COLLECTIVE REVIEW

Surgical Technical Evidence Review for Colorectal Surgery Conducted for the AHRQ Safety Program for Improving Surgical Care and Recovery

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Enhanced recovery has sparked excitement in the surgical community primarily because it works, but also because it is an innovative approach to delivering standardized, evidence-based care. Adoption of enhanced recovery pathways (ERPs) has been associated with reducing surgical complications, improving patient experience, and decreasing length of stay (LOS) and associated hospital costs without increasing readmission rates.[1-3] To successfully implement ERPs and achieve improvements, the entire perioperative team must function as a coordinated and collaborative group, breaking down silos among preoperative, operating room, recovery room, and inpatient units, and creating a transdisciplinary collaboration across perioperative disciplines (eg surgery, anesthesiology, nursing, pharmacy, physical therapy, and others).

The AHRQ, in partnership with the American College of Surgeons and the Armstrong Institute for Patient Safety and Quality at Johns Hopkins University, has developed the Safety Program for Improving Surgical Care and Recovery (ISCR), which is a national effort to disseminate best practices in perioperative care to more than 750 hospitals across multiple procedure areas during the next 5 years. The program will integrate evidence-based processes central to enhanced recovery, as well as surgical site infection (SSI), venous thromboembolic events (VTEs), and catheter-associated urinary tract infections (CAUTIs), with socioadaptive interventions to meaningfully improve surgical outcomes, patient experience, and perioperative safety culture. Evidence-based clinical pathways will serve as the foundation for these efforts. To assist hospitals with transforming their perioperative care, the ISCR program will also include a registry for hospitals to track their progress in adhering to the clinical pathway and for benchmarking, patient engagement and education materials, change management and leadership training, as well as tools to facilitate local pathway adaptation, implementation, and program sustainability.

The objective of this article is to provide a comprehensive review of the evidence supporting the surgical components of the ISCR colorectal (CR) pathway. The anesthesiology components were reviewed in parallel and are being reported separately. This review will evaluate the evidence supporting CR pathways and develop an evidence-based CR protocol to help hospitals participating in the ISCR program implement evidence-based practices.

METHODS

A review protocol was developed with input from stakeholders (eDocument 1). Two researchers reviewed current CR ERPs from several major US health systems and sought expert feedback to identify individual components for the CR ISCR protocol in each perioperative phase of care (preoperative through postoperative) (Table 1).

Individual literature reviews for each protocol component were performed using PubMed for English-language articles published before December 2016. Specific search terms are provided in eTable 1. First, each search targeted CR operations, and if no literature on CR operations was identified, the search was broadened to surgical procedures in general. To be included, studies had to report on the

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Abbreviations and Acronyms

CAUTI = catheter-associated urinary tract infection
CR = colorectal
ERP = enhanced recovery pathway
ISCR = Improving Surgical Care and Recovery
LOS = length of stay
MA = meta-analysis
MBP = mechanical bowel preparation
NGT = nasogastric tube
PO = per os
POD = postoperative day
RCT = randomized controlled trial
SR = systematic review
SSI = surgical site infection
VTE = venous thromboembolic event

specific protocol components. Studies were excluded if they did not report clinical outcomes, included fewer than 10 patients, were non-English language, or were nonsystematic reviews.

Given the large amount of evidence within this field, we used a hierarchical method of inclusion based on study design. If we identified a well-designed systematic review (SR) or meta-analysis (MA), then we included it along with additional randomized controlled trials (RCTs) or observational studies published after the SR/MA, when possible. Data extraction was completed, including sample size, surgical procedure category, comparator (varied by component), and main outcomes of interest (varied by component). Results are described narratively.

Table 1. Colorectal Protocol for the AHRQ Safety Program for Improving Surgical Care and Recovery: Surgical Components

Component
Preoperative
Patient education
Immediate preoperative
Bowel preparation
Preoperative at-home bathing
Preoperative VTE chemoprophylaxis
Intraoperative
Skin preparation
Surgical technique (laparoscopic vs open)
Minimize drains
Postoperative
Early mobilization
Early alimentation
Early urinary bladder catheter removal
Early IV fluid discontinuation
Postoperative VTE prophylaxis
Glucose management

VTE, venous thromboembolic event.

RESULTS

Preoperative

Patient education

Rationale. Detailed preoperative patient education is theorized to set expectations for the patient about the operation, which in turn allows the patient to become a partner in their recovery.

