Improving Individual Measurement of Postoperative Pain: The Pain Trajectory

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Abstract: The purpose of this study was to demonstrate a method for increasing the precision and information yield of postoperative pain assessment. We recorded pain intensity ratings over 6 days after surgery in 502 elective surgery patients and examined individual pain trajectories. A linear fit of an individual patient's scores defines a trajectory with two features: (1) the intercept or initial pain intensity; and (2) the slope, or rate of pain resolution. Three pain trajectory patterns emerged from examination of the pain trajectory slopes. Most patients (63% of the sample) demonstrated a negative slope trajectory characterized by a decline in pain intensity over days after surgery. Other patients (25% of the sample) demonstrated a flat trajectory with no meaningful change over 6 days from pain they reported initially. A third patient group (12% of the sample) had a positive slope trajectory in which pain scores increased over 6 days after surgery. Measures derived from individual pain trajectories yielded much lower standard errors of measurement and therefore had better measurement precision than did conventional pain assessment methods. Pain trajectory measures proved sufficiently precise to characterize pain patterns reliably in individual patients.
Perspective: Progress in acute pain management requires effective pain assessment. The acute pain trajectory quantifies rate of pain resolution as well as pain intensity. It affords more precise measurement than conventional pain assessment and can identify abnormal postoperative pain resolution.

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Despite increased attention to the problem in recent decades, acute postoperative pain (POP) control remains an ongoing challenge.[1,4,9] Failure to control POP effectively increases the cost of care and causes significant suffering. Widespread speculation based on emerging literature holds that inadequately controlled postoperative pain is one of the major risk factors for the development of chronic postoperative pain.[3,5]

Progress in POP management depends on quality of POP assessment. Current pain assessment practices hinder progress in pain control because of three limitations. First, postoperative pain, like all pain, is complex and multidimensional,[10] and reducing it to a single number is a pragmatic oversimplification. Clinicians may sometimes reify the number and treat it rather than the person in pain. Second, the 11-point numerical rating scale (NRS) and the 101-point visual analog scale (VAS), though adequate for epidemiological purposes, are too imprecise to characterize individual patient POP meaningfully.[2] Third, POP assessment methods typically ignore the self-limiting nature of acute pain and fail to determine the rate of POP resolution. Because acute pain is self-limiting, its chronological dimension merits inclusion in pain assessment.

Measurement precision is a function of measurement error. All measurement involves some degree of error, and measures with less error are more precise than those with more error. Rating scale scores include error because they correspond imperfectly to the patient's true underlying pain. The standard error of measurement (SEM) gauges a measurement tool's precision, indicating the typical error of measurement, the give-or-take amount by which a single score is likely to be off. Measurements with small SEMs are quite accurate and therefore reasonably precise, whereas measurements with large SEMs have poor accuracy and low precision. For a given measurement instrument, the SEM is the standard deviation of the measurement errors across individuals in a population. Improved precision is a fundamental goal of innovation in POP measurement.

Table 1. Education Level by Ethnicity

ETHNICITY	COLLEGE DEGREE	HIGH SCHOOL DIPLOMA	POSTGRADUATE DEGREE	SOME COLLEGE	SOME HIGH SCHOOL
African American	6	24	0	6	6
Asian/Pacific Islander	12	6	0	24	6
Caucasian	714	636	282	936	138
Hispanic	12	36	18	78	36
Native American or Alaskan Native	6	6	0	0	6
Other	0	0	12	0	6

Resolution over time is a key feature of POP, and the rate of pain resolution is a potentially important clinical outcome. Yet, conventional POP measurement practices focus on static measures of pain that simply gauge POP intensity for a particular time epoch, sometimes averaging multiple pain reports obtained over time to arrive at a single score. This approach provides no information about the rate of pain resolution or POP duration. Simply plotting an individual patient's pain scores over time reveals a monotonic trend of pain resolution, or a trajectory, that informs the clinician not only about pain intensity but also rate of change in POP. Defining POP as a trajectory rather than as one or more simple point estimates of intensity increases the information yield of pain assessment and improves measurement precision.

The primary purpose of this report is to demonstrate and evaluate a method for modeling the POP trajectories of individual patients over 6 days after elective surgery. The trajectory approach to POP measurement permits classification of patients as (1) resolving pain over time; (2) maintaining a constant level of pain over time; or (3) increasing in pain over time. The secondary purposes of this report are to (1) demonstrate that measurement precision of the pain trajectory is superior to that of conventional NRS point estimation; (2) demonstrate the application of the POP trajectory to individual cases; and (3) examine differences in the POP trajectory across age, sex, surgical site, education level, and ethnic group.

Materials and Methods

Subjects

A convenience sample of 711 elective surgery patients in the University of Utah Healthcare System gave informed consent to participate in a study of larger scope that included daily reports of postoperative pain intensity. The study had the approval of the University of Utah Institutional Review Board. Of the 711 patients consented, 502 provided complete NRS data over 6 days after surgery. These patients ranged in age from 18 to 84 years, with a median age of 46 years, and 260 were female. The proportion of female sex by surgical sites was as follows: abdomen, 100 of 154; back, 13 of 32; chest, 20 of 27; head/neck, 23 of 51; hip, 22 of 42; limb, 74 of 174; and shoulder, 8 of 22. Table 1 breaks down the sample by ethnicity and education level.

Inclusion criteria for study participation were age ≥18 years and elective orthopedic or general surgery at the University of Utah. Exclusion criteria were inability to

speak English, physical or psychiatric comorbidities that could compromise the ability of the patient to comply with study requirements, ongoing treatment for a preexisting chronic pain condition, and ophthalmic surgery. We also excluded patients who would be unavailable for postdischarge follow-up.

Pain Measurement

Patients provided a pain report daily using an 11-point NRS ranging from zero to 10, with the anchors "no pain" at zero and "worst possible pain" at 10. Participants agreed to provide pain ratings at interview while in the hospital and to provide subsequent pain ratings on a daily basis after discharge until they had completed the full 6-day record. Using postage-paid return envelopes, they mailed their completed data forms to the study coordinator, who entered the ratings into the database and deidentified the records.

Procedures

Data collectors performed initial screening on medical records, contacted potential volunteers before surgery on surgical wards, and obtained informed consent. They instructed consented subjects in the use of the booklet to report their pain levels on a daily basis, telling them to record their report at their convenience each day. Patients rated their postoperative pain at rest for the day. Day 1 in the data record was the first full day of recovery after surgery. Participants who completed and returned the full 6 days of data recording received a coupon worth $30 at a local store. Seventy-one percent of consented subjects provided a complete data record.

Design and Statistical Approach

The pain trajectory is a longitudinal characterization of acute pain as a growth curve, normally resolving in intensity over days. The psychometric goal of growth curve modeling is to estimate the true, dynamic course of acute pain resolution in each individual. A basic assumption of this approach is that acute pain is an attribute of the individual patient that follows a dynamic trajectory, with individuals differing in the specific features of their unique pain trajectories. The most parsimonious characterization of an individual trajectory across six measures is a linear fit, and simple linear plots of pain intensity over days provide reasonable approximations of the true underlying pain trajectories. With this simple linear model, each patient's trajectory has two key features: