Interactions Between Pulmonary Performance and Movement-Evoked Pain in the Immediate Postsurgical Period: Implications for Perioperative Research and Treatment

Jason Erb, M.D., Elizabeth Orr, R.N., C. Dale Mercer, M.D., F.R.C.S.C., and Ian Gilron, M.D., M.Sc., F.R.C.P.C.

Background and Objectives: Previous data suggest that movement-evoked pain is more closely correlated with pulmonary performance than rest pain beyond 24 hours following lower abdominal surgery. Because adverse alterations in lung physiology are initiated intraoperatively and impact upon pulmonary morbidity, this study tests the hypothesis that movement-evoked pain correlates negatively with pulmonary performance in the immediate postoperative period.

Methods: We measured pain at rest and pain evoked by sitting, forced expiration, and coughing as well as peak expiratory flow (PEF), forced expiratory volume in 1 second, and forced vital capacity for the first 3 hours after laparoscopic cholecystectomy in 65 patients.

Results: Immediately after surgery, all pain measures were significantly correlated with PEF with a medium effect size. Also, sitting-evoked pain and cough-evoked pain were significantly more intense than rest pain. Pain intensity improved significantly over the first 3 postoperative hours.

Conclusions: Considering these and previous results, pulmonary function tests such as PEF should be considered for more routine use as functional surrogates of movement-evoked pain in analgesic trials of thoracic and abdominal surgery. Mechanisms of immediate postoperative movement-evoked pain may differ from those in effect at later time points after which tissue inflammation and spinal sensitization develop. Because pain adversely impacts upon postoperative rehabilitation, these results further imply that aggressive treatment of movement-evoked pain could improve the outcome of postoperative rehabilitation measures if both are implemented very early after surgery. *Reg Anesth Pain Med 2008;33:312-319.*

Key Words: Surgical pain, Postoperative complications, Central sensitization, Peripheral sensitization, Hyperalgesia, Respiratory physiology.

Over 40 million surgeries are performed in North America per year and moderate to severe postsurgical pain occurs in over half of these.[1,2] While postoperative pain itself is an important source of morbidity,[3] evidence also exists to suggest that pain is an important contributor to adverse outcomes following surgery.[4,5] One important condition in which pain, and treatment thereof, may affect adverse outcomes is that of postoperative lung dysfunction.[6] Postoperative lung dysfunction has long been recognized as a multifactorial condition affected by intraoperative body position, general anesthesia, muscle relaxation, and endotracheal positive-pressure ventilation, as well as postoperative pain.[7-9]

The development of postoperative pain measurement scales initially focused on the assessment of spontaneous pain or pain at rest.[10,11] However, incorporation of measures of "movement-evoked" pain or pain during normal activities (e.g., sitting, breathing, or coughing) has gradually become a more common research practice,[12,13] although this is not homogeneously done across all current post-

From the Departments of Anesthesiology (J.E., E.O., I.G.), Surgery (C.D.M.), and Pharmacology and Toxicology (I.G.), Queen's University and Kingston General Hospital, Kingston, Ontario, Canada.

Accepted for publication January 16, 2008.

This work was supported by Physicians' Services Incorporated Foundation Grant number 03-30 and Queen's University Grant number 383-861. Ian Gilron is supported by a Canadian Institutes of Health Research New Investigator Award. The authors have no conflict to declare.

Reprint requests: Ian Gilron, M.D., M.Sc., F.R.C.P.C., Departments of Anesthesiology and Pharmacology & Toxicology, Queen's University, Kingston General Hospital, 76 Stuart St., Kingston, Ontario K7L 2V7, Canada. E-mail: gilroni@post.queensu.ca

1098-7339/08/3304-0001$34.00/0
doi:10.1016/j.rapm.2008.01.003

operative pain studies.[14] The importance of differentiating between pain at rest and pain evoked by movement is that movement-evoked pain is generally more intense than rest pain,[13,15] movement-evoked pain is more resistant than rest pain to treatment with opioids (as opposed to other analgesic drugs such as nonsteroidal anti-inflammatory drugs and local anesthetics),[13,16,17] and finally, movement-evoked pain has been specifically shown to contribute to postoperative pulmonary dysfunction.[18]