Evidence. No randomized or observational studies of CR operations have isolated the effect of detailed patient education on outcomes. Two MAs including 11 RCTs evaluated the effect of ERP implementation on outcomes and included patient education as a component of ERPs.[1,2] Both MAs concluded that ERP implementation was associated with a reduction in morbidity and LOS.[1,2] No studies in CR operations have evaluated the optimal medium for education materials. Options used in the RCTs included verbal information provided by the provider, information booklets, and informational videos.

Summary. There is no direct evidence to support patient education as a component of the CR ISCR protocol, however, patient education is recommended, as it can only be beneficial and is endorsed by guidelines (Tables 2 and 3).

Immediate preoperative

Bowel preparation

Rationale. The use of bowel preparations (mechanical alone, per os [PO] antibiotics alone, or a combination of both) has been proposed to reduce the risk of SSI after CR operation, but can also cause physiologic derangements leading to prolonged recovery.

Evidence. We identified 5 MAs of bowel preparation for CR operations, including one of combined mechanical and PO antibiotic bowel preparation vs mechanical bowel preparation (MBP) alone or vs IV antibiotics alone.[13-17] This study of 7 RCTs found that patients who received combined PO antibiotic and MBP had lower total SSI and incisional SSI compared with patients who received MBP and systemic antibiotics alone (total: 7.2% vs 16.0%, $p < 0.001$; incisional: 4.6% vs 12.1%, $p < 0.001$).[17] Three MAs of MBP alone vs no MBP showed neither benefit nor harm to the use of MBP with regard to anastomotic leak, SSI, reoperation, or mortality.[14-16] One MA of RCTs found that SSI was lower without MBP, although the number needed to harm was high at 333 patients.[13]

Table 2. Summary of Improving Surgical Care and Recovery Colorectal Protocol Components, Associated Outcomes, and Support from the Literature and/or Guidelines

Intervention	Outcomes	Studies	Population	Evidence	Guidelines
Preoperative					
Patient education	↓LOS; ↓complications	2 MAs (indirect evidence)	CR operation	+*	√†
Immediate preoperative					
Bowel preparation (PO antibiotic and MBP)	↓SSI	1 MA	CR operation	+‡	√§
Preoperative at-home bathing	↓SSI	1 MA, 1 SR	All operations	−‖	√§
Preoperative VTE prophylaxis	↓VTE		CR operation	±¶	√†
Intraoperative					
Skin preparation	↓SSI	2 MAs	Clean and clean-contaminated operations	+‡	√†
Laparoscopic surgical technique	↓LOS; ↓complications; faster return of bowel function	4 MAs	CR operation	+‡	√†
Minimization of tubes/drains	- Anastomotic dehiscence; - SSI; - reoperation; - mortality	4 MAs, 1 SR	CR operation	+‡	√†
Postoperative					
Early mobilization	↓/- LOS; ±faster return of bowel function	1 SR	Abdominal operation	±¶	√†
Early alimentation	↓LOS; ↓complications; -/↓mortality	4 MAs, 1 SR	Abdominal operation	+‡	√†
Early urinary bladder catheter removal	↓UTI	2 MAs, 1 SR	CR operation	+‡	√†
Early IV fluid discontinuation	↓LOS; ↓complications	1 MA	Abdominal and CR operation	+‡	√†
Postoperative VTE prophylaxis	↓VTE	1 MA	All and CR operation	+‡	√†
Glucose management	↓SSI	1 MA	All and CR operation	+‡	√†

*Designates a component where evidence was indirect, but supported given practice.
†Designates a component where all guidelines supported a given practice.
‡Designates a component where all evidence supported a given practice.
§Designates a component where some, but not all, guidelines supported a given practice.
‖Designates a component where evidence showed no effect of a given practice.
¶Designates a component where evidence was mixed (some showing benefit, some showing no effect) for a given practice.
CR, colorectal; LOS, length of stay; MA, meta-analysis; SR, systematic review; SSI, surgical site infection; UTI, urinary tract infection; VTE, venous thromboembolism.

Summary. Despite the possibility that combined bowel preparations cause physiologic derangements in the preoperative period, combined PO antibiotic and MBP is recommended in the ISCR protocol because of the evidence that this practice decreases SSI (Table 2).

Preoperative at-home bathing

Rationale. Preoperative at-home bathing has been proposed to decrease both skin surface pathogen counts and SSIs after CR operations.

