Patient Attributes Influencing Pain and Pain Management in Postoperative Total Knee Arthroplasty Patients

Concurrent Session 1F
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Study Goal
Generate the best predictive models for pain intensity, opioid consumption, and comfort goal attainment for use in clinical management of postoperative pain for knee arthroplasty patients

Study Design
• Retrospective descriptive study
• Data extracted from a pre-existing dataset created from a clinical data repository
Research Questions

• What patient demographic, ethnocultural, and biomedical attributes, individually or in combination, influence postoperative pain intensity on postoperative day one through three?

• Is there a significant interaction between the demographic, ethnocultural, and biomedical attributes associated with pain intensity over time?

Research Questions

• What patient demographic, ethnocultural, and biomedical attributes, individually or in combination, influence postoperative opioid consumption on postoperative day one through three?

• Is there a significant interaction between the demographic, ethnocultural, and biomedical attributes associated with opioid consumption over time?

Research Questions

• What is the relationship between patient attributes and postoperative comfort goal attainment on postoperative day one through three?

• Is there a significant interaction between the demographic, ethnocultural and biomedical attributes and postoperative day associated with comfort goal attainment?
Background

• Unrelieved postoperative pain has profound consequences
• Pain following orthopedic surgery is often reported as moderate or severe
• Knee arthroplasty is one of the most common surgical procedures performed in the U.S. and is expected to increase by 300% per year through 2030

Significance

• Identified demographic, biological, and ethnocultural factors that contribute to postoperative pain intensity, opioid consumption, and comfort goal attainment for total knee arthroplasty patients
• Clinical management of acute pain has failed due to lack of individualized treatment

Significance

• Past studies of pain intensity rating and opioid consumption have dealt mainly with the 12 – 24 hour postoperative period
• No studies had examined factors that influence comfort goal attainment in adults with acute pain
Research Framework

• Multidimensional approach
  - Demographic
  - Biological
  - Ethnocultural

Literature Review

• Preoperative pain intensity
• Age
• Sex
• Race/ethnicity
• Obesity
• Smoking
• Psychological factors
• Goal setting

Variables

<table>
<thead>
<tr>
<th>Modifiable</th>
<th>Unmodifiable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obesity</td>
<td>Preoperative pain intensity</td>
</tr>
<tr>
<td>Smoking</td>
<td>Age</td>
</tr>
<tr>
<td></td>
<td>Sex</td>
</tr>
<tr>
<td></td>
<td>Race/ethnicity</td>
</tr>
</tbody>
</table>
Setting and Sample

• Midwestern 13 hospital system
• January 1, 2008 – December 31, 2008

Inclusion criteria

• Unilateral total knee arthroplasty (ICD-9 code 81.54)
• 18 to 89 years of age
• Consistent use of numeric rating scale for pain intensity

Exclusion Criteria

• Addictive disorders
• Selected pain syndromes
• Depression
Procedure

- Data acquired from Oracle database using SQL-based language called CCL
- Data was de-identified
- No text extraction
- Preprocessing of data

Generalized Estimating Equations

- Models linear, logistic, or logarithmic relationships between the patient attributes and the outcomes
- Can use with interval, dichotomous, ordinal, or categorical outcomes
- Allows for inclusion of fixed variables as well as variables that changed at each observation
- Incorporates different numbers of observations for different clusters
- Accommodates random missing data
- Handles unequal intervals between observations

Types of Models Generated

- Unadjusted
- Adjusted
- Best predictive model

Best predictive model = \( \beta_0 \) (intercept) + \( \beta_1 \) + \( \beta_2 \) + \( \beta_3 \) + \( \beta_4 \) …
Description of the Sample

- 1123 unique patient records
- 95% Caucasian
- 63% female
- Age ranged from 26 to 89 years
- 25% overweight, 66% obese
- 51% never smoked
- 31% quit smoking >12 months prior to surgery

Significant Findings

Pain Intensity: Unadjusted

- Black race ↑ (p = 0.01)
- Males ↓ (p < 0.0001)
- Current smokers ↑ (p < 0.0001)
- Former < 12 months ↑ (p = 0.01)
- BMI 32.8 ↑ (p = 0.001)
- Age 65 ↓ (p < 0.0001)
- Preoperative pain ↑ (p < 0.0001)

