal operation, but results from ICUs and elective abdominal operations suggest that early mobilization can be beneficial and adopted safely.

Table 4. Improving Surgical Care and Recovery Emergency General Surgery Components Included in Studies of Perioperative Bundles

ISCR EGS component	First author, year							
	Mohsina, 2018[139]	Gonenc, 2014[137]	Wisely, 2016[144]*	Lohsiriwat, 2014[138]	Moller, 2011[140]	Aggarwal, 2019[29]	Tengberg, 2017[32]	Huddart, 2015[30]
Preoperative component								
Education and counseling	—	—	—	√	—	—	—	—
Medical assessment and optimization	—	—	—	—	√	√	√	√
Early evaluation by surgeon and anesthesiologist†	—	—	—	—	√	√	√	√
Sepsis screening†	—	—	—	—	√	√		√
On-demand abdominal CT (within 2 h)†	—	—	—	—			√	
Early use of broad-spectrum antibiotics†	—	—	—	—	√	√	√	√
Minimization of surgical delay (within 6 h)†	—	—	—	—	√	√	√	√
Early goal-directed resuscitation†	—	—	—	—	√	√	√	√
Admission to intensive care unit†	—	—	—	—	√	√		√
Multimodal pre-anesthesia medication	√	—	—	—	—	—	—	—
Epidural and/or regional analgesia	√	—	—	—	—	—	—	—
Intraoperative component								
Antimicrobial prophylaxis	—	—	—	—	—	—	—	—
Skin antisepsis	—	—	—	—	—	—	—	—
Venous thromboembolism prophylaxis	—	√	—	—	—	—	—	—
Standard anesthetic protocol†	√	—	—	√	—	—	—	—
Goal-direct fluid therapy†					√	—	—	—
Normothermia†	—	—	—	√	√	—	—	—
Postoperative nausea and vomiting prophylaxis†	—	—	—	√	—	—	—	—
Laparoscopic surgical technique (or modification of surgical access†)	—	—	—	√	—	—	—	—
Wound protector use	—	—	—	√	—	—	—	—
No routine nasogastric tube placement (or early removal†)	√	√	—	√	—	—	—	—
No routine intra-abdominal drain placement (or early removal†)	√	—	√	√	—	—	—	—
Local analgesia infiltration†	—	—	—	√	—	—	—	—
Postoperative component								
Venous thromboembolism prophylaxis	—	—	—	—	—	—	—	—
Multimodal analgesia	√	√	√	√	√	—	—	—
Early urinary catheter removal	√	√	√	√	√	—	—	—
Early oral alimentation	√	√	√	√	√	—	√	—
Early mobilization	√	—	—	√	√	—	√	—
Minimize intravenous fluid†	—	—	√	√	√	—	—	—
Discharge evaluation and planning	—	—	—	√	—	—	—	—
Postdischarge component								
Telephone call after discharge†	—	—	—	√	—	—	—	—

*Component not specified, and assumed based on significant reported differences between the cohorts.
†Not included in the emergency general operation evidence review.
EGS, emergency general surgery; ISCR, improving surgical care and recovery.

Postoperative multimodal analgesia

Rationale

Multimodal nonopioid oral pain medications can optimize pain control, reduce reliance on opioid-based analgesia, and prevent opioid-related adverse effects.

Evidence

We did not identify studies examining use of postoperative acetaminophen, NSAIDs, or gabapentinoids for emergency major abdominal operations. Our earlier review of elective colorectal operations found these agents had efficacy in reducing pain scores, opioid administration, and opioid-related adverse effects (ie postoperative nausea and vomiting) compared with placebo.[41]

Summary and recommendations

In spite of the lack of evidence specific to emergency major abdominal operations, data from elective operations support postoperative use of nonopioid medications. Route of administration, dosing, and selection of agents should be tailored to clinical condition or organ function.

Discharge evaluation and planning

Rationale

Use of proactive, evidence-based discharge planning strategies can decrease readmissions and complications, shorten LOS, and improve patient experience, in spite of the unplanned nature of emergency procedures, particularly in older, frail patients.

Evidence

There is no literature evaluating discharge criteria or planning strategies for emergency major abdominal operations. Our earlier review (2 RCTs and 1 observational study) on hip fracture operation evaluated discharge planning after hip fracture operation, which is typically emergent and likely applicable to emergency major abdominal operations.[133] Study findings included decreased LOS and improved survival, functional ability, independence, self-care knowledge, and quality of life.[134-136]

Summary and recommendations

Evidence from emergency hip fracture operations supports the feasibility and benefit of discharge evaluation and planning in the emergency setting.