Evidence. We identified 1 MA and 1 SR of studies evaluating the effect of preoperative antiseptic bathing vs non-antiseptic bathing or no bathing in all operations.[18,19] The MA included 8 RCTs and 8 quasi-experimental studies and concluded that there was no difference in SSIs among any of the intervention arms (antiseptic bathing with chlorhexidine, non-antiseptic bathing, no bathing).[18] Similarly, the SR concluded that there was no difference in SSI rates between antiseptic vs non-antiseptic preoperative showering.[19] Both reviews noted that many included studies had suboptimal rates of patient compliance with recommended bathing protocols.[18,19]

Summary. RCTs and quasi-experimental studies have not shown that routine preoperative at-home

Table 3. Summary of Guidelines Supporting Improving Surgical Care and Recovery Protocol Components

Intervention	Guideline	Year	Recommendation
Preoperative			
Patient education	ERAS Society[4]	2013	Routine preoperative patient education recommended, as it can only be beneficial.
Immediate preoperative			
Bowel preparation (PO antibiotic and MBP)	ACS/SIS SSI Guidelines[5]	2016	Combination mechanical and PO antibiotic bowel preparation recommended for elective colorectal operation.
	ERAS Society[4]	2013	Recommends against routine use of mechanical bowel preparation alone.
	SHEA/IDSA Practice Recommendation[6]	2013	Mechanical bowel preparation alone is not recommended. Reduction in SSIs has been shown with combined mechanical and PO antibiotic bowel preparation.
Preoperative at-home bathing	ACS/SIS SSI Guidelines[5]	2016	Chlorhexidine bathing reduces skin surface pathogen counts, but has not been shown to reduce SSIs.
	HICPAC*	Update pending	Bathing with soap or an antiseptic agent is recommended the night before the operative day.
Preoperative VTE prophylaxis	American College of Chest Physicians[7]	2012	Preoperative administration of VTE chemoprophylaxis is recommended.
	American Society of Clinical Oncology[8]	2013	VTE chemoprophylaxis with low-dose unfractionated heparin or LMWH is recommended for patients undergoing major cancer operation beginning preoperatively and continuing until PODs 7 to 10.
	European Society of Medical Oncology[9]	2011	Postoperative VTE prophylaxis options include compression stockings and chemoprophylaxis with low-dose unfractionated heparin and LMWH.
Intraoperative			
Skin preparation	ACS/SIS SSI Guidelines[5]	2016	Preparation with an alcohol-containing agent is recommended. No 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.
	ERAS Society[4]	2013	Chlorhexidine-alcohol is recommended over iodine alone for skin preparation.
	SHEA/IDSA Practice Recommendation[6]	2013	Skin preparation with an alcohol-containing agent is recommended unless contraindications exist.
Laparoscopic surgical technique	ERAS Society[4]	2013	Laparoscopic operation is recommended if the expertise is available.
Minimization of tubes/drains	ERAS Society[4]	2013	Routine postoperative nasogastric drainage and abdominal drainage are not recommended.
Postoperative			
Early mobilization	ERAS Society[4]	2013	Prompt postoperative mobilization is recommended, as prolonged bed rest has been shown to be harmful.
Early alimentation	ERAS Society[4]	2013	Patients should be encouraged to take normal food as soon as possible after operation.
Early urinary bladder catheter removal	ERAS Society[4]	2013	Urinary catheter removal is recommended between PODs 1 and 2, even in the presence of a thoracic epidural.
	HICPAC[10]	2009	Urinary catheter removal within 24 hours of operation is recommended.

(Continued)

Table 3. Continued

Intervention	Guideline	Year	Recommendation
Early IV fluid discontinuation	ERAS Society[4]	2013	Early initiation of PO fluid intake is recommended, as is early discontinuation of IV fluids if patient is tolerating PO.
Postoperative VTE prophylaxis	ASCRS Guidelines[11]	2006	Chemical thromboprophylaxis is recommended for all patients undergoing CR operation, and addition of mechanical thromboprophylaxis is recommended in high-risk patients. Patients with cancer should receive post-hospital prophylaxis with LMWH.
	ERAS Society[4]	2013	Combined chemical and mechanical thromboprophylaxis is recommended for all patients. Extended chemical prophylaxis for 28 days is recommended for patients with cancer.
	NICE Guidelines[12]	2010	At-risk patients should receive combined mechanical and chemical thromboprophylaxis.
Glucose management	ACS/SIS SSI Guidelines[5]	2016	Blood glucose between 110 and 150 mg/dL is recommended for all patients regardless of diabetic status to reduce SSI.
	ERAS Society[4]	2013	Hyperglycemia increases the risk of SSI and should be avoided.