Adjusted Analysis Pain Intensity

- Race (p = 0.02)
- Sex (p < 0.0001)
- Smoking status (p = 0.0049)
- Age (p < 0.0001)
- Preoperative pain intensity (p < 0.0001)
- Postoperative day (p < 0.0001)
Best Predictive Model

| Parameter       | Regression Coefficient Estimate | 95% Confidence Limits | Pr>|Z| |
|-----------------|---------------------------------|-----------------------|-----|
| Intercept       | 3.5                             | 0.3307–1.2899         | 0.0009 |
| Black           | 0.8                             | -0.3307–1.2899        | 0.0009 |
| Male            | -0.5                            | -0.6276–0.3238        | <0.0001|
| Smoking Current | 0.4                             | 0.1820–0.6734         | 0.0007 |
| AGEc            | -0.04                           | -0.0418–0.0290        | <0.0001|
| Day 2           | 0.8                             | 0.6580–0.9708         | <0.0001|
| Day 3           | 0.4                             | 0.2861–0.5292         | <0.0001|

Applying the Model

- **Day 1 Pain Intensity Prediction** = 3.5161 + 0.8103 - 0.4752 + 0.4287 - 0.0364 = 4.2435
- **Day 2 Pain Intensity Prediction** = 3.5161 + 0.8103 - 0.4752 + 0.4287 - 0.0364 + 0.7644 = 5.0079
- **Day 3 Pain Intensity Prediction** = 3.5161 + 0.8103 - 0.4752 + 0.4287 - 0.0364 + 0.4076 = 4.6511

Clinical Example

- **Patient is black, 55-year-old female who never smoked**
- Calculate postoperative pain intensity for day 3

3.5161 + 0.8103 - 0.4752*0 + 0.4287*0 - 0.0364(55-65) + 0.4076 = 5.098
**Significant Findings**

**Opioid Consumption: Unadjusted**

- Smoking status
  - Current ($p = <0.0018$)
  - Former < 12 m prior to surgery ($p = <0.0075$)
- BMI ($p = <0.0284$)
- Age ($p = <0.0001$)
- Preoperative pain intensity ($p = <0.0009$)
- Postoperative day ($p = <0.0001$)

**Adjusted Analysis**

**Opioid Consumption**

| Parameter                  | Regression Coefficient Estimate | 95% Confidence Limits | Pr>|Z|  |
|-----------------------------|----------------------------------|-----------------------|-----|
| Intercept                   | 16.2                             | 14.7649-17.6079       |     |
| AGEc                        | -0.4                             | -0.473 - 0.2668       | <0.0001 |
| Preoperative Pain Intensity | 0.5                              | 0.1132-0.9010         | 0.0116 |
| Postoperative Day 2         | 9.2                              | 8.0949-10.3486        | <0.0001 |
| Postoperative Day 3         | 5.0                              | 3.7714-6.4109         | <0.0001 |

**Best Predictive Model**

| Parameter                  | Regression Coefficient Estimate | 95% Confidence Limits | Pr>|Z|  |
|-----------------------------|----------------------------------|-----------------------|-----|
| Intercept                   | 17.2                             |                       |     |
| Black                       | 8.4495                           | 6.1776-10.7214        | 0.0453 |
| Smoking Former < 12 m       | 9.9435                           | -1.1857-11.0727       | 0.1139 |
| AGEc                        | -0.0837                          | -0.1683-0.0010        | <0.0001 |
| Postoperative Day 2         | 9.6779                           | 8.5775-10.7784        | <0.0001 |
| Postoperative Day 3         | 5.5044                           | 4.2255-6.7833         | <0.0001 |
Applying the Model

- Day 1 Opioid Consumption Prediction = 17.2074 + 8.4495 + 4.9435 - 0.4037 = 30.1967 morphine equivalents
- Day 2 Opioid Consumption Prediction = 17.2074 + 8.4495 + 4.9435 - 0.4037 + 9.6779 = 39.8746 morphine equivalents
- Day 3 Opioid Consumption Prediction = 17.2074 + 8.4495 + 4.9435 - 0.4037 + 5.5044 = 35.7011 morphine equivalents

Clinical Example

- Patient is not black and 55 years old
- Calculate opioid consumption for postoperative day 2
  - 17.2074 + 8.4495*0 + 4.9435 - 0.4037(55-65) + 9.6779 = 35.8658 morphine equivalents

Significant Findings

Comfort Goal Attainment: Unadjusted

- Age ($p = 0.0001$)
- Smoking status
  - Current ($p = 0.0013$)
  - Unconfirmed ($p < 0.0001$)
- Preoperative pain intensity ($p = 0.0001$)
- Postoperative day
  - Day 2 ($p = 0.0001$)
  - Day 3 ($p = 0.0001$)
### Adjusted Analysis

