REVIEW ARTICLE

Consensus Review of Optimal Perioperative Care in Colorectal Surgery

Enhanced Recovery After Surgery (ERAS) Group Recommendations

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Objectives: To describe a consensus review of optimal perioperative care in colorectal surgery and to provide consensus recommendations for each item of an evidence-based protocol for optimal perioperative care.

Data Sources: For every item of the perioperative treatment pathway, available English-language literature has been examined.

Study Selection: Particular attention was paid to meta-analyses, randomized controlled trials, and systematic reviews.

Data Extraction: A consensus recommendation for each protocol item was reached after critical appraisal of the literature by the group.

Data Synthesis: For most protocol items, recommendations are based on good-quality trials or meta-analyses of such trials.

Conclusions: The Enhanced Recovery After Surgery (ERAS) Group presents a comprehensive evidence-based consensus review of perioperative care for colorectal surgery. It is based on the evidence available for each element of the multimodal perioperative care pathway.

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FAST-TRACK OR ENHANCED-recovery programs integrate a range of perioperative interventions proven to maintain physiological function and facilitate postoperative recovery, especially after elective colonic resections in dedicated centers.[1-4] The Enhanced Recovery After Surgery (ERAS) Group has achieved similar results in general surgical departments using an evidence-based care platform.[5,6]

We present an updated and expanded consensus review of perioperative care for colorectal surgery based on the evidence available for each element of the multimodal pathway.

METHODS

The MEDLINE database was searched up to December 31, 2007 (3 exceptions were made: 2 meta-analyses and an editorial published in 2008), and the ERAS protocol[6] from 2005 was updated. Recommendations were evaluated according to the system developed by the Centre for Evidence Based Medicine, Oxford, England.[7] Those based on at least 2 good-quality randomized controlled trials (RCTs) (in patients undergoing gastrointestinal surgery) or 1 meta-analysis of RCTs with homogeneity were designated as grade A. Other recommendations were designated as consensus recommendations based on the best available evidence. The evidence is presented in the text and the recommendations are summarized in the **Table**.

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RESULTS

PREADMISSION INFORMATION AND COUNSELING

Explicit preoperative information can facilitate postoperative recovery and pain control, particularly in patients exhibiting denial and anxiety.[8,9] A clear explanation of expectations during hospitalization facilitates adherence to the care pathway and allows early recovery and discharge.[10,11] At this first encounter, the patient should also be given a clear role with specific tasks, including targets for postoperative food intake, oral nutritional supplements, and mobilization.[12,13]

PREOPERATIVE BOWEL PREPARATION

Mechanical bowel preparation can cause dehydration and fluid and electrolyte abnor-

Table. Consensus Guidelines

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

malities, particularly in elderly patients.[14] Two recent large, multicenter RCTs[15,16] confirm the conclusions of earlier meta-analyses[17-19] that bowel preparation is not beneficial in elective colonic surgery, and 2 smaller recent RCTs suggest that it increases the risk for anastomotic leak.[20,21] Bucher et al[20] included only left-sided colonic resections and demonstrated increased morbidity after routine bowel cleansing. Bowel preparation may be necessary in selected patients who require intraoperative colonoscopy. For colonic surgery, data indicate that bowel preparation is stressful and prolongs postoperative ileus.[22]

A 2005 Cochrane analysis[23] included 231 low anterior resections without finding an increased leak rate in those without bowel preparation. A recent RCT that included a substantial proportion of ultralow rectal anastomoses[24] reported that bowel preparation protects against anastomotic leaks requiring reoperations. There was, however, increased cardiovascular mortality in the group receiving bowel preparation. Further trials are needed to establish the optimal routine for very low rectal resections. Nevertheless, logic dictates that the bowel distal to the stoma should be cleansed if

a diverting stoma is constructed to protect the anastomosis.