Perioperative enhanced recovery protocol or pathway

Rationale

Perioperative bundles or protocols have been adopted for elective abdominal operations and a similar approach can benefit patients undergoing emergency major abdominal operations.

Evidence

We identified 2 RCTs and 9 observational studies evaluating ERP bundles or preoperative assessment and optimization bundles.[29,30,32,137-144] Protocols are summarized in Table 4 and results in Tables 5 and 6. Two additional observational studies evaluated patients managed with an ERP and compared emergency status with elective status.[142,143]

The 2 RCTs compared ERP with conventional care for perforated ulcer repairs.[137,139] One RCT of duodenal ulcer repair found decreased LOS (3.8 $\pm$ 1.9 days vs 6.9 $\pm$ 2.2 days; $p < 0.001$) and accelerated return of bowel function (1.55 $\pm$ 1.27 days vs 4.82 $\pm$ 1.28 days; $p < 0.001$) with ERP, without differences in morbidity or mortality.[137] Another RCT of peptic ulcer repair found decreased LOS (5.36 $\pm$ 1.39 days vs 9.78 $\pm$ 4.30 days; $p < 0.001$), earlier functional recovery, and reduced morbidity with ERP.[139]

Three observational studies compared ERPs with conventional care (Tables 5 and 6).[138,140,144] Wisely and colleagues[144] studied emergency major abdominal operations and found decreased major complications ($p = 0.002$) with ERP, without differences in LOS, mortality, or 30-day readmission. Lohsiriwat and colleagues[138] studied emergent colorectal resections for obstructing cancer and found shorter LOS, return of bowel function, and time to chemotherapy with ERP (all, $p < 0.05$), and no differences in mortality or readmissions. Moller and colleagues[140] studied perforated peptic ulcer repairs and found reduced mortality (17.1% vs 27.0%; $p = 0.005$) and LOS (8 days vs 10 days; $p = 0.03$).

Three observational studies evaluated multidisciplinary perioperative protocols involving early preoperative medical assessment and optimization before emergent laparotomy (Tables 5 and 6).[32] Aggarwal and colleagues[29] studied a "6-point care bundle" after emergency laparotomy and found lower mortality (5.1% vs 5.5%; $p < 0.05$) and LOS (18.9 days vs 20.1 days; $p < 0.05$) in the intervention group. Tengberg and colleagues[32] found lower mortality with the preoperative protocol (15.5% vs 21.8%; $p = 0.005$) without a difference in LOS. Similarly, Huddart and colleagues[30] found reduced risk of 30-day mortality (10.1% vs 17.4%; $p < 0.001$) without a difference in LOS (Tables 5 and 6).

Two retrospective analyses compared emergency with elective status in ERP patients and found ERP feasible in the emergent setting with no difference in complications.[142,143]

Summary and recommendations

There is evidence to support the use of perioperative protocols in the emergent setting, although there was

Table 5. Studies of Perioperative Bundles for Emergency General Surgery, All Results Presented as Intervention vs Comparison

Studies				Length of stay, d, mean ± SD		p Value	Reoperation, %		p Value	Readmission, %		p Value	Mortality, %		p Value
				I	C		I	C		I	C		I	C	
ERP															
Mohsina, 2018[139]	RCT; open Graham patch repair	ERP (n = 50)	SC (n = 49)	5.36 ± 1.39	9.78 ± 4.30	< 0.0001	0	4	NS	0	0	NS	0	0	NS
Gonenc, 2014[137]	RCT; laparoscopic Graham patch repair	ERP (n = 21)	SC (n = 26)	3.8 ± 1.9	6.9 ± 2.2	0.0001	9.5	7.7	0.823	19.0	7.7	0.471	0	3.8	0.363
Wisely, 2016[144]	Pre/post OS; major emergency abdominal operation (open)	ERP (n = 201)	HC (n = 169)	8*	8*	NR	9	9	0.89	10	8	0.88	10	10	0.9
Lohsiriwat, 2014[138]	Matched cohort (1:2) OS; emergency colon resection for obstructing colorectal cancer (open)	ERP (n = 20)	CC (n = 40)	6.0 ± 2.9	9.4 ± 5.1	0.002	NR	NR	NR	0	0	NS	0	0	NS
Moller, 2011[140]	Non-RCT; operation for perforated peptic ulcer	ERP (n = 117)	CNC (n = 512)	8*	10*	0.030	17.1	15	0.53	NR	NR	NR	17.1	27	0.005
Perioperative protocol/bundle															
Aggarwal, 2019[29]	Pre/post OS; emergency laparotomy	PP (n = 9247)	HC (n = 5562)	18.9	20.1	< 0.05	NR	NR	NR	NR	NR	NR	5.1	5.5	< 0.05
Tengberg, 2017[32]	Pre/post OS; emergency laparotomy or laparoscopy	PP (n = 600)	HC (n = 600)	11*	10*	0.783	NR	NR	NR	NR	NR	NR	15.5	21.8	0.005
Huddart, 2015[30]	Pre/post OS; emergency laparotomy	PP (n = 427)	HC (n = 299)	11	11	NR	NR	NR	NR	NR	NR	NR	10.1	17.4	< 0.001

