Elastomeric Pain Pump as a Bridge for Local Pain Control After Epidural Removal in Abdominal Surgery Patients

J F Rose, J Gordon, A Romero, B Najafi, P K Boyle, E S Ong

Citation

Abstract
Postoperative pain control can be challenging. There are a number of different modalities that can be used to treat postoperative pain. The benefits of good pain control, aside from keeping patients comfortable, are early mobility, decreased incidence of cardiopulmonary complications, decreased ileus, improved sleep, decreased overall complications, and shorter hospital stay. To date there has not been a study comparing the benefit of pain control modalities in enhancing the benefits described above. Another purpose for our study was to evaluate if using both an epidural and elastomeric pump together could be done safely with minimal complications. Adverse effects including skin necrosis, wound infection, and cellulitis have been reported with infusion pump systems. We wanted to demonstrate that our patients treated with this method of pain control did not suffer additional complications.

INTRODUCTION
Postoperative pain control can be challenging. There are a number of different modalities that can be used to treat postoperative pain. The benefits of good pain control, aside from keeping patients comfortable, are early mobility, decreased incidence of cardiopulmonary complications, decreased ileus, improved sleep, decreased overall complications, and shorter hospital stay. To date there has not been a study comparing the benefit of pain control modalities in enhancing the benefits described above.

There are a number of medications that can be used to help control pain including narcotics, non-steroidal anti-inflammatories (NSAIDs), and acetaminophen; each with known side effects. Narcotics are frequently used to control postoperative pain, but their use can lead to respiratory depression, sedation, pruritus, ileus, and urinary retention. NSAIDs can cause renal insufficiency, peptic ulcers, diminished platelet function, and bronchospasm. Side effects of acetaminophen are uncommon, but an overdose can lead to irreversible liver damage.

To help reduce unwanted medication side effects, a modality using a local anesthetic may be advantageous. Epidural anesthesia using only a local anesthetic alleviates narcotic side effects, particularly post-operative nausea and vomiting. Epidurals provide comparable pain relief while limiting the need for systemic intravenous and/or oral analgesics. Many groups have reported superior pain control with epidurals alone when compared to intravenous analgesia. Studies conducted on patients with epidurals containing both local anesthetics and narcotic medications have reported even better pain control than local anesthetic alone. In addition, it appears that adding narcotics to the epidural solution did not increase the incidence of postoperative nausea and vomiting. Additional benefits of epidural analgesia include earlier return of gastrointestinal function, attenuation of the stress response, lower overall pain scores, and diminished stress induced immunosuppression during the post-operative period.

Although epidural anesthesia has many benefits, it is not without complications. Complications of epidurals include spinal headache, hypotension, motor blockade, and rarely epidural abscess, meningitis, and epidural hematoma. Infiltration of a local anesthetic at the incision site(s) may be useful as an adjunct in post-operative pain management. The use of an elastomeric pain pump delivery system (OnQ Pain Buster Post-Op Pain Relief System, I-FLOW Corporation, Lake Forest, CA) to provide continuous infusion of local anesthetic may be more beneficial than a single bolus injection at the incision site, as the effects of...
local anesthetics dwindle rather quickly. Placing catheters that allow continuous post-operative administration of local anesthetic may allow for a much longer duration of action, and in effect, additional pain relief. Local anesthetics directly at the incision site decreases the transmission of nociceptive impulses from the site of injury. This has shown to be true for many major operations by decreasing the overall quantity of intravenous narcotics needed, and consequently diminishing the systemic side effects of narcotics. Placement of the catheters is important as demonstrated by initial studies with subcutaneously placed pumps not proving beneficial. Since the fascia and peritoneum are both injured and painful after abdominal surgery, placing the catheters in the pre-peritoneal space (blocking peritoneal afferents) improves pain control and decreases overall narcotic use. It has been suggested that this method of delivery may provide better pain control than an epidural for the type of pain at the incision site that is associated with movement. The ability to decrease narcotic requirements while improving analgesia with this method has been demonstrated by prospective randomized studies.