PREOPERATIVE FASTING AND PREOPERATIVE CARBOHYDRATE LOADING

Although fasting from midnight has been standard practice to avoid pulmonary aspiration in elective surgery, a review has found no evidence to support this.[25] Equally, a Cochrane review[26] of 22 RCTs in adult patients provides robust evidence that reducing the preoperative fasting period for clear fluids to 2 hours does not increase complications. National Anaesthesia Societies now recommend intake of clear fluids until 2 hours before induction of anesthesia as well as a 6-hour fast for solid food.[27-30] Obese and even morbidly obese patients have the same gastric emptying characteristics as lean patients.[31,32] Diabetic patients with neuropathy may have delayed gastric emptying, possibly increasing the risk of regurgitation and aspiration.[33] Patients with uncomplicated type 2 diabetes mellitus can have normal gastric emptying, and a study of preoperative carbohydrate loading did not find increased aspiration rates in such patients.[34]

Having patients undergo surgery in a metabolically fed state can be achieved by provision of a clear carbohydrate-rich beverage before midnight and 2 to 3 hours before surgery. This reduces preoperative thirst, hunger, and anxiety[26,35] and postoperative insulin resistance.[36] Patients in a more anabolic state have less postoperative nitrogen and protein losses[37,38] as well as better-maintained lean body mass[39] and muscle strength.[40] Data from RCTs indicate accelerated recovery and shorter hospital stay in patients receiving preoperative carbohydrate loading in colorectal surgery.[41,42]

PREANESTHETIC MEDICATION

Adverse effects from long-acting premedication such as opioids, long-acting sedatives, and hypnotics hamper recovery (eg, immediate ability to drink and mobilization after surgery), leading to prolonged length of stay.[43] Short-acting anxiolytics do not prolong recovery or length of stay.[44]

PROPHYLAXIS AGAINST THROMBOEMBOLISM

Meta-analyses have shown subcutaneous low-dose unfractionated heparin regimens to be effective in reducing deep vein thrombosis, pulmonary embolism, and mortality in patients undergoing colorectal surgery.[45-48] Meta-analyses comparing low-molecular-weight heparin (LMWH) with unfractionated heparin have shown no difference in efficacy[47,48] or associated bleeding risks.[49,50] The LMWH is preferable because of its once-daily dosage and a lower risk of heparin-induced thrombocytopenia.[50-52]

Although antiplatelet drugs and intravenous dextran are less effective for prophylaxis of deep vein thrombosis and in reducing mortality, they can be as effective for the prevention of pulmonary embolism.[48,53] Their adverse effect profiles[53,54] make them advisable only in high-risk patients when LMWH and unfractionated heparin are contraindicated.

The safety of continuing LMWH and continuous epidural analgesia is debatable. In the United States, higher doses of LMWH are used twice daily and may account for the greater numbers of epidural hematomas reported.[55] Prophylactic doses of LMWH should be given no later than 12 hours prior to insertion and removal of an epidural catheter.[56,57] Although concomitant use of nonsteroidal anti-inflammatory drugs and LMWH is considered safe, a potential link with epidural hematoma is debated. Care should be taken with other factors affecting coagulation, and alternative thromboprophylaxis (such as thromboembolism-deterrent stockings) should be used when appropriate.

ANTIMICROBIAL PROPHYLAXIS

The use of prophylactic antibiotics effective against both aerobes and anaerobes can minimize infectious complications in colorectal surgery,[58] with the first dose being administered about 1 hour prior to skin incision.[59] A single dose is as effective as multidose regimens, but further doses should be given in prolonged cases (>3 hours).[58] The optimal combination of antibiotics is not established, but a second-generation cephalosporin and metronidazole are suggested. New generations of antibiotics should be reserved for infectious complications.

STANDARD ANESTHETIC PROTOCOL

There is no evidence to direct the choice of the optimal anesthetic method for colorectal procedures. However, it is rational to use short-acting agents (propofol, remifentanil hydrochloride)[60] instead of long-acting intravenous opioids (morphine sulfate, morphine hydrochloride, fentanyl citrate), thereby allowing proactive recovery to start soon after surgery. Short-acting inhalational anesthesia is a reasonable alternative to total intravenous anesthesia. There is no evidence that intraoperative epidural analgesia improves postoperative outcome in colorectal procedures, but its use reduces the dose of general anesthetic agents. For colonic surgery, the epidural catheter is best placed at the midthoracic level (T7/8) to achieve both analgesia and sympathetic blockade, preventing gut paralysis.[61] If activated before commencement of surgery, it blocks stress hormone release and attenuates postoperative insulin resistance.[62] The catheter is inserted in the awake patient to avoid neurological complications. Intraoperatively, the block can be maintained by continuous infusion of local anesthetic (eg, bupivacaine hydrochloride, 0.1%-0.25%, or ropivacaine hydrochloride, 0.2%) plus a low-dose opiate (eg, 2.0-μg/mL fentanyl citrate or 0.5- to 1.0-μg/mL sufentanil citrate) at 4 to 10 mL/h. Epidural opioids in small doses act synergistically with epidural local anesthetics in providing analgesia,[63] without major systemic effects.[64-66] Addition of epinephrine (1.5- to 2.0-μg/mL) to the thoracic epidural infusion improves analgesia.[67-69]