*Median.

C, comparison; CC, conventional care; CNC, concurrent national control; ERAS, enhanced recovery after surgery; ERP, enhanced recovery pathway; HC, historical control; I, intervention; NR, not reported; NS, not significant; OS, observational study; PP, perioperative protocol; RCT, randomized controlled trial; SC, standard care.

Table 6. Studies of Perioperative Bundles for Emergency General Surgery, Postoperative Complication and Functional Outcomes, Intervention vs Comparison

Study, complication/outcomes	Intervention	Comparison	p Value
Enhanced recovery pathway			
Mohsina, 2018[139]			
Postoperative complication			
Overall, %	NR	NR	NR
PONV, %	18	63	< 0.0001
Superficial SSI, %	10	29	0.021
Organ space SSI with leak, %	2	4	0.54
Pulmonary complication, %	4	16	0.049
Urinary tract infection, %	2	18	0.007
Functional outcomes			
Overall, %	NR	NR	NR
First bowel sound, d, mean ± SD	1.46 ± 0.54	2.02 ± 0.60	< 0.001
First flatus, d, mean ± SD	2.0 ± 0.78	3.47 ± 1.02	< 0.001
First stool, d, mean ± SD	3.52 ± 0.79	5.78 ± 1.26	< 0.001
Duration of ileus, d, mean ± SD	1.4 ± 0.07	2.02 ± 0.09	< 0.001
Need for NGT reinsertion, %	4	6	0.629
Gonenc 2014[137]			
Postoperative complication			
Overall, %	23.8	26.9	0.807
Superficial SSI, %	0	3.8	0.377
Organ/space-type SSI, %	9.5	7.7	0.679
Pulmonary complication, %	4.8	15.4	0.485
Postoperative bleeding, %	0	3.8	0.377
Incarcerated trocar site hernia, %	4.8	0	0.929
Functional outcomes			
Overall, %	NR	NR	NR
Postoperative ileus, %	9.5	19.2	0.760
Time to start oral intake, d, mean ± SD	1.55 ± 1.27	4.82 ± 1.28	0.0001
Need for NGT reinsertion, %	9.5	11.5	0.823
Wisely 2016[144]			
Postoperative complication			
Overall, %	NR	NR	NR
Major complication,%*	—	—	0.002
Minor complication, %	79	81	0.46
Functional outcomes			
Overall, %	NR	NR	NR
Drain placement, %	43	60	0.001
NGT placement, %	—	—	NS
Indwelling catheter for > 2 d, %	57	77	< 0.001
Lohsiriwat 2014,[138]			
Postoperative complication			
Overall, %	25	48	0.090
Clavien-Dindo grade II–V, %	10	20	0.470
Functional outcomes			
Overall, %	NR	NR	NR
Time to first flatus, d, mean ± SD	1.6 ± 0.7	2.8 ± 1.3	< 0.001
Time to first stool, d, mean ± SD	3.4 ± 1.2	3.7 ± 1.4	0.43

(Continued)

Table 6. Continued

Study, complication/outcomes	Intervention	Comparison	p Value
Time to normal diet, d, mean ± SD	3.4 ± 1.7	5.5 ± 2.4	0.002
Time to adjuvant chemotherapy, d, mean ± SD	37.0 ± 8.9	49.4 ± 20.4	0.009
Moller, 2011[140]			
Postoperative complication, overall, %	NR	NR	NR
Functional outcomes, overall, %	NR	NR	NR
Perioperative protocol/bundle			
Aggarwal, 2019[29]			
Postoperative complication, overall, %	NR	NR	NR
Functional outcomes, overall, %	NR	NR	NR
Tengberg 2017[32]			
Postoperative complication			
Overall, %	NR	NR	NR
Clavien-Dindo grade III–V, %	46	52.3	0.028
Functional outcomes			
Overall, %	NR	NR	NR
Time to OR > 6 h, %	26.5	29.1	NS
Huddart, 2015[30]			
Postoperative complication, overall, %	NR	NR	NR
Functional outcomes, overall, %	NR	NR	NR

*31% overall, lower in enhanced recovery after surgery.
NGT, nasogastric tube; NR, not reported; NS, not significant; OR, operating room; PONV, postoperative nausea and vomiting; SSI, surgical site infection.

considerable variability in the components used across protocols.