*Personal communication with Dr Bratzler, January 2017.
ACS, American College of Surgeons; ASCRS, American Society of Colon and Rectal Surgeons; ERAS, Enhanced Recovery After Surgery; HICPAC, Healthcare Infection Control Practices Advisory Committee; IDSA, Infectious Diseases Society of America; LMWH, low-molecular-weight heparin; MBP, mechanical bowel preparation; NICE, National Institute for Health and Care Excellence; SIS, Surgical Infection Society; SHEA, Society for Healthcare Epidemiology of America; VTE, venous thromboembolism.

bathing/showering with chlorhexidine reduces SSIs, however, routine preoperative bathing with an antiseptic or non-antiseptic agent is supported by current guidelines and recommended in the ISCR protocol (Tables 2 and 3).

Preoperative venous thromboembolic event prophylaxis

Rationale. Preoperative VTE chemoprophylaxis (vs postoperative alone) can reduce VTEs in the perioperative period.

Evidence. We identified 1 RCT and 1 large observational study of preoperative VTE chemoprophylaxis vs postoperative VTE chemoprophylaxis alone. The RCT included patients undergoing CR operations and failed to show a decrease in early postoperative VTEs, 30-day VTEs, or mortality with the administration of preoperative chemical VTE prophylaxis.[20] The observational study, in contrast, showed that in patients undergoing a major operation, preoperative chemoprophylaxis lowered rates of deep venous thrombosis (1.3% vs 0.2%; 95% CI 0.7% to 1.4%) and pulmonary embolism (1.0% vs 0.4%; 95% CI 0.2% to 1%). Neither study demonstrated increased bleeding risk with the administration of preoperative VTE chemoprophylaxis.[20,21]

Summary. There is mixed evidence that preoperative VTE chemoprophylaxis should be given for CR operations to reduce VTEs (Table 2). This practice is supported by multiple society guidelines (Table 3) and is recommended in the ISCR protocol.

Intraoperative

Skin preparation

Rationale. Skin preparation before operation with antiseptic agents is thought to decrease SSIs.

Evidence. We identified 2 MAs evaluating the efficacy of various antiseptic agents in preventing SSIs after clean or clean and clean-contaminated operations.[22,23] One MA included 4 RCTs and concluded that chlorhexidine + alcohol significantly reduced the risk of SSIs compared with aqueous iodine.[22] The second MA included 10 RCTs and concluded that chlorhexidine + alcohol was likely the most effective treatment (compared with iodophor + alcohol), but acknowledged that all effect estimates were judged to be low or very low quality.[23]

Summary. Evidence from 2 MAs supports the use of chlorhexidine + alcohol over iodine alone, and showed little difference between chlorhexidine + alcohol and iodine + alcohol for skin preparation before operation (Table 2).

Surgical technique

Rationale. Minimally invasive (laparoscopic) surgical technique is believed to decrease postoperative pain, speed recovery, and shorten LOS.

Evidence. We identified 4 MAs comparing laparoscopic with open surgical approach for CR operations within the setting of ERPs.[24-27] We did not query studies of robotic vs open technique. The most recent MA included 4 RCTs and 6 clinical controlled trials and concluded that the laparoscopic surgical approach was associated with shorter LOS (weighted mean difference −1.65 days; $p < 0.001$), shorter time to return of bowel function, decreased postoperative complications, decreased readmissions, and decreased mortality.[24] Additional MAs found similar benefits to laparoscopic operation for LOS and complications, but some failed to show reduced readmission or mortality.[25-27]

Summary. Evidence from 4 MAs concludes that the laparoscopic approach (vs open) is associated with improved outcomes in the setting of ERPs. If surgeon expertise is available and there are no patient contraindications, a laparoscopic surgical approach is recommended (Table 2) in the ISCR protocol.

Minimize drains and tubes

Rationale. Minimization of drains (intraperitoneal abdominal and nasogastric tubes [NGTs) after CR operation has been promoted to speed recovery without increasing complications.