PREVENTING AND TREATING POSTOPERATIVE NAUSEA AND VOMITING

Patient experience suggests that postoperative nausea and vomiting can be more stressful than pain.[70-73] Risk fac-

tors include being female and having nonsmoking status, history of motion sickness (or postoperative nausea and vomiting), and postoperative administration of opioids.[74,75] Individuals at moderate risk (2 factors) should receive prophylaxis with dexamethasone sodium phosphate at induction or serotonin receptor antagonist at the end of surgery.[76] High-risk individuals (3 factors) should receive general anesthesia with propofol and remifentanil as well as 4 to 8 mg of dexamethasone sodium phosphate at the beginning of surgery, supplemented with serotonin receptor antagonists or droperidol[76] or with 25 to 50 mg of metoclopramide hydrochloride 30 to 60 minutes before the end of surgery.[77]

LAPAROSCOPY-ASSISTED SURGERY

The most recent meta-analysis[78] confirms that significant improvements in short-term outcomes are achievable by laparoscopy-assisted colonic resection as a single intervention. This was associated with significant reductions in short-term wound morbidity, time to first bowel movement, and discharge from the hospital.

The potential of combining laparoscopy and enhanced-recovery care has been evaluated in only 2 small trials randomizing patients to either laparoscopy-assisted or open surgery within an established enhanced-recovery protocol.[79,80] In the setting of a long-established and efficient enhanced-recovery protocol, no further improvement in short-term outcome was seen by adding laparoscopy (median postoperative length of stay of 2 days in both groups).[79] The second study had longer hospitalizations, and here a reduction in postoperative stay was seen in the laparoscopy-assisted group as compared with the group undergoing open surgery (3.5 vs 6 days, respectively).[80] Further investigation will hopefully more clearly evaluate the full potential of combining laparoscopy and enhanced-recovery care.[81]

SURGICAL INCISIONS

Some RCTs suggest that transverse or curved incisions cause less pain and pulmonary dysfunction than vertical incisions following abdominal procedures,[82,83] while others have found no advantage of transverse incisions.[84,85] A recent Cochrane review[86] of RCTs comparing midline with transverse incisions for abdominal surgery confirms that although analgesic use and pulmonary compromise may be reduced with transverse or oblique incisions, complication rates and recovery times are the same as with midline incisions. Hence, while incision length affects patient recovery,[87] the choice of incision for abdominal surgery still remains the preference of the surgeon.

NASOGASTRIC INTUBATION

A meta-analysis[88] in 1995 showed that routine nasogastric decompression should be avoided after colorectal surgery since fever, atelectasis, and pneumonia are reduced in patients without a nasogastric tube. A recent Cochrane meta-analysis[89] of 33 trials with more than 5000 patients confirmed this and also found earlier return of bowel function in patients when nasogastric decompression was avoided. Gastroesophageal reflux is increased during laparotomy if nasogastric tubes are inserted,[90] and there is no rationale for routine insertion of a nasogastric tube during elective colorectal surgery, except to evacuate air that may have entered the stomach during ventilation by facial mask prior to endotracheal intubation. Nasogastric tubes placed during surgery should be removed before reversal of anesthesia.