Elastomeric infusion pumps seem to be rate limited, and can have irregular flow rates. Studies have shown that elastomeric pumps initially flow at rates higher than expected, and when the device has less volume, infuse lower than expected. Temperature also appears to affect the flow rate with approximately a 10% increased rate of infusion at elevated temperatures. This change in flow rate can be concerning, but may be potentially beneficial as post-operative patients have decreasing pain as time goes on, so an initially faster rate that gradually decreases may be helpful. It can be very difficult to predict the exact rate of the pump as it can vary 15% faster or slower than is advertised.

Desiring the ability to provide good multi-modal analgesia to our post-operative abdominal surgery patients, we sought to maximize the use of local anesthetic delivery devices. Knowing the pain pump infusion rates can be unpredictable, we did not want to run both the epidural and the elastomeric pain pump synchronously related to concern about local anesthetic toxicity. We decided to place the catheters for the elastomeric pain pumps intra-operatively, but not activate them until the epidural was no longer being used. Anecdotally, our patients who had both the epidural and the elastomeric pain pumps were very pleased with their pain control. We looked back at objective data to see if it affected hospital stay or narcotic use.

Another purpose for our study was to evaluate if using both an epidural and elastomeric pump together could be done safely with minimal complications. Adverse effects including skin necrosis, wound infection, and cellulitis have been reported with infusion pump systems. We wanted to demonstrate that our patients treated with this method of pain control did not suffer additional complications.

METHODS

We retrospectively analyzed inpatient records of all consecutive patients over a three-year period at The University of Arizona who underwent an open abdominal operation with the senior author as the primary surgeon. Only patients who had an open laparotomy or subcostal incision were included. Mini-laparotomy patients and hand-assisted laparoscopic cases were excluded. Those who initially had a diagnostic laparoscopy but were converted to an open operation were also included. Patients who had more than one incision (i.e. Ivor-Lewis esophagectomy), as well as patients who were documented to have substantial chronic outpatient narcotic needs, a history of narcotic abuse, or allergies to all narcotics, were also excluded from our study.

Multiple factors in the study group were examined, including patient age, gender, type of operation (and whether or not for malignancy), type of incision (subcostal versus laparotomy), length of hospital stay, method of pain control, total narcotic use for their hospital stay (in intravenous morphine equivalents and morphine units/hospital day), presence of any postoperative complications, and method of pain control (epidural, elastomeric pain pump, both epidural and elastomeric pain pump, and neither epidural or elastomeric pain pump).

Only the patient population of one surgeon was included for consistency in catheter placement and postoperative prescribing methods. All patients who had epidurals received them pre-operatively by the anesthesiologist. All patients who had elastomeric pain pumps had them placed intra-operatively by the surgeon by tunneling two catheters (one on either side of the wound) in between the peritoneum and the transversalis fascia. For the patients whose only method of pain control was the elastomeric pain pump, the catheters were immediately connected after placement with a total volume of 400 mL 0.5% bupivacaine infusing at approximately 2 mL per hour per catheter (4 mL per hour
Elastomeric Pain Pump as a Bridge for Local Pain Control After Epidural Removal in Abdominal Surgery Patients

For the patients who also had an epidural, the elastomeric pain pump catheters were placed in the same fashion intra-operatively and were capped for later use after the epidural was discontinued. Patients who did not receive either method typically had patient controlled analgesia pumps (PCA) with narcotics until transitioned to oral pain medications.

Patients received the following narcotics in various amounts: intravenous and/or oral hydromorphone; intravenous and/or oral morphine; intravenous and/or transdermal fentanyl; intravenous meperidine; oral oxycodone; oral propoxyphene; and oral hydrocodone. See Table 1 for conversions utilized in this study.