DISCUSSION

EGS remains an area that has largely been untouched by clinical pathways. Here, we put forward the first review, to our knowledge, of the available evidence for ERP-like protocols as well as the key ERP-related care processes for common emergency major abdominal operations. Overall, there was a paucity of high-quality evidence in the emergency setting, likely due to the difficulty of studying this complex and heterogeneous patient population. When necessary and clinically reasonable, we broadened our inclusion criteria to the elective setting or other similar patient populations. As such, we identified evidence specific to emergency abdominal operations for 7 components, including medical optimization, VTE prophylaxis, regional analgesia, laparoscopic technique, nonroutine use of intra-abdominal drains, early oral alimentation, and use of a perioperative protocol or pathway. Three components—antimicrobial prophylaxis, use of wound protectors, and nonroutine use of NGTs—had evidence from both emergency and elective abdominal surgical literature, although groups were not analyzed separately. Evidence from elective operations was generalizable for 4 components, including patient education, skin antisepsis, urinary catheter removal, and postoperative multimodal analgesia. The evidence was extended to similar patient populations for 2 components: early mobilization in surgical ICU patients and discharge evaluation and planning for emergency hip fracture patients. Finally, evidence specific to major emergency abdominal operations was not identified, but also was determined to be not generalizeable from other settings or populations for 1 component, that is, preoperative multimodal analgesia.

This review highlights the key gaps in the literature, specifically lack of evidence specific to emergency abdominal operations across many ERP processes. Even in areas where there are specific data or including EGS, there is a lack of robust randomized data. Nevertheless, this work serves as a foundation on which surgeons, anesthesia providers, nurses, and hospitals can begin to develop hospital-based standardized pathways for EGS. Then, as implementation expands, it will be essential to continuously evolve these pathways from modifications of elective operation pathways to ones that truly represent the best evidence for EGS patients.

The AHRQ ISCR program has garnered important lessons about dissemination and implementation of ERPs across multiple surgical areas that are applicable to developing and implementing an EGS ERP. First, hospitals have the greatest opportunity for success when pathways are simple and adaptable to the local environment—it is better to start with a modest pathway with broad

consensus processes as opposed to a comprehensive pathway including more controversial elements. Second, ISCR hospitals have found implementation challenging when their clinical volume is low. For example, hospitals performing 1 to 2 colectomies per month have difficulty sustaining an isolated colorectal ERP program. Given this need to reach a "critical mass" of patients to establish ERPs as the clinical norm, it is advisable to begin with an integrated approach with a common pathway for all EGS patients and then add in specific elements relevant for more complex patients, such as those undergoing emergency major abdominal operations. Third, variations in procedure complexity can necessitate variations or flexibility in the pathway. For example, the needs of a patient undergoing a straightforward hysterectomy might be very different from a patient undergoing a complex hysterectomy for gynecologic malignancy, and the ERP must be flexible enough to allow for these variations. Finally, ERP implementation takes time, a lesson consistently reinforced across all ISCR cohorts. The development of a major abdominal operation ERP is an important first step, but meaningful practice change will require time, iteration, and transdisciplinary collaboration.

Building on the foundation of this review, the ISCR EGS ERP program will operationalize ERP implementation through 2 pathways sharing a common core pathway. One ERP will address appendectomies and cholecystectomies, and the pathway for these lower-acuity procedures will emphasize multimodal pain control and appropriate antibiotic stewardship. A second ERP will focus on emergency major abdominal operations and emphasize more traditional ERP elements of early feeding and mobilization. Both ERPs include thoughtful consideration of prompt and appropriate treatment of sepsis, early source control, antibiotic stewardship, minimizing opioids in the postdischarge period, and consideration for geriatric patients. Although not all of these are traditional ERP elements, we believe that incorporation of bests practices from other surgical quality improvement areas can contribute to meaningful improvements in patient outcomes, especially given the limited evidence specific to ERPs in emergency operations.