Evidence. We identified 4 MAs and 1 SR in CR operations of outcomes with vs without drains/NGTs.[28-32] Three MAs including RCTs of CR patients with both peritoneal and pelvic drains failed to show a statistically significant difference in anastomotic dehiscence, SSIs, reoperation, or mortality with drain use.[29,30,32] In contrast, 1 MA (3 RCTs and 5 non-RCTs) of pelvic drains concluded that drain use was associated with a decreased risk of anastomotic dehiscence, however, MA of the RCTs alone revealed no difference.[28]

We found 1 MA of 7 RCTs of prophylactic NGT use after CR operation, which concluded that NGT use was associated with higher rates of respiratory complications and more pharyngolargyngitis.[31] Although the MA demonstrated that NGT use was associated with less vomiting and less frequent NGT replacement, there was no difference in LOS or return of bowel function with routine prophylactic NGT use.[31]

Summary. Evidence from 3 MAs supports avoidance of routine peritoneal drainage, but there might be a role for prophylactic drainage for patients with a pelvic anastomosis (Table 2). Evidence from 1 MA fails to support a significant clinical benefit from routine NGT use (Table 2).

Postoperative

Early mobilization

Rationale. Early mobilization has been proposed to reduce LOS and complications like VTEs and ileus.

Evidence. We identified 1 SR including 3 RCTs and 1 observational study of patients undergoing abdominal operation evaluating the effect of early mobilization protocols.[33] Most early mobilization protocols entailed supervised, mandatory exercises performed at 12 to 24 hours postoperative vs delayed ambulation or activity totally at the patient's discretion.[33] No studies showed a difference in overall complications. In early mobilization cohorts, 1 study demonstrated shorter LOS and 1 study showed improved gastrointestinal function.[33] The authors concluded that, overall, study methodology was poor and there was no evidence to support any specific early mobilization protocol; however, they concluded that bed rest might be harmful.[33]

Summary. Evidence from 1 SR did not support any specific postoperative mobilization protocol, but there is evidence that prolonged bed rest is harmful (Table 2). Based on expert consensus, it is recommended in the ISCR protocol that patients be mobilized (out of bed to a chair) at least once on postoperative day (POD) 0 and ambulate twice a day on POD 1 and thereafter.

Early alimentation

Rationale. Early postoperative alimentation is proposed to speed gastrointestinal recovery after CR operation and contribute to shorter LOS without increasing complications.

Evidence. We found 4 MAs and 1 SR comparing outcomes after early vs traditional feeding after abdominal operation.[34-38] The MA of patients undergoing elective CR operation included 7 RCTs and found that early feeding was associated with reduced LOS, reduced complications, and no difference in anastomotic dehiscence, SSI, emesis, NGT reinsertion, or mortality.[37] Two additional MAs in gastrointestinal operations reported mixed results, with 1 supporting reduced complications, and the other supporting decreased mortality, but no additional clinical benefit.[34,36] Of note, early feeding was defined differently in each RCT, but typically entailed introduction of a diet within 24 hours.

Summary. Early postoperative alimentation is recommended in the ISCR protocol as RCTs support an association with reduced LOS and reduced complications (Table 2).

Early urinary bladder catheter removal

Rationale. Presence of a urinary bladder catheter is a risk factor for UTI, and one strategy for reducing CAUTI is prompt removal or avoiding their use. Early removal for mid- to low-rectal operation can be associated with urinary retention.

Evidence. We found 2 MAs, 1 retrospective cohort study, and an SR in rectal operations on interventions to reduce duration of catheter use.[39-42] Both MAs demonstrated that interventions to reduce the use or duration of urinary bladder catheters reduce rates of CAUTI, with the best evidence supporting "stop orders" in the electronic health record (CAUTI rates reduced by 53%; $p < 0.001$).[39,40] In the setting of CR ERPs, the cohort study showed that early catheter discontinuation was associated with decreased LOS, although, early catheter discontinuation was defined differently for colon (24 hours) vs rectal procedures (72 hours).[41] The SR (RCTs and observational studies) gave special consideration to urinary catheter management in patients undergoing rectal resections, where early catheter removal (POD 1 vs POD 5) decreased UTIs (20% vs 42%) at the cost of increased urinary retention (31% vs 10%).[42] Overall, the SR author concluded that in patients undergoing mid- to low rectal resection, evidence supported consideration of catheterization through PODs 3 to 5 due to the increased incidence of urinary retention in this population.[42]

Summary. Evidence from 2 MAs, 1 SR, and 1 retrospective observational cohort study supports routine early urinary bladder catheter removal for colon or upper rectal operations (Table 2). For mid to low rectal operations, evidence from 2 RCTs summarized in an SR supports consideration of routine drainage through PODs 3 to 5 based on the higher risk of urinary retention.