PREVENTING INTRAOPERATIVE HYPOTHERMIA

Several RCTs have demonstrated that preservation of normothermia by using an upper-body forced-air heating cover reduces wound infections,[91,92] cardiac complications,[92-94] bleeding, and transfusion requirements.[92,95] Extending systemic warming to 2 hours before and after surgery had additional benefits.[96]

PERIOPERATIVE FLUID MANAGEMENT

It has been standard practice in recent years to infuse volumes of intravenous fluids substantially in excess of actual perioperative losses.[97] Traditional perioperative intravenous fluid regimens in abdominal surgery can lead to patients receiving 3.5 to 7 L of fluid on the day of surgery and more than 3 L/d for the following 3 to 4 days, leading to a 3- to 6-kg weight gain.[98,99] Such regimens can delay the return of normal gastrointestinal function,[98] impair wound or anastomotic healing, and affect tissue oxygenation, leading to prolonged hospitalization.[99,100] Several trials have compared restrictive and liberal fluid or sodium regimens.[98-102] The results are not uniform and comparison is difficult as administered volumes and electrolytes in both arms differed substantially, reflecting nonuniform standard practice.

However, evidence does suggest that avoidance of overload and restricting fluid intake to that which will maintain balance, guided by body weight, may significantly reduce postoperative complications and shorten hospital stay and should therefore be recommended.[98,100] The best way to limit postoperative intravenous fluid administration is to stop intravenous infusions and return to oral fluids early, which should be feasible on the first postoperative day.[1] Patients with epidural anesthesia experiencing hypotension due to vasodilation and relative intravascular hypovolemia, which is traditionally treated with fluid loading, can be treated with the judicious use of a vasopressor.[103]

Intraoperative transesophageal Doppler monitoring helps titrate fluids in relation to cardiac output and may be useful in high-risk patients. Four RCTs[104-107] and a meta-analysis[108] with patients undergoing major bowel surgery found that when intraoperative fluid administration was guided by transesophageal Doppler monitoring, there was a better ejection fraction, better oxygenation, and fewer postoperative complications. Although patients in these trials were not treated according to enhanced-recovery protocols, it seems that transesophageal Doppler monitoring enables optimization of intravascular volume and tissue perfusion in major abdominal surgery. In low-risk patients undergoing sur-

gery of moderate magnitude, flow-guided therapy may not be warranted. High-grade evidence regarding the optimal regimen in terms of timing, type of fluid, and risk stratification is currently lacking.

DRAINAGE OF PERITONEAL CAVITY FOLLOWING COLONIC ANASTOMOSIS

Meta-analyses[109,110] have demonstrated that the use of drains after colonic surgery does not reduce the incidence or severity of anastomotic leaks or other complications. Drainage of the pelvic cavity for 24 hours following low anterior resection is supported by the Dutch total mesorectal excision trial,[111] although this remains to be proven in RCTs specifically designed to answer this question.

URINARY DRAINAGE

A recent meta-analysis[112] of RCTs concluded that suprapubic catheterization is more acceptable to patients and reduces morbidity compared with urethral catheterization. Most trials have been undertaken in patients requiring 4 to 7 days of urinary drainage. The risk of urinary retention after only 24 hours of catheterization is low after colonic resection above the peritoneal reflection during epidural analgesia.[113] Therefore, the advantages of suprapubic over urethral catheterization are probably small for colonic surgery, while the benefits are significant for pelvic surgery with longer catheterization times.

PREVENTION OF POSTOPERATIVE ILEUS

Prevention of postoperative ileus, a major cause of delayed discharge after abdominal surgery, is a key objective of enhanced-recovery protocols. While no current prokinetic agent is effective in attenuating or treating postoperative ileus, several other interventions have been successful. Midthoracic epidural analgesia[61] as compared with intravenous opioid analgesia is highly efficient at preventing postoperative ileus.[65,114] Fluid overloading during[101] and after[98] surgery impairs gastrointestinal function and should be avoided. Oral magnesium oxide has been demonstrated to promote postoperative bowel function in a double-blinded RCT in abdominal hysterectomy[115] and in reports from a well-established enhanced-recovery program in colonic resection.[1,116] Laparoscopy-assisted colonic resection also leads to faster return of bowel function as well as resumption of an oral diet compared with open surgery.[78] Oral alvimopan, a μ-opioid receptor antagonist approved for clinical use in postoperative ileus, accelerates gastrointestinal recovery and reduces the duration of hospitalization in patients undergoing colonic resection compared with postoperative intravenous opioid analgesia.[117]

POSTOPERATIVE ANALGESIA

Meta-analyses have shown that optimal analgesia is achieved by continuous epidural local anesthetic with or without opioids for 2 to 3 days postoperatively in both open[64,114] and laparoscopic[118] surgery. Analgesia based on intravenous opioids does not provide the same efficient analgesia[114] and has fewer beneficial effects on surgical stress responses compared with epidural local anesthetic techniques. While it is possible to achieve almost the same pain scores with patient-controlled analgesia at rest compared with epidural analgesia, this is at the expense of patients remaining sedated and in bed. Some RCTs[114,119] have demonstrated that continuous epidural local anesthetic techniques reduce pulmonary morbidity but not other types of morbidity, hospital stay, or convalescence.