This review has several limitations. Heterogeneity of disease processes, surgical procedures, and evidence for each component made it challenging to evaluate the quality of evidence. Only broad parameters for SRs were used, and formal quality assessment was not possible. Overall, there was a lack of high-quality evidence specific to emergency major abdominal operations, likely due to the challenges of performing clinical trials in this population. Therefore, evidence was extrapolated from elective settings or similar patient populations where appropriate. Nevertheless, this work provides an up-to-date review of the current literature, summarizing knowledge gaps where further research is needed and supporting active implementation efforts in quality improvement in EGS, recognizing that these pathways will evolve with experience and as new evidence emerges.

CONCLUSIONS

Seventeen components of perioperative care for emergency major abdominal operations were reviewed and many are supported by evidence and guidelines specific to these operations. However, reasonable extrapolations from elective settings and similar patient populations were required for several components. The review serves as an evidence-based foundation to expand enhanced recovery efforts to the patient population undergoing emergency major abdominal operations and to guide future research. It is our hope that this work will accelerate expansion of ERPs into EGS and spur research to generate more robust data to advance quality improvement in this critical area.

Author Contributions

Study conception and design: Hu, Grant, Hornor, Liu, Ko, Maggard-Gibbons, Wu, Wick
Acquisition of data: Hu, Grant, Hornor, Merchant, Liu
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Invited Commentary

Every Emergency General Surgery Patient Deserves Pathway-Driven Care

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A patient is brought urgently from the emergency department to the operating room due to perforated diverticulitis. During the pre-incision timeout, anesthesia communicates that prophylactic antibiotics were not ordered. The surgeon makes the incision for a sigmoid colectomy while the pharmacy draws up the appropriate antibiotic. Feedback about the improper timing of antibiotic administration does not reach the surgeon. Postoperatively, the patient receives morphine as needed for pain. Ileus and surgical site infection complicate his hospital course. He is discharged on postoperative day 10 with instructions to pack his open surgical wound.

Imagine instead that this patient presents in the elective setting for colectomy. Prophylactic antibiotics are administered correctly based on orders placed by the preoperative clinic. A mistake in the timing of antibiotic dosing would be captured and fed back to the surgeon and hospital, informing future efforts to improve compliance. Postoperatively, the patient receives multimodal analgesia to help reduce opioid use and ileus rates. These components of the care pathway for elective colectomy improve the patient's odds of discharging sooner and with fewer complications.

The introduction of standardized, evidence-based, and multidisciplinary protocols has led to substantial reductions in hospital length of stay, morbidity, mortality, and healthcare costs across surgical disciplines.[1] However, these enhanced recovery pathways and their subsequent gains in health outcomes have been restricted to elective surgery. Expansion into emergency general surgery (EGS) is an obvious next step. Hu and colleagues[2] have identified candidate measures relevant and feasible for adoption in emergency major abdominal operations. This article is rigorous and comprehensive, informed by significant clinical expertise, and represents an important template for improving EGS care.

EGS is beset by a disproportionate share of morbidity and mortality among surgical fields. During a 6-year period in Michigan, emergency cases accounted for 11% of total operations, but 47% of perioperative mortality and 27% of surgical complications.[3] This burden falls on the shoulders of the vulnerable; compared with elective surgery patients, EGS patients are more likely to be uninsured, have low incomes, identify as a racial or ethnic minority, and have poor access to the healthcare system.[4] Enhanced recovery pathways in EGS, therefore, have the opportunity to simultaneously impact outcomes and health disparities.

Considering that EGS providers increasingly practice trauma and critical care, both highly protocolized domains of surgery, it is somewhat ironic that EGS has such variation in care and outcomes. The American College of Surgeons Trauma Quality Improvement Program represents a national effort of more than 450 trauma centers to improve the quality of care for trauma patients through education and training in evidence-based, best practice guidelines.[5] These initiatives are transforming trauma management. Care is increasingly protocol-driven and off-protocol events are captured and reported to inform continuous quality improvement.[5] EGS pathways should follow this example.

In Michigan, we have advocated for standard pathways in common operations,[6] but have not focused on EGS because of measured and perceived barriers to pathway implementation, including heterogeneity in pathology, complexity of patients, and poor compliance with existing process measures.[2] For example, we found that compliance with administration of appropriate prophylactic antibiotics within 60 minutes of incision was markedly lower in emergency colectomy (42%) than in elective colectomy (82%).[3] The case example above illustrates this common disparity in adherence to process measures in the real world.

