Perioperative Care Implementation

Evidence-based practice for patients with pancreaticoduodenectomy using the Enhanced Recovery After Surgery guidelines

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BACKGROUND: Pancreatic adenocarcinoma is an aggressive cancer that carries a poor prognosis. Pancreaticoduodenectomy (PD) offers the only potential cure, but the associated morbidity is high. The Enhanced Recovery After Surgery (ERAS) evidence-based guidelines for perioperative care for PD can be used to reduce variations in practice.

OBJECTIVES: The primary aim was to evaluate the feasibility of the ERAS guidelines for patients undergoing PD. Secondary aims were to assess length of stay (LOS), readmission within 30 days, 30-day mortality, and total surgical complication rates.

METHODS: Guideline feasibility was evaluated by percentage completion and compliance to each of the perioperative phases of the guideline. Hospital LOS, 30-day readmission, 30-day mortality, and total surgical complication rates were compared before and after ERAS implementation.

FINDINGS: The ERAS guidelines were feasible and safely implemented with no change in LOS, readmission, morbidity, and mortality rates.

KEYWORDS
operative surgical procedures; outcome assessment; pancreatic adenocarcinoma

PANCREATIC ADENOCARCINOMA (PA) IS AMONG THE FIVE MOST FREQUENT CAUSES of cancer-related deaths in the United States. An estimated 53,670 new diagnoses of pancreatic cancer and 43,090 deaths occurred in the United States in 2016 (American Cancer Society, 2017). PA is relatively resistant to radiation and chemotherapy and has a high rate of local and systemic recurrence (Abrams et al., 2009; Ghaneh, Costello, & Neoptolemos, 2007; Orr, 2010). Five-year overall survival is 5%–6% (Bassi et al., 2001). Surgery is currently the only potential cure and the most relevant predictor of long-term survival.

Pancreaticoduodenectomy (PD) is the current standard operation for resectable pancreatic tumors situated in the head of the pancreas (see Figure 1). Improvement in surgical techniques has led to PD mortality rates of less than 5% in high-volume centers (Büchler et al., 2002); however, perioperative morbidity remains high (30%–40%) (Bassi et al., 2001) from bile leak, bleeding, cardiac dysrhythmias, delayed gastric emptying, ileus, pancreatic fistula, reoperations, respiratory distress and failure, sepsis, urinary tract infections, and surgical site infections.

Because of the complex surgical and medical management of these patients, the Enhanced Recovery After Surgery (ERAS) evidence-based guidelines for perioperative care for PD were implemented. The Carolinas Medical Center in Charlotte, North Carolina, performs about 100 PD operations per year. The morbidity and mortality rates at this center are similar to national levels, according to the historic data of 140 consecutive post-PD patients seen from January 2013 to August 2015.

Guidelines

The ERAS guidelines for perioperative care for PD are systematically developed statements that facilitate decision making by healthcare providers for specific clinical circumstances, help reduce inappropriate variations in practice, and promote the delivery of high-quality, evidence-based health care (Varadhan, Lobo, & Ljungqvist, 2010). The ERAS guidelines represent a fundamental shift in the perioperative care of patients (Varadhan, Lobo, et al., 2010), and their implementation encourages full recovery, shortens hospital length of stay (LOS), and reduces complications after certain types of major
abdominal surgery (Bakker, Cakir, Doodeman, & Houdijk, 2015; Basse et al., 2002; Basse, Hjort Jakobsen, Billesbolle, Werner, & Kehlet, 2000; Khoo, Vickery, Forsyth, Vinall, & Eyre-Brook, 2007; Muller, Zalunardo, Hubner, Clavien, & Demartines, 2009; Serclová et al., 2009; Varadhan, Neal, et al., 2010). A systemic review of four randomized, controlled trials and seven controlled clinical trials found that ERAS implementation reduces surgical stress, maintains postoperative physiologic function, enhances mobilization after surgery, and significantly reduces hospital LOS when compared with traditional care (Gouvas, Tan, Windsor, Xynos, & Tekkis, 2009). Morbidity was also lower in the ERAS group, and readmission rates were similar among the groups (Gouvas et al., 2009).

**Objectives**
The authors’ primary aim was to evaluate the feasibility of using ERAS guidelines for perioperative care of patients undergoing PD for PA. Secondary aims were to assess LOS, readmission within 30 days, 30-day mortality, and total surgical complication rates.

**Methods**
Feasibility of the ERAS protocols was evaluated by the percentage completion and compliance to each of the perioperative phases of the ERAS guidelines. A comparative outcomes design was used to evaluate clinical outcomes before and after implementation of ERAS. Historic data were collected from 140 consecutive patients who underwent PD from January 2013 to August 2015. The postimplementation sample included 40 patients undergoing PD from September 2015 to January 2016. Patients diagnosed with metastatic PA were excluded from the study. The institutional review board from Carolinas Medical Center approved the study before implementation.

**PHASE 1**
Patients received one hour of preoperative counseling by the inpatient nurse practitioner at the pre-anesthesia clinic on cessation of smoking and/or alcohol consumption, preoperative nutrition, mechanical bowel preparation, preoperative fasting, and preoperative carbohydrate loading. Historically, patients have been instructed to start fasting at midnight prior to surgery. ERAS guidelines suggest intake of clear fluids up to two hours prior to surgery and intake of solids six hours prior. Providing nondiabetic patients with a carbohydrate-loading beverage has shown to reduce hunger, thirst, and postoperative insulin resistance (Lassen et al., 2013). Insulin resistance causes a disturbance in metabolism, which may lead to multiple postoperative complications (Ljungqvist, 2014). Patients received 5,000 U of unfractionated heparin two hours before the operation, 1 g of ertapenem within one hour of the surgical incision, and 8 mg of ondansetron prior to induction if two or more risk factors for developing nausea or vomiting were identified. Mid-thoracic epidurals were routinely placed preoperatively.

**PHASE 2**
During the operation, patients received early goal-directed therapy by the use of stroke volume variance technology. Sequential compression devices were placed and appropriate body temperature was maintained during surgery with a forced air garment system.

**PHASE 3**
Patients were admitted to the intensive care unit, and mid-thoracic epidural analgesia with bupivacaine and fentanyl was initiated immediately after extubation. Early goal-directed therapy was continued through postoperative day (POD) 1. On POD 1, the nasogastric tube was removed, antithrombotic prophylaxis was administered with 40 mg of enoxaparin once at night and sequential compression devices, gastric prophylaxis was administered by 40 mg of pantoprazole, nausea and vomiting were treated with 8 mg of ondansetron every eight hours as needed, blood glucose levels were maintained at less than 150 mg/dl with use of insulin as necessary, a clear liquid diet was given, and mobilization was encouraged. On POD 2, near-zero fluid balance was maintained with IV fluid. The urinary catheter was removed unless the patient had a diagnosis of benign prostatic hyperplasia, and a daily
bowel regimen was initiated with 100 mg docusate twice per day, magnesium oxide 200 mg, and one packet of polyethylene glycol as needed for constipation. On POD 3, a full liquid diet was given, and the mid-thoracic epidural was removed. Patients without renal dysfunction were given multimodal analgesia with 15 mg of ketorolac every six hours, 650 mg of acetaminophen every eight hours, and 50 mg of tramadol every eight hours as needed. For patients with a visual analog scale pain score greater than 5 (on a scale from 0-10, with 0 indicating no pain and 10 indicating worst pain imaginable), oral or IV opioids were given. A regular diet began on POD 4, and the abdominal drain was removed when drain amylase concentration was less than three times that of the serum and drain output was less than 300 ml per day. Patients were discharged once functional recovery criteria were met, including good pain control with oral analgesia, tolerance of solid diet, no need for IV fluid, passage of stool, independent mobilization, and willingness to be discharged. Patients were seen within one week postdischarge at an outpatient clinic by the nurse practitioner.

Implementation and Sustainability Plan
A key factor to successful implementation of ERAS guidelines is education of the nursing staff. Without assistance from nursing staff, it would be difficult to achieve a high compliance rate to ERAS protocols. During the study period, the nursing staff on the hepatopancreaticobiliary (HPB) specialty unit completed extensive training through morning huddles and staff meetings and on an individual basis. The ERAS guidelines were converted into a printed and electronic checklist to facilitate completion and compliance. The printed checklist was reduced to the size of a hospital badge and distributed to all providers caring for patients undergoing PD.