Early IV fluid discontinuation

Rationale. Early postoperative discontinuation of IV fluid in patients who are euvolemic and tolerating enteral intake is thought to speed return of bowel function and minimize postoperative complications.

Evidence. There is no literature isolating the effect of early IV fluid discontinuation after abdominal or CR operations. We identified 1 MA of 9 RCTs comparing standard, restrictive, and liberal fluid administration in the perioperative period after major elective open abdominal operation.[43] The authors opted to compare "balanced" vs "imbalanced" fluid administration, with balanced defined as between 1.75 and 2.75 L of crystalloid/d, and imbalanced as any volume of crystalloid less than or greater than this amount.[43] Patients who received balanced fluid administration had fewer complications (relative risk 0.59; 95% CI 0.44 to 0.81) and shorter LOS (weighted mean difference −3.44; 95% CI −6.33 to −0.54).[43]

Summary. Evidence from RCTs supports balanced fluid administration in the perioperative period (Table 2). Based on expert consensus, it is recommended in the ISCR protocol that maintenance IV fluid be discontinued on POD 1 unless the patient has difficulty taking PO and/or evidence of kidney injury.

Postoperative venous thromboembolic event prophylaxis

Rationale. Timely administration of VTE chemoprophylaxis is thought to reduce VTEs. Extended VTE chemoprophylaxis is thought to be beneficial for CR cancer patients, as they are at increased risk of VTEs.

Evidence. We identified 1 MA of RCTs comparing combined mechanical and chemoprophylaxis with either modality alone after any operation and 1 observational study evaluating the timing of VTE chemoprophylaxis and outcomes after CR operation.[44,45] The MA concluded that combination mechanical and chemical VTE prophylaxis was most effective in preventing VTEs.[44] The observational study concluded that patients who received VTE chemoprophylaxis within 24 hours after operation had lower mortality, clinical VTEs, and composite adverse events compared with patients who did not receive VTE chemoprophylaxis.[45]

Looking at the role of extended chemoprophylaxis in the cancer population, we identified 1 MA of RCTs and non-RCTs of prolonged VTE chemoprophylaxis (1 month after operation) compared with in-hospital VTE chemoprophylaxis alone in patients undergoing major abdominal operation.[46] Patients receiving prolonged VTE chemoprophylaxis were less likely to have a confirmed VTE (odds ratio 0.41; 95% CI 0.26 to 0.63) than those who received in-hospital VTE chemoprophylaxis alone.[46]

Summary. Evidence from RCTs supports the use of combined mechanical and chemoprophylaxis for the duration of hospitalization in all patients to prevent VTEs (Table 2). Extended VTE chemoprophylaxis until 28 days total is recommended for patients undergoing operations for CR cancer in the ISCR protocol. Multiple guidelines support these practices (Table 3).

Glucose management

Rationale. Blood glucose control in the perioperative period can decrease the risk of SSI.

Evidence. We identified 1 MA of 15 RCTs comparing intensive glucose management (<150 mg/dL) vs conventional glucose management (≤220 mg/dL), and 1 large observation study that examined blood glucose levels and SSIs in patients undergoing bariatric and CR operations.[47,48] The MA determined there was significant benefit to an intensive protocol, resulting in decreased odds of SSI (odds ratio 0.43; 95% CI 0.29 to 0.64), with no difference in stroke or mortality. One adverse end point associated with intensive glucose management was increased odds of hypoglycemia.[47] Of note, these results were consistent among patients with and without diabetes.[47] The retrospective study concluded that CR patients (both diabetic and non-diabetic) with perioperative hyperglycemia had increased odds of infection, reoperation, and mortality.[45] Additionally, there was a dose-response relationship between blood glucose control and SSIs.[45]

Summary. Perioperative blood glucose control is recommended for all patients in the ISCR protocol regardless of diabetic status to prevent SSIs (Table 2). Current guidelines recommended a target range of 110 to 150 mg/dL (Table 3).