Despite decades of compelling research and increasing consensus on the effectiveness of enhanced recovery

eTable 1. Search Terms for Improving Surgical Care and Recovery Emergency Major Abdominal Operation Components

Component	Operation	Pathway component	Qualifiers
Education and counseling	((((("Colectomy"[MeSh] OR (colon resect*[tw]) OR colectom*[tw] OR (large bowel resect*[tw]) OR (hemicolectom*[tw]) OR ((((stomach ulcer*[tiab]) OR (curling* ulcer*[tiab]) OR (duodenal ulcer*[tiab]) OR "gastric ulcer"[tiab] OR "gastric ulcers"[tiab] OR gastrointestinal [tiab]) AND (repair*[tiab] OR surger*[tiab] OR surgical*[tiab])) OR ("Stomach Ulcer"[MeSh] OR "Duodenal Ulcer"[MeSh]) AND ("Surgical Procedures, Operative"[MeSh:NoExp] OR "Digestive System Surgical Procedures"[MeSh]) OR "Stomach Ulcer/surgery"[MeSh] OR "Duodenal Ulcer/surgery"[MeSh])) OR (((hernia[tiab] OR hernias[tiab]) AND (surger*[tiab] OR repair*[tiab])) OR herniorrhaph*[tiab] OR "Herniorrhaphy"[MeSh])) OR (((bowel[tw] OR intestine*[tw]) AND (resect*[tw] OR surger*[tw] OR surgic*[tw]))))) OR ("Laparotomy"[MeSh] OR laparotomy*[tiab] OR "Laparoscopy"[MeSh] OR laparoscop*[tiab]))) OR "surgery"[Subheading] OR "surgery"[All Fields] OR "surgical procedures, operative"[MeSH Terms] OR ("surgical"[All Fields] AND "procedures"[All Fields] AND "operative"[All Fields]) OR "operative surgical procedures"[All Fields] OR "surgery"[All Fields] OR "general surgery"[MeSH Terms] OR ("general"[All Fields] AND "surgery"[All Fields]) OR "general surgery"[All Fields])) AND (("emergency"[All Fields] OR "emergent"[All Fields] OR "urgent"[All Fields]))))	Patient Education as Topic[MeSh] OR "pre-operative education"[tiab] OR "preoperative education"[tiab]	
Medical optimization		("nutrition"[tiab] OR "Nutritional Status"[MeSh]) OR ("Smoking"[MeSh] OR "Smoking Cessation"[MeSh] OR "smoking"[tiab] OR "Smoking Cessation"[tiab]) OR ("Diabetes Mellitus"[MeSh] OR "Diabetes Mellitus, Type 2"[MeSh] OR "Hemoglobin A, Glycosylated"[MeSh] OR "Hyperglycemia"[MeSh] OR "Diabetes"[tiab] OR "Diabetes Mellitus"[tiab] OR "Diabetes Mellitus, Type 2"[tiab] OR "Hemoglobin A, Glycosylated"[tiab] OR "Hyperglycemia"[tiab] OR "blood glucose"[tiab]) OR optimiz*[tiab]	"Preoperative Period"[MeSh] OR "Preoperative Care"[MeSh] OR "Preoperative Period"[all fields] OR "Preoperative Care"[all fields]
Preoperative multimodal analgesia		"acetaminophen"[tiab] OR "paracetamol"[tiab] OR "gabapentin"[tiab] OR "gabapentinoid"[tiab] OR "pregabalin"[tiab] or "non-steroidal anti-inflammatory"[tiab] OR "NSAID"[tiab] OR "celecoxib"[tiab]	preoperative[tiab]
Regional analgesia		"epidural"[tiab] OR "spinal"[tiab] OR "neuraxial analgesia"[tiab] OR "nerve block"[tiab] OR "truncal analgesia"[tiab] or "truncal nerve block"[tiab]	
Antimicrobial prophylaxis		antibiotic*[tiab] OR antimicrobial[tiab]	prophyla*[tiab] OR preoperative[tiab]
Skin antisepsis		"skin"[tiab] AND (antisep*[tiab] OR "prep"[tiab] OR preparation*[tiab])	
Laparoscopic surgical technique		laparoscopic [tiab] AND (technique[tiab] OR approach[tiab])	
Wound protector use		Wound protect*[All Fields] or Alexis[All Fields] or "wound edge" protect*[All Fields] or wound guard[All Fields]	
Routine nasogastric tube placement		"nasogastric decompression"[tiab] OR "nasogastric tube"[tiab]	
Routine intra-abdominal drain placement		drain*[tiab]) AND (abdominal[tiab] OR routine[tiab] OR intraperitoneal[tiab] OR prophylac*[tiab])	
VTE prophylaxis		("anticoagulation"[tw] OR "thromboembolism"[MeSh] OR "thromboembolism"[tw]) OR "thromboprophylaxis"[tw]	prophyla*[tiab]
Early urinary catheter removal		"urinary catheter"[tw] OR "foley"[tw] OR "urinary catheterization"[tw] OR "bladder decompression"[tw]	
Early oral alimentation		early[tw] AND (nutrition[tw] OR feeding[tw] OR alimentation[tw] or enteral[tw])	
Early mobilization		"early ambulation"[tw] OR "early mobilization"[tw]	