Table 1
Narcotic Conversions[14]

<table>
<thead>
<tr>
<th>1 mg of specified narcotic</th>
<th>IV Morphine equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO Hydrocodone</td>
<td>0.33mg</td>
</tr>
<tr>
<td>PO Oxycodone</td>
<td>0.5mg</td>
</tr>
<tr>
<td>PO Morphine</td>
<td>0.33mg</td>
</tr>
<tr>
<td>PO Hydromorphone</td>
<td>1.33mg</td>
</tr>
<tr>
<td>PO Propoxyphene</td>
<td>0.0495mg</td>
</tr>
<tr>
<td>IV Meperidine</td>
<td>0.13mg</td>
</tr>
<tr>
<td>IV Hydromorphone</td>
<td>6.67mg</td>
</tr>
<tr>
<td>IV Fentanyl</td>
<td>100mg</td>
</tr>
<tr>
<td>Transdermal Fentanyl</td>
<td>165mg</td>
</tr>
</tbody>
</table>

The methods of pain management were categorized as the following: only Epidural usage (Group E); only elastomeric/OnQ pain pump usage (Group P); both epidural and elastometric pain pump usage (Group E+P); and neither epidural or elastomeric pain pump usage (Group N).

The aim of the study was first, to assess differences in pain control outcomes between designated groups, and second, to assess complication rates between groups. When assessing the differences in pain control outcomes between groups, we included the length of stay, amount of morphine equivalents used per day, and the total overall morphine equivalents used.

ANOVA and Fisher's Exact Test, or chi-square as appropriate, were used to characterize group differences taking into account patient demographics and patient attributes. Analysis of covariance (MANCOVA) was used to compare the effect of the intervention (type of pain management) on outcomes parameters (i.e. length of stay, total IV morphine equivalents) after adjustment for multiple comparisons (Sidak model) for age, gender, and presence of cancer. Chi-square-tests were used for between group comparisons for dichotomous outcomes (i.e. incidence of complications, incidence of infection). All data are reported as the mean +/- standard deviation. A p value of less than or equal to 0.05 was considered statistically significant. Statistical analyses were performed using SPSS Statistics (IBM Co., Version 22).

RESULTS

A total of 109 patients who met the outlined criteria were included in final analysis. Table II summarizes the demographics and patient characteristics for each specified intervention. Overall, no differences between groups were observed for demographics and patient attributes. Results suggest that patients with cancer have an increased likelihood of having an epidural, an elastomeric pain pump, or a combination of both for pain management (p=0.040). On a similar note, 33.3% of the ninety identified cancer patients fell in the epidural subset, which was higher than any other pain management modality utilized (p=0.040).

Table 2
Subject demographics and clinical characteristics

<table>
<thead>
<tr>
<th></th>
<th>Neither epidural or pain pump (Group N) N=38</th>
<th>Epidural (Group E) N=32</th>
<th>OnQ pain pump (Group P) N=32</th>
<th>Both epidural and pump (Group E+P) N=35</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>59.5±13.6</td>
<td>59.7±13.8</td>
<td>55.4±13.3</td>
<td>60.6±14.3</td>
<td>0.662</td>
</tr>
<tr>
<td>Gender (% Male)</td>
<td>50.0</td>
<td>50.4</td>
<td>59.3</td>
<td>57.0</td>
<td>0.652</td>
</tr>
<tr>
<td>Subcutual infection (%)</td>
<td>30.0</td>
<td>51.2</td>
<td>40.9</td>
<td>44.0</td>
<td>0.448</td>
</tr>
<tr>
<td>Cancer (%)</td>
<td>66.7</td>
<td>93.8</td>
<td>86.4</td>
<td>84.0</td>
<td>0.040</td>
</tr>
<tr>
<td>Whipple (%)</td>
<td>13.3</td>
<td>28.1</td>
<td>22.7</td>
<td>28.6</td>
<td>0.491</td>
</tr>
</tbody>
</table>