DISCUSSION

The benefits of CR ERPs are well documented and include improved patient outcomes, reduced LOS, reduced morbidity, and no change in readmission rates. This report expands on guidelines endorsed by the Enhanced Recovery After Surgery Society and the American Society for Enhanced Recovery and includes additional best practices for preventable harms.[4,49] Protocol elements were supported in the literature, though the contribution of publication bias favoring the publication of positive findings cannot be discounted.

CONCLUSIONS

We identified 23 overall components (eTable 2) for the ISCR CR protocol, including the 12 surgical components in this review, supported by the literature, existing guidelines, and/or expert consensus that should be delivered consistently for optimal surgical care of the CR patient. Structural limitations at individual hospitals (eg formulary, hospital policy, and technical expertise) will require local adaptation of these recommendations for successful implementation. The ISCR CR protocol components span the preoperative, immediate preoperative, intraoperative, and postoperative phases of care and will require transdisciplinary collaboration among surgeons, anesthesia providers, nurses, hospital leadership, and patients. Hospitals participating in the AHRQ Safety Program for ISCR will be supported in expeditiously and sustainably translating this evidence base into practice during the next few years, with the goal of moving the needle on surgical outcomes in the US. Importantly, as we unite to improve patient care for this work, such collaborations will extend to other areas with anticipated improvement in clinical outcomes, patient experience, and workplace culture.

Author Contributions

Study conception and design: Ban, Gibbons, Ko, Wick
Acquisition of data: Ban
Analysis and interpretation of data: Ban, Gibbons, Ko, Wick
Drafting of manuscript: Ban
Critical revision: Ban, Gibbons, Ko, Wick

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eDocument 1.

GENERAL OVERVIEW

The goal of our evidence review is find the highest-level evidence for each component of the clinical pathways.

Steps

1. Protocol components

Identify the critical components of the Optimal Surgical Recovery protocol(s). These components will form the general foundation for the searches. Topics include: CR surgery, emergency general surgery, orthopaedic (hip/knee), gynecology (hysterectomy), and bariatric.

2. Search

For each component, perform a literature search that is procedure-specific. Search should be limited to English only. Keep track of the search terms. Initial searches can be for the specific component or for ERAS—this can vary by procedure so adjust as you see appropriate. We will also run our search terms by a librarian, as time permits. Also, you might need to search for broad surgical procedures. Examples of terms for ERAS: *fast track, enhanced recovery, clinical pathway, critical pathway, multimodal perioperative,* and *perioperative protocol*. (Do not limit searches by study design.)

3. Inclusion/exclusion terms and screening

Develop these terms for each protocol component—inclusion: specific procedure, perioperative period, component topic, reports outcomes, not case report, and sample size >10. Not necessary to track the reasons for exclusion at the title and abstract level.

For the full-text article screen, track reasons for includes and excludes. Includes: SR/MA, RCTs, prospective/case controlled observational studies, retrospective observational studies; excludes: not on the specific procedure, lack of postoperative outcomes, not primary data, and non-SR.

Hierarchy of the selecting includes:

First identify well-done recent SRs/MAs (within the past 5 years, if possible). If you have multiple SRs/MAs then pick the most recent or the better-quality ones. For example:

1. Was a specific question(s) defined that the SR/MA set out to answer? Yes
2. Provided inclusion/exclusion terms and the search terms? Yes
3. Did the studies they included make clinical sense to do so? Yes (this is often a fail)
4. They did not pool RCT and observation data together unless state a strong justification. Yes
5. Was a quality assessment of the studies performed? (does not really matter which tool). Yes

Of note, if there is a well-done SR/MA cross-reference with search results looking for additional studies—ones performed after the SR/MA or ones that simply were not included. Include RCTs and observational studies performed after the SR/MA.

If you use observational studies primarily (find none or just a few RCTs) then limit to the highest study design. For example, limit by sample size (n > 100)/matched cohort/multi-institutional. Need to keep track of any specific decisions that change the inclusion/exclusions at this point.