Table 1: Sample Characteristics by Group

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>HISTORIC COMPARISON (N = 140)</th>
<th>ERAS INTERVENTION (N = 40)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>M 66, range 58–72</td>
<td>M 68.5, range 58.5–74.5</td>
<td>0.324</td>
</tr>
<tr>
<td>Body mass index</td>
<td>26.3, range 22.4–30.5</td>
<td>25.4, range 22.6–28.8</td>
<td>0.652</td>
</tr>
<tr>
<td>Male</td>
<td>n 74, % 53</td>
<td>n 24, % 60</td>
<td>0.424</td>
</tr>
<tr>
<td>ASA 2 score</td>
<td>n 11, % 8</td>
<td>n 9, % 23</td>
<td>0.009</td>
</tr>
<tr>
<td>ASA 3 score</td>
<td>n 106, % 76</td>
<td>n 29, % 73</td>
<td>0.679</td>
</tr>
<tr>
<td>ASA 4 score</td>
<td>n 23, % 16</td>
<td>n 2, % 5</td>
<td>0.065</td>
</tr>
</tbody>
</table>

ASA—American Society of Anesthesiologists; ERAS—Enhanced Recovery After Surgery; M—median

“Changing a culture in a complex healthcare environment can be a difficult task.”

Laminated sheets of the guidelines were placed on each anesthesia cart and adjacent to workstations. An electronic standard order set containing many ERAS elements was created to facilitate workflow. The goal was a knowledgeable staff that could guide or question the surgical team as orders were placed for patients, resulting in an engaged nursing staff more involved with patient care decisions.

To optimize intraoperative compliance, patients received anesthesia from an ERAS-trained group of anesthesiologists and nurse anesthetists throughout the study period. All study participants were grouped in one postoperative unit, and care was provided by nurses specializing in the management of patients undergoing PD. The use of the guidelines was monitored daily, and reasons for deviation of care were recorded with audits performed by the inpatient nurse practitioner at 14, 30, and 90 days.

To further increase effective sustainability of the ERAS guidelines, education of nurses, physicians, and residents took place weekly after implementation of the guidelines by the inpatient nurse practitioner. Topics included the evidence-based literature behind the innovation and how guideline compliance could improve clinical outcomes. Key leaders in the organization helped to promote the sustainability of the project.

Data Collection
Data were collected and entered by the inpatient nurse practitioner and managed by the data entry specialist and research data manager. Data were abstracted from patients’ electronic health records, which had been highlighted for easy identification during the intervention period. Data on ERAS compliance were captured by the nurse practitioner via the REDCap data entry mobile platform.

Statistical Analysis
Feasibility of ERAS protocol implementation was evaluated by percent completion and compliance to each of the three phases of the ERAS guidelines and analyzed using descriptive statistics. LOS before and after ERAS guidelines implementation was analyzed using the Mann–Whitney U test. Differences in 30-day readmission and mortality in the pre- and postimplementation groups were analyzed using the chi-square test. Differences in overall complication rates before and after implementation were analyzed using Fisher’s
exact test. A p value of less than 0.05 was considered significant. Statistical analysis was performed using STATA, version 13.0.

**Results**

When comparing the demographics in both groups, the intervention group had more men than women and an older population, and the two groups had similar body mass index and American Society of Anesthesiology scores (see Table 1). The ERAS cumulative percent completion and compliance means were 95.3% and 59.7%, respectively. When comparing secondary outcomes, the intervention group showed an improvement in the hospital LOS of 0.5 days, whereas the 30-day readmission and 30-day mortality remained the same when compared to the historic group (see Table 2).

The overall postoperative surgical complications show that the intervention group had a higher rate of bile leak, bleeding, delayed gastric emptying, pancreatic fistula, sepsis, and surgical site infections; similar rates of respiratory distress or failure and urinary tract infection; and smaller rates of cardiac dysrhythmias, reoperations, and postoperative ileus when compared to the historic group (see Table 3). In the current study, various elements of the ERAS guidelines were identified with reduced compliance. Barriers to compliance are shown in Figure 2.

None of the variables reached statistical significance when comparing demographics, secondary outcomes, and overall postoperative surgical complications. The results of the overall postoperative surgical complications represent data collected retrospectively in the historic group; therefore, process indicators may not have been recorded with similar accuracy in all patients. The meticulous prospective registration of postoperative surgical complications in the current study may have contributed to a higher complication rate in the intervention group than in the historic group.

**TABLE 2. OUTCOMES OF ERAS GUIDELINES**

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>HISTORIC COMPARISON (N = 140)</th>
<th>ERAS INTERVENTION (N = 40)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital LOS (days)</td>
<td>M 8–18</td>
<td>M 7–21</td>
<td>0.796</td>
</tr>
<tr>
<td>Death within 30 days</td>
<td>n %</td>
<td>n %</td>
<td>0.434</td>
</tr>
<tr>
<td>Readmission within 30 days</td>
<td>39 28</td>
<td>11 28</td>
<td>0.398</td>
</tr>
</tbody>
</table>

ERAS—Enhanced Recovery After Surgery; LOS—length of stay; M—median
Note. In the ERAS intervention group, the mean percentage of module completion was 95.3%, and the mean percentage of module compliance was 59.7%.