Table III summarizes between group comparisons for the outcomes of this study. Although the rate of complications was almost half for groups ‘N’ and ‘E+P’ when compared to other groups, no significant between-group difference was noted for the number of complications (p=0.462). Additionally, no between group difference was noted for the rate of wound infection (p=0.735).
Elastomeric Pain Pump as a Bridge for Local Pain Control After Epidural Removal in Abdominal Surgery Patients

Table 3

Between subject effects comparison for outcomes after adjustment for age, gender, and presence of cancer

<table>
<thead>
<tr>
<th></th>
<th>Neither epidural or pump (Group N) N=20</th>
<th>Epidural (Group E) N=22</th>
<th>On pump (Group P) N=22</th>
<th>Both epidural and pump (Group E+P) N=25</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complications, (%)</td>
<td>0.0</td>
<td>21.9</td>
<td>22.7</td>
<td>12.0</td>
<td>0.462</td>
</tr>
<tr>
<td>Wound infection (%)</td>
<td>0.0</td>
<td>3.1</td>
<td>4.5</td>
<td>4.0</td>
<td>0.735</td>
</tr>
<tr>
<td>Total IV morphine equivalents*</td>
<td>299.5±269.3</td>
<td>471.1±516.2</td>
<td>491.0±555.6</td>
<td>433.0±607.6</td>
<td>0.605</td>
</tr>
<tr>
<td>Morphine per day*</td>
<td>45.3±43.6</td>
<td>48.3±60.0</td>
<td>63.1±96.5</td>
<td>42.3±32.2</td>
<td>0.464</td>
</tr>
<tr>
<td>Length of hospitalization (Days)*</td>
<td>8.8±5.4</td>
<td>10.6±7.2</td>
<td>9.0±6.8</td>
<td>8.8±1.1</td>
<td>0.523</td>
</tr>
</tbody>
</table>

* Adjustment for multiple comparisons Sidak. Covariates appearing in the model are evaluated at the following values: Age (years) = 59.972, Cancer (1 yes, 0 no) = 0.825, Gender (1 M, 0 F) = 0.550.

After adjusting for age, presence of cancer, and gender, no between group difference was observed for any of the outcomes of this study (p>0.05). However, group ‘N’ had a trend to use less total IV morphine equivalents on average when compared to groups ‘E’, ‘P’, and ‘E+P’ by 36.3%, 39.1%, and 27.1% respectively (Figure 1). Group ‘E+P’ had the least morphine equivalent per day usage compared to groups ‘N’, ‘E’, and ‘P’ on average by 7.0%, 12.4%, and 33.3%, respectively (Figure 2). But this trend didn’t achieve statistical significance in our sample (p>0.05).

Figure 1

Total IV morphine equivalents as a function of pain management modalities.
Elastomeric Pain Pump as a Bridge for Local Pain Control After Epidural Removal in Abdominal Surgery Patients

Figure 2
Morphine per day usage as a function of pain management modalities.

![Figure 2](image.png)

Figure 3
Length of hospitalization as a function of pain management modalities

![Figure 3](image.png)

Results suggest that a combination of epidural and elastomeric pump for pain management may reduce the length of hospitalization by 16.7% compared to epidural alone, and 10.4% compared to isomeric pump alone modalities (Figure 3). This trend however also did not achieve statistical significance in our sample (p>0.05). Additionally, no noticeable difference was observed between groups ‘E+P’ and ‘N’ for length of hospitalization.

DISCUSSION

Although a trend was observed towards decreased overall and daily morphine use our results failed to reach statistical significance. Baig et al and Beaussier both found that narcotic use was diminished in patients using the elastomeric pain pump when compared to patients who did not have this modality (or those who had saline infused as a control)\(^1,3\). In a randomized trial, Rigg et al found decreased pain scores on the first three postoperative days when a continuous epidural was used postoperatively\(^13\). Considering these studies, a diminished use of morphine would be expected.
with combined modalities. It is possible that with a larger
study population statistical significance may have been
reached. Another factor that may have contributed to the
lack of correlation is the diversity of the study patient
population. Though accounting for narcotic sensitivity by
excluding patients with chronic opiate use and opiate abuse
history, patients in general have differing tolerance to
opiates. Patients who underwent different operations may
differ in different requirements related to the nature of their
operation. Another confounding factor is the variability with
narcotic conversion. We used the conversions listed in
Table I14, although frequently these conversions can be
represented by ranges.