(Continued)

eTable 1. Continued

Component	Operation	Pathway component	Qualifiers
Postoperative multimodal analgesia		"acetaminophen"[tiab] OR "paracetamol"[tiab] OR "gabapentin"[tiab] OR "gabapentinoid"[tiab] OR "pregabalin"[tiab] or "non-steroidal anti-inflammatory"[tiab] OR "NSAID"[tiab] OR "celecoxib"[tiab] OR "ibuprofen"[tiab]	
Discharge evaluation		"patient discharge"[MeSh] OR patient discharge[tiab]	
Perioperative enhanced recovery protocol or pathway		"Enhanced Recovery After Surgery"[All Fields] OR "fast track"[All Fields] OR "enhanced recovery"[All Fields] OR "ERAS"[All Fields]	

MeSH, medical subject heading; tiab, title or abstract; tw, text word.

eTable 2. Summary of Evidence for Laparoscopic Technique

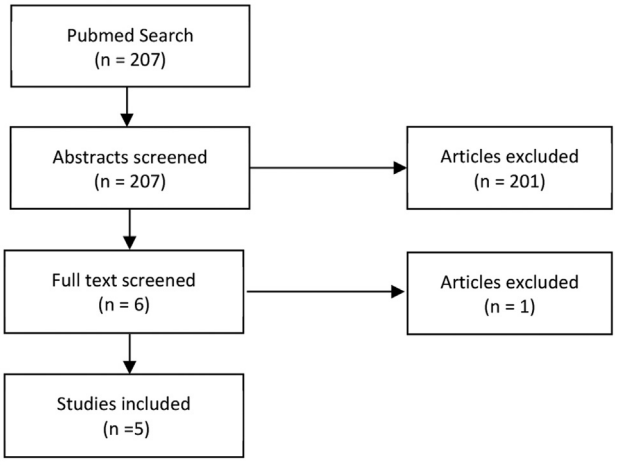
Condition, study author and year	Study design	Data source	Operation and indication/sample size	Laparoscopic (vs open) results*
Peptic ulcer disease				
Sanabria, 2013[55]	SR	3 RCTS	Repair of perforated peptic ulcer, 163 lap vs 152 open	No difference in LOS/ complication
Bertleff, 2010†,[56]	SR	56 studies (3 RCTs, 33 observational, 5 reviews, 3 describing new techniques, 12 general) 1989–2009	Repair of perforated peptic ulcer, 843 lap vs 1,031 open	↓ LOS ↓ Mortality ↓ Pain ↓ Complication ↑ Operative time
Shah, 2015†,[58]	RCT	Single institution (India) 2009–2011	Repair of perforated peptic ulcer, 25 lap vs 25 open	↓ LOS ↓ Complication ↓ Pain ↓ Time to functional recovery ↓ Operative time
Motewar, 2013[57]	RCT	Single institution (India) 2012‡	Repair of perforated duodenal ulcers, 70 lap vs 70 open	↓ Complication
Mirabella, 2018†,[62]	OS	Multi-institution (Italy) 2006–2016	Repair of perforated peptic ulcer, 75 lap vs 109 open	↓ Mortality No difference in complication
Vakayil, 2019†,[64]	OS	National US population (ACS NSQIP) 2005–2016	Repair of perforated peptic ulcer, 616 lap vs 1,846 open	↓ LOS ↓ Mortality ↓ Complication ↑ Operative time
Leusink, 2018[61]	OS	National English population (Hospital Episode Statistics) 2005–2012	Repair of perforated peptic ulcer, 895 lap vs 12,127 open	↓ LOS ↓ Mortality ↓ Complication
Laforgia, 2017†,[60]	OS	Single institution (Italy) 2007–2015	Repair of perforated peptic ulcer 21 lap vs 37 open	↓ LOS ↓ Complication ↓ Pain ↓ Time to functional recovery ↓ Operative time
Siow, 2018[63]	OS	Single institution (Malaysia) 2010 –2014	Repair of perforated peptic ulcer, 63 lap vs 68 open	↓ LOS ↓ Complication ↓ Pain
Wilhelmsen, 2015[65]	OS	National Danish (Danish Clinical Register for Emergency Surgery) 2011–2013	Repair of perforated peptic ulcer, 238 lap vs 310 open vs 178 lap converted to open	↓ Reoperation
Diverticulitis, obstructing colon cancer				
Cirocchi, 2019[73]	SR/MA	4 OS (Italy, Netherlands, Canada, US)	Sigmoid resection for complicated diverticulitis, 181 lap vs 255 open	↓ Complication
Cirocchi, 2017[72]	SR/MA	5 OS (China, UK, Singapore, US, Hong Kong)	Colectomy for obstructing right colon cancer, 75 lap vs 124 open	↓ LOS ↓ Complication ↓ Time to functional recovery ↑ Operative time
Abraha, 2017[74§]	SR	3 RCTs (Switzerland, Netherlands, and Germany)	Sigmoid resection for sigmoid diverticulitis, 195 lap vs 197 open	No difference in LOS ↑ Operative time
Vallance, 2018[82]	OS	National English (National Bowel Cancer Audit) 2010 to 2016	Resection of colorectal cancer, 3,435 lap vs 12,081 open	↓ LOS ↓ Mortality
Sujatha-Bhaskar, 2017[81]	OS	National US population (ACS NSQIP) 2012–2014	Colectomy, 995 lap vs 9,023 open	↓ Mortality ↓ Complication