**TABLE 3. POSTOPERATIVE COMPLICATIONS PRIOR TO AND AFTER ERAS GUIDELINES IMPLEMENTATION**

<table>
<thead>
<tr>
<th>COMPLICATION</th>
<th>HISTORIC COMPARISON (N = 140)</th>
<th>ERAS INTERVENTION (N = 40)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bile leak</td>
<td>1 1</td>
<td>2 5</td>
<td>0.062</td>
</tr>
<tr>
<td>Bleeding</td>
<td>5 4</td>
<td>3 8</td>
<td>0.288</td>
</tr>
<tr>
<td>Cardiac dysrhythmia</td>
<td>17 12</td>
<td>1 3</td>
<td>0.073</td>
</tr>
<tr>
<td>Delayed gastric emptying</td>
<td>40 29</td>
<td>17 43</td>
<td>0.095</td>
</tr>
<tr>
<td>Ileus</td>
<td>5 4</td>
<td>– –</td>
<td>0.225</td>
</tr>
<tr>
<td>Pancreatic fistula</td>
<td>10 7</td>
<td>6 15</td>
<td>0.124</td>
</tr>
<tr>
<td>Reoperation</td>
<td>19 14</td>
<td>2 5</td>
<td>0.136</td>
</tr>
<tr>
<td>Respiratory distress or failure</td>
<td>11 8</td>
<td>3 8</td>
<td>0.941</td>
</tr>
<tr>
<td>Sepsis</td>
<td>5 4</td>
<td>3 8</td>
<td>0.288</td>
</tr>
<tr>
<td>Surgical site infection</td>
<td>8 6</td>
<td>5 13</td>
<td>0.144</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>6 4</td>
<td>2 5</td>
<td>0.847</td>
</tr>
</tbody>
</table>

ERAS—Enhanced Recovery After Surgery
Note. Historic comparison does not total 100 because not all complications were included in this listing. Percentages in the ERAS group total more than 100 because more than one complication could be selected.

**Discussion**

The ERAS guidelines are now well established, particularly in colorectal surgery. The implementation and sustainability of these guidelines, however, requires a multidisciplinary approach to perioperative care and an acceptance that certain traditional aspects of surgical management may no longer be appropriate (Kehlet & Dahl, 2003; Kehlet & Wilmore, 2002). The focus of the ERAS implementation program is cultivating teams from various units involved in surgical care, introducing changes to current routines to conform to best practice, and providing the tools to monitor and analyze the effects of those changes. The ERAS implementation program is based on teamwork only in the perioperative process—nurses, anesthesiologists, and surgeons. To date, medical and radiation oncology are not part of the implementation process.

In the authors’ HPB specialty unit, an ERAS nurse was assigned to improve compliance among physicians and nurses, focusing on educating nursing staff, completing real-time patient tracking, and communicating with physicians regarding ERAS goals. The real-time tracking allows for immediate recognition of low-compliance elements to determine why compliance is lacking and how it
can be improved. Whether a nursing or physician issue, the ERAS nurse works collaboratively with the team to increase knowledge and compliance and acts as the liaison between the surgical team and nursing staff to keep patient care moving in the right direction. Study results suggest that 59.7% compliance in daily clinical practice is possible for many individual elements in the ERAS guidelines, with resulting outcomes similar to the study historic controls. However, the authors’ audit results also highlight the need for further improvements in compliance to optimize postoperative outcomes such as readmission, mortality, morbidity rates, and LOS.

A study by Bakker et al. (2015) showed that compliance to the ERAS guidelines in colonic surgery was inversely proportional to the duration of LOS. Positive results were achieved when compliance was greater than 62%, and optimal results were achieved when compliance was 82%. This study also highlighted factors that significantly improved postoperative outcomes, such as carbohydrate-loaded drinks, omission of a nasogastric tube, early oral nutrition, early mobilization, early removal of a urinary catheter, early removal of an epidural, and nonopioid oral analgesia. Therefore, many elements characterized by suboptimal compliance in the study may have a direct effect on postoperative outcomes. The importance of ERAS compliance is further strengthened by a review article that showed an association between greater compliance and decreased LOS (Ahmed, Khan, Gatt, Kallam, & MacFie, 2010). Another study showed that an increase in compliance from 40% to 71% resulted in significant improvements in postoperative surgical outcomes (Gustafsson et al., 2011).