#### Comfort Goal Attainment

| Parameter               | Regression Coefficient Estimate | 95% Confidence Limits     | Pr>|Z| |
|-------------------------|---------------------------------|---------------------------|------|
| Intercept               | 0.1696                          |                           |      |
| Black                   | -1.3473                         | 0.6396–2.0557             | 0.0002|
| Smoking unconfirmed     | -1.7060                         | 1.0986–2.3257             | <0.0001|
| AGEc                    | 0.0283                          | -0.0420–0.0147            | <0.0001|
| BMIC                    | 0.0419                          | -0.0292–0.0245            | <0.0001|
| Day 2                   | -0.7416                         | 0.9270–0.0562             | <0.0001|
| Day 3                   | -0.4319                         | 0.2973–0.5666             | <0.0001|
| Preoperative pain       | -0.1517                         | 0.0945–0.2088             | <0.0001|

### Best Predictive Model

| Parameter               | Regression Coefficient Estimate | 95% Confidence Limits     | Pr>|Z| |
|-------------------------|---------------------------------|---------------------------|------|
| Intercept               | -0.1607                         |                           |      |
| Black                   | -1.0976                         | 1.1024–2.2919             | <0.0001|
| Smoking unconfirmed     | -2.0142                         | 1.3748–2.6536             | <0.0001|
| BMIC                    | 0.0361                          | -0.0531–0.0191            | <0.0001|
| AGEc                    | 0.0333                          | -0.0346–0.0020            | <0.0001|
| Day 2                   | -0.7620                         | 0.6520–0.8721             | <0.0001|
| Day 3                   | -0.4650                         | 0.3346–0.5955             | <0.0001|

### Applying the Model

- **Day 1 Attainment:** 
  \[-0.1607 - 1.6976 - 2.0142 + 0.0361 + 0.0333 = -3.8031\]

- **Day 2 Attainment:** 
  \[-0.1607 - 1.6976 - 2.0142 + 0.0361 + 0.0333 - 0.7620 = -4.5651\]

- **Day 3 Attainment:** 
  \[-0.1607 - 1.6976 - 2.0142 + 0.0361 + 0.0333 - 0.4650 = -4.2681\]
Clinical Example

- Patient is not black, smokes, has a BMI of 25 and is 75 years old
- Calculate comfort goal attainment on all postoperative days
  - Day 1: $-0.1607 - 1.6976 \cdot 0 - 2.0142 \cdot 0 + 0.0361 \cdot (25-32.8) + 0.0333 \cdot (75-65) = -0.1092$
  - Day 2: $-0.1607 - 1.6976 \cdot 0 - 2.0142 \cdot 0 + 0.0361 \cdot (25-32.8) + 0.0333 \cdot (75-65) - 0.7620 = -0.8712$
  - Day 3: $-0.1607 - 1.6976 \cdot 0 - 2.0142 \cdot 0 + 0.0361 \cdot (25-32.8) + 0.0333 \cdot (75-65) - 0.4650 = -0.5742$

Implications

- Added to pain management knowledge base
- Unique contributions
  - New predictive models
  - Presents comfort goal attainment as opposed to need to set comfort goals
- Highlighted documentation issues

Limitations

- Retrospective
- Multiple surgeons
- Multiple protocols
- Some say use of numeric rating scale is a limitation
Recommendations

• Validate predictive models
• Further investigation into modifiable predictors
• Studies with matched samples
• Replication with new preemptive, multimodal analgesia protocols
• Better exploitation of clinical databases for research
• Research into pain mechanisms

Research and the Electronic Patient Record:
Lessons Learned

Patient-Centered data vs Research-Centered data

Patient 1 data

Patient 2 data

Patient 3 data

Research Data
Approvals

- Organizational priority for data extraction
- Human resources (if personnel are participants)
- Chief nurse executives
- Informed consent from participants

Data Extraction Issues

- Who can extract the data?
- When will the data be in queue?
- Cost of data extraction?
- Use of variables table to facilitate data extraction

Variables Table

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Variable Label</th>
<th>Variable Location</th>
<th>Values</th>
<th>Value Labels or Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE</td>
<td>Age</td>
<td>Cerner&gt;Patient Information&gt;Patient Demographics&gt;Age</td>
<td>Integer</td>
<td>Date of admission - Minus birth date</td>
</tr>
<tr>
<td>PNSOURCE</td>
<td>Pain Source</td>
<td>Cerner&gt;Task List&gt;Patient Care&gt;Physical Assessment&gt;Pain Assessment&gt;Pain Source</td>
<td>Categorical</td>
<td>Patient, Family, RN, Caregiver, Other</td>
</tr>
</tbody>
</table>
Missing Data

- Amount
- Methodologies to account for missing data
  - Mixed-effects model
  - Generalized estimating equations

Other Issues

- Data cleaning time allotted
- Duplicate time stamps
- Sanity check
  - Doses
  - Time stamp
  - Route of administration

Recommendations

- Biostatistician upfront
- Aware of data cleaning time
- Panel of EHR users to validate data
- Relationship with data extractor
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