(Continued)

eTable 2. Continued

Condition, study author and year	Study design	Data source	Operation and indication/sample size	Laparoscopic (vs open) results*
Keller, 2016[78]	OS	National US population (Premier Perspectives) 2008−2011	Colectomy, 945 lap vs 21,774 open	↓ LOS ↓ Complication
Schlussel, 2016[80]	OS	National US population (National Inpatient Sample) 2008−2011	Transverse and total abdominal colectomy, 818 lap vs 6,443 open	↓ LOS ↓ Mortality ↓ Cost
Ballian, 2012[75]	OS	National US population (ACS NSQIP) 2005−208	Colectomy, 341 lap vs 3,211 open	↓ LOS ↑ Operative time
Catani, 2011[76]	OS	Single institution (Italy) 2007−2009	Colectomy, 32 lap vs 61 open	↓ LOS ↓ Complication
Li, 2009[79]	OS	Single institution (Hong Kong) 2001−2006	Right colectomy for cecal diverticulitis, 6 lap vs 12 open	↓ Time to functional recovery
Dunker, 2000[77]	OS	Two institutions (Netherlands) 1996−1999	Colectomy for inflammatory bowel disease (severe acute colitis), 10 lap vs 32 open	↓ LOS ↑ Operative time
SBO				
Hackenberg, 2017[88†]	OS	Single institution (Finland) 2010−2012	Adhesiolysis for SBO 25 lap vs 67 open (25 PS-matched)	↓ LOS No difference in severe complication
Sharma, 2015[89]	OS	National US population (ACS NSQIP) 2006-2011	Bowel resection for SBO 51 lap vs 1,699 open	↓ LOS ↓ Complication No difference in operative time and mortality
Yau, 2005[90]	OS	Single institution (Hong Kong) 1998−2003	Surgical management for bezoar-induced SBO 10 lap vs 14 open	↓ LOS ↓ Complication ↓ Operative time
Hernia				
Andresen, 2014[91]	OS	National Danish population (Danish Hernia Database) 1998−2012	Primary femoral hernia repair Emergency (57 lap vs 1500 open); elective (454 lap vs 1,959 open)	↓ Reoperation
Emergency laparotomy				
Pucher, 2018[96]	OS	National English population (National Emergency Laparotomy Audit) 2014−2016	Laparotomy for acute abdominal pathology 228 lap vs 520 open	↓ ICU LOS ↓ Mortality

*All results are statistically significant, except those stated as "no difference."
†Emergency status not specified, but implied, given the nature of disease and operation.
‡Study dates not specified in manuscript, but article received for publication in 2012.
§Although SR inclusion criteria allowed both elective and emergent cases, the 3 RCTs were on elective sigmoidectomies.
ACS, American College of Surgeons; lap, laparoscopic; LOS, length of stay; MA, meta-analysis; OS, observational study; RCT, randomized controlled trial; SR, systematic review, SBO, small bowel obstruction.



eFigure 1. Example (routine nasogastric tube placement) preferred reporting items for systematic reviews and meta-analyses flow diagram for pathway.