In a recent study of women following abdominal hysterectomy, we reported that pain evoked by sitting up, and by coughing, correlated more consistently with reductions in peak expiratory flow (PEF) rate than did pain at rest on postoperative days 1 and 2.[15] This further suggests that movement-evoked pain may exert a negative impact on postoperative pulmonary function. However, this study measured only PEF rate in the setting of lower abdominal surgery and measurements were not done during postanesthetic recovery immediately after surgery.[15] Thus, the present study seeks to test the hypothesis that movement-evoked pain is significantly correlated with a wider range of pulmonary function measures (i.e., PEF, forced vital capacity [FVC], and forced expiratory volume in 1 second [FEV1]) in the immediate postoperative period. We chose laparoscopic cholecystectomy patients for this study because this surgical procedure is more likely to be associated with pain evoked by respiratory movement, and also because patients were considered alert enough in the immediate postoperative period to participate according to the study protocol.

Methods

Patients

Ethics approval was obtained from the Queen's University Research Ethics Board. This was a prospective study of 65 consenting American Society of Anesthesiologists classification I or II patients undergoing elective laparoscopic cholecystectomy. Exclusion criteria included: (1) a body mass index greater than 35 (weight [kg] divided by height [m^2]); (2) cardiopulmonary disease/dysfunction; (3) neuromuscular disease/dysfunction; (4) persistent pain prior to surgery; (5) history of alcohol or substance abuse; and (6) any hypersensitivity or intolerance to opioids.

Anesthetic/Analgesic Protocols

Intraoperatively, patients received a balanced anesthetic with intravenous fentanyl, an intravenous induction agent (propofol or sodium thiopental), muscle relaxant, and an inhalational volatile agent with or without nitrous oxide, at the discretion of the attending anesthesiologist. No more than 15 mL of 0.25% bupivicaine was used to infiltrate laparoscopic equipment insertion sites. Intraoperative prophylactic antiemetic therapy included ondansetron 4 mg intravenously given 30 minutes before anticipated completion of surgery. Perioperative analgesia in the postanesthetic care unit (PACU) included intravenous fentanyl as titrated by a nurse (12.5-25 mcg intravenously every 3 minutes as needed), and patients could also receive nonopioid coanalgesics.

Study Measures

Prior to surgery (baseline) and at each study time point (i.e., 60, 90, 120, 150, and 180 minutes after arrival in the PACU), patients completed a series of pulmonary function tests and pain ratings under various conditions. These study measures included assessment of pain intensity, on a 0 to 10 numerical rating scale (0-10 NRS), in the following order: (1) at rest (REST); (2) during sitting up, in a standardized fashion, from the supine position (SIT), followed by a 60-second rest period; (3) upon an FVC maneuver (BLOW) using a portable computerized spirometer (Spirolab II, Roxon Medi-tech Ltd, Montreal, Quebec, Canada), followed by a 60-second rest period; and (4) during a cough (COUGH). In addition to measuring BLOW pain at each time point, the resulting PEF, FEV1, and FVC were also recorded (best of 3 attempts corresponding to the highest PEF). Other measures, at each time point, included oxygen saturation by finger pulse oximeter (Onyx®, Nonin Medical Inc., Plymouth, MN), and presence of ongoing administration of supplemental oxygen. Pain intensity scores, and PEF, FEV1, and FVC measurements, were recorded at 30-minute intervals starting at 60 minutes after arrival in the PACU and continuing until the patient was discharged from the PACU.

Data Analysis

In our previous study examining the relationship between pain and pulmonary function following hysterectomy, a sample size of 25 was estimated to have 80% power to measure a correlation of 0.6 with a 2-tailed α value of 0.05.[15] However, in the PACU on the day of surgery, less than half of the patients in that study were able to comply with pulmonary function testing (e.g., due to excessive sedation). Therefore, we estimated that—for the present study—a sample of 65 patients would pro-