4. Data abstraction

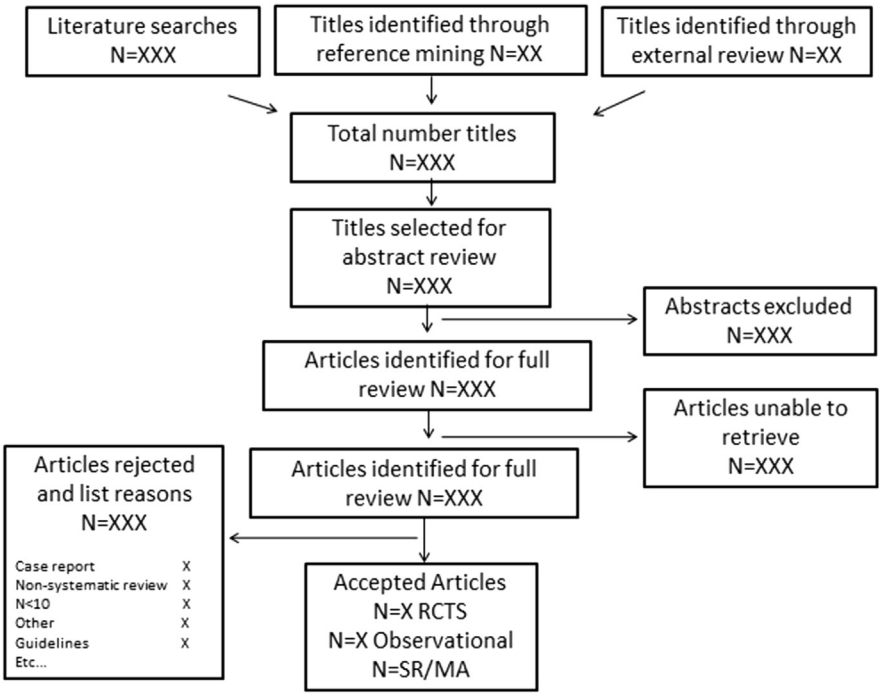
Evidence tables for randomized controlled trials. This can be done later, but it will be helpful to develop these and include article, author name and year of publication, study design, multi- or single institution, sample size (follow-up rate if relevant), surgical procedure(s), details of the component of interest, outcomes measured, and findings (follow-up time period for some outcomes).

Evidence tables for observational studies. Include author name and year of publication, study design, multi- or single institution, sample size (follow-up rate if relevant), surgical procedure(s), details of the component of interest, outcomes measured, and findings (follow-up time period for some outcomes).

5. Reference mining

Check the references of the better studies for articles that might have been missed. Then those identified from this step need to be screened.

Flow example:



eTable 1. Search Terms

Search terms
Preoperative
Patient education: *patient education*
Immediate preoperative
Bowel preparation: *bowel preparation*
Preoperative bathing (chlorhexidine): *preoperative bathing*
Reduced fasting: *fasting*
Intraoperative
Skin preparation: *skin preparation*, *surgical site infection*
Surgical technique: *surgical technique*
Minimize drains: *drain*, *nasogastric*
Postoperative
Early mobilization: *early mobilization*, *early ambulation*, *ambulation*, *mobilization*
Early alimentation: *early feeding*
Early urinary bladder catheter removal: *Foley avoidance*, *urinary catheter avoidance*, *urinary bladder catheter avoidance*, *intervention*, *catheter-associated urinary tract infection*, *urinary tract infection*
Early IV fluid discontinuation: *IV fluid discontinuation*, *intravenous fluid discontinuation*, *fluid therapy*
Postoperative VTE prophylaxis: *venous thromboembolism prophylaxis*, *VTE prophylaxis*, *thromboprophylaxis*
Glucose management: *glucose control surgical site infection*
General search terms: *surgery*, *colon*, *fast track*, *enhanced recovery*, *meta-analysis*, *meta*, *systematic review*, *randomized controlled trial*, *randomized trial*, *abdominal surgery*

VTE, venous thromboembolism.

eTable 2. AHRQ Safety Program for Improving Surgical Care and Recovery Colorectal Protocol

Preoperative
Patient education
Immediate preoperative
Mechanical and per os antibiotic bowel preparation
Preoperative (at home) bathing
Reduced fasting
Carbohydrate loading
Preoperative VTE chemoprophylaxis
Multimodal pre-anesthesia medication
μ-Opioid antagonists
Intraoperative
Antibiotic prophylaxis
Skin preparation
Surgical technique
Blood transfusion
Fluids/goal-directed fluid therapy
Normothermia
Minimization of drains/nasogastric tube
Standard intraoperative anesthesia pathway
Postoperative
Early mobilization
Early alimentation
Early urinary bladder catheter removal
Early discontinuation of maintenance In vitro fertilization
Postoperative VTE chemoprophylaxis
Glucose management
Standard postoperative multimodal analgesic regimen

VTE, venous thromboembolism.