Our institution records pain scores when patients are
receiving pro re nata (PRN) pain medications. Therefore,
data were not available for daily pain scores on patients not
receiving PRN medications. It is possible that study patients
who utilized both epidural and elastomeric pain pump
analgesia were more comfortable than the other groups
despite not demonstrating significant narcotic use
differences.

Studying these factors in a prospective manner may be
worthwhile. Clinician bias concerning patients who were
assumed to be higher risk for difficulty with pain
management may have influenced which patients received
specific treatment modalities. For instance, those patients
that were assumed would experience worse pain were likely
to get both an epidural and elastomeric pump for pain
control. This may have masked potential differences.
Patients who were receiving an operation for cancer
diagnoses had a statistically significant higher use of
epidurals, demonstrating a difference between sample
groups in terms of diagnosis and type of operation.

No statistical significance was seen when length of hospital
stay was compared between groups. This may be the result
of having an uncontrolled patient population. Complications
contributed to increased length of stay. Some patients
underwent a number of different operations, therefore type
of surgery and indication for surgery likely contributed
significantly to the length of hospital stay. We attempted to
look at the patients undergoing the Whipple procedure
specifically, but lacked numbers in order to look at this
group individually. Other contributions to length of
hospitalization that were not accounted for in our study
include patients who were waiting in the hospital for a bed at
a nursing home or rehabilitation institution to become
available, and other medical co-morbidities contributing to
prolonged hospital stay.

Fortunately, there were relatively few complications in any
of the study groups. There were no differences seen in
complications between groups, specifically when wound
infection, the most likely adverse effect from an elastomeric
pain pump, was considered. This suggests that initially using
an epidural and transitioning to an elastomeric pain pump is
a safe way to incorporate local anesthesia as an adjunct into
postoperative pain management plans. We were unable to
infer from chart review if those who used narcotics had
additional untoward side effects such as nausea/vomiting
and ileus, or if using multimodal of local anesthetics
diminished these side effects.

In conclusion, though no statistical significance was seen
with the method of transitioning from an epidural to
isomeric pain pumps, it appears to be a safe option. And of
course, a multimodal and individualized approach to post-
operative pain management is recommended.

DISCLOSURES
Drs. Rose, Gordon, Romero, Najafi, Boyle, and Ong have no
conflict of interest or financial disclosures relevant to the
topic of the submitted manuscript.

All authors were involved in the drafting of the manuscript
or revised it critically for important intellectual content, and
all authors gave final approval of the version of the article to
be published.

Additionally,
Jessica Rose: Concept design, acquisition of data, analysis of
data
Janalee Gordon: Concept design, acquisition of data
Andrew Romero: Acquisition of data
Bijan Najafi: Analysis of data
Patrick Boyle: Concept design
Evan Ong: Concept design

QUESTIONS:
1. The best modality for post-operative pain control is…?
   a. Narcotics
   b. Benzodiazepines
Elastomeric Pain Pump as a Bridge for Local Pain Control After Epidural Removal in Abdominal Surgery Patients

- Local anesthetics
- Multimodal

Answer = D. As stated in the introduction, there are pros and cons of all groups of medications. One can infer that using multiple different types of medications, in our case both narcotics and local anesthetics, is beneficial in postoperative pain control.

2. True or false. A higher complication rate can be expected if you combine epidural anesthesia with elastomeric pain pumps?

a. True
b. False

Answer is B. We did not find any increased complications with both modalities.

References
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