There are some concerns about the risk of anastomotic complications after epidural analgesia for colonic resection.[114,120,121] Perfusion of the splanchnic area after establishment of the epidural block is probably more closely associated with changes in mean arterial pressure than with changes in cardiac output.[122] Therefore, vasopressors to maintain pressure should be considered. In the case of cardiac insufficiency, an adequate preload and positive inotropes are mandatory to improve colonic blood flow. Low-dose norepinephrine and dobutamine hydrochloride are probably not harmful for splanchnic perfusion.[123-127] The unanswered questions are the acceptable range of blood pressure in individual patients and the duration for which vasopressors should be used.[120]

Avoidance of opioids and their adverse effects is the goal after removal of the epidural catheter, and nonsteroidal anti-inflammatory drugs have been shown to be opioid sparing[128] and to provide efficient analgesia during this period.[1,129] Nabumetone is a widely used nonsteroidal anti-inflammatory drug that does not affect bleeding time and may be a safer choice in patients with epidurals.[130]

POSTOPERATIVE NUTRITIONAL CARE

The RCTs of early enteral or oral feeding vs "nil by mouth" conclude that there is no advantage of keeping patients fasted after elective gastrointestinal resection.[131-133] Early feeding reduced both the risk of infection and the length of hospital stay and was not associated with an increased risk of anastomotic dehiscence. However, the risk of vomiting increased in patients fed early, and in the absence of multimodal anti-ileus therapy, early feeding was associated with bloating, impaired pulmonary function, and delayed mobilization.[134,135]

For malnourished patients, there is a clear advantage of prescribing postoperative oral nutritional supplements for 8 weeks in terms of recovery of nutritional status, protein economy, and quality of life.[136] Positive clinical outcomes from oral nutrition supplements have also been documented in studies of patients undergoing elective surgery who are not screened for malnutrition.[137,138] In enhanced-recovery programs, oral nutritional supplements have been used successfully on the day prior to operation and for at least the first 4 postoperative days to achieve recommended intakes of energy and protein.[1,139,140] When used in combination, preoperative oral carbohydrate loading, epidural analgesia, and early enteral nutrition have been shown to result in nitrogen equilibrium without concomitant hyperglycemia.[141]

EARLY MOBILIZATION

Bed rest not only increases insulin resistance and muscle loss but also decreases muscle strength, pulmonary function, and tissue oxygenation.[142] Additionally, there is an increased risk of thromboembolism. Effective pain relief using ambulatory thoracic epidural analgesia is a key adjuvant measure to encourage postoperative mobilization. A prescheduled care plan should list daily goals for mobilization, and a patient diary for out-of-bed activities is helpful. It is essential that the patient is nursed in an environment that encourages early mobilization (food and television removed from the bedroom) and one that maintains the patient's independence (ordinary ward or level 1 facility). The aim is for patients to be out of bed for 2 hours on the day of surgery and for 6 hours per day until discharge. Abdominal drains and urinary catheters hinder mobilization and should be avoided whenever possible.

AUDIT

A systematic audit is mandatory to determine clinical outcome and to establish the successful implementation of the care protocol. Distinguishing between unsuccessful implementation and lack of desired effect from an implemented protocol is vital if results are short of desired quality standards. Comparison with other centers using similar protocols via identical tools of registration and identical definitions of key factors is needed.

COMMENT

This article outlines the recommendations of the ERAS Group for clinical perioperative care of patients undergoing elective colorectal surgery, based on the best available evidence. However, neither evidence nor protocol is sufficient to ensure evidence-based care. Evidence dictates care only to a very limited extent,[143] and an evidence-based protocol alone is insufficient to ensure change.[144] We echo the words of Urbach and Baxter: "the immediate challenge to improving the quality of surgical care is not discovering new knowledge, but rather how to integrate what we already know into practice."[145]

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