**FIGURE 2.** BARRIERS TO COMPLIANCE WITH ENHANCED RECOVERY AFTER SURGERY GUIDELINES

**PHASE 1**
- Lack of face-to-face interaction with a provider
- Lack of coordination of patient care
- Carbohydrate drinks not available

**PHASE 2**
- Patient-specific conditions
- Contraindication to specific items in the intervention
- Providers’ preference

**PHASE 3**
- Underlying comorbidities
- Variations in equipment availability
- Lack of knowledge in hemodynamic monitoring
- Providers’ preference

**PHASE 4**
- Lack of close follow-up after discharge
- High cost of postdischarge medications

**IMPLICATIONS FOR PRACTICE**
- Provide education to patients with pancreatic adenocarcinoma undergoing a pancreaticoduodenectomy
- Improve team morale and emphasize patient-centered outcomes to create positive consequences through guideline implementation
- Be responsible for the coordination of patient care among the multiple disciplines actively involved in patient management during guideline implementation

To address barriers and improve compliance, nurses will apply the Plan-Do-Study-Act (PDSA) theoretical framework (Donnelly & Kirk, 2015). In phase 1, the ERAS nurse serves as a patient advocate, educator, and counselor. The counseling and preoperative education will be offered during the preoperative anesthesia visit to increase convenience for the patient.

Improving compliance in phase 2 will be challenging. Intraoperative patient-specific conditions or medical contraindications to the intervention are the main barriers to ERAS guidelines compliance in this phase. Future plans to improve compliance in phase 3 will include the purchase of two hemodynamic monitors and training of the nursing staff on advanced hemodynamics. Postoperative complications will be difficult to avoid; however, care will be taken to reduce underlying comorbidities. Measures to improve compliance in this phase will include the discharge of high-risk patients to selected institutions that are accustomed to managing PD surgical patients.

Additional findings during the study period include wide variations in perioperative surgical care among the four surgeons in this study. Two of the four surgeons continue to delay nasogastric tube and urinary catheter removal and continue to transition patients to opioid-based patient-controlled analgesia following epidural removal. However, only those patients who developed delayed gastric emptying required a nasogastric tube replacement. Replacement of urinary catheters was only required for those patients with a history of benign prostatic hyperplasia or marginal urine output regardless of the presence or absence of epidural anesthesia. After epidural removal, most patients were able to successfully transition to the first-line pain regimen that consisted of oral or IV nonsteroidal anti-inflammatory drugs, oral acetaminophen, and tramadol. Most patients did not require a patient-controlled analgesia after epidural removal. These results confirm other studies that describe substantial variations in perioperative surgical management despite the widespread introduction of ERAS guidelines (Hasenberg et al., 2009; Lassen et al., 2005).

Changing a culture in a complex healthcare environment is a difficult task. A successful introduction of the ERAS guidelines is possible through the collaboration of a multidisciplinary team for patient-centered care. Having leadership support and a workforce that embraces continuous learning and close cooperation is important. Some elements of the ERAS guidelines were difficult to implement. The authors have identified these and plan to overcome them by continuing to capture barriers to compliance with...
current, real-time compliance tracking data on tablet devices, as well as through the use of the PDSA theoretical framework.

**Strengths and Limitations**

In this study, data on compliance with individual elements in the ERAS guidelines were captured and monitored in real time, adding to the strength of the study. The meticulous prospective registration of postoperative complications is another major strength of the study. Improved team morale and increased emphasis on patient-centered outcomes were two unintended but positive consequences observed with ERAS guidelines implementation.

This evidence-based project is limited by its single-center nature. Because of the relatively short study period, a small number of patients were enrolled, which limited the statistical significance of the study. The results are also limited by the fact that data were collected retrospectively in the historic group; therefore, process indicators may not have been recorded with similar accuracy in all patients. The prospective registration of postoperative complications in the current study may have contributed to a higher complication rate in the study group than in the historic group. Another major limitation in this study was the failure to use standardized definitions in the historic group for surgical complications.

**Conclusion**

This study demonstrates that ERAS guidelines were feasible and safely implemented with no change in LOS, readmission, morbidity, and mortality rates. However, a longer study period is needed to draw conclusions with statistical significance. In addition, with a larger sample, nurses will be able to apply multivariate analysis to find a direct relationship of cause and effect between elements of the guidelines and outcome measures. Adopting and sustaining evidence in daily practice is challenging and requires dedicated and motivated health professionals and a multidisciplinary team approach. Multicenter prospective studies can validate the transferability of the ERAS guidelines for patients undergoing PD. The prospective data gathered will aid in the identification and evaluation of patients’ quality of life and cost incurred after a PD.

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**REFERENCES**


