Quality of Recovery from Anesthesia in Neurosurgical Patients


Background: Factors influencing quality of recovery in cranial and spinal neurosurgical patients are not known, possibly because of lack of a suitable instrument. Therefore, the authors measured quality of recovery using the QoR-40 score (a 40-item questionnaire on quality of recovery from anesthesia).

Methods: With informed consent, 200 patients undergoing elective neurosurgery were recruited. The QoR-40 score, visual analog scores for pain and quality of recovery, and data on complications were collected over 90 days. The psychometrics of the QoR-40 were tested and regression models were developed to determine predictors of quality of recovery and postoperative pain.

Results: The QoR-40 score demonstrated significant responsiveness, validity, and reliability. In cranial surgery patients, QoR-40 scores were lower on days 1 and 2 than either preoperatively or on days 3, 30, and 90. In spinal surgery patients, QoR-40 scores were lower preoperatively and on days 1 and 2 than on days 3, 30, and 90. Longer duration of surgery, more complications, and higher visual analog scores for pain were predictors of poor quality of recovery on day 3. Cranial surgery patients had moderately severe pain on days 1 and 2, whereas spinal surgery patients reported moderate pain for the whole study period. Neurologic deficits were negatively correlated with QoR-40 scores in cranial and spinal surgery patients.

Conclusions: The QoR-40 score is a useful instrument with which to assess quality of recovery in cranial and spinal surgery patients. Postoperative pain and neurologic deficits correlate with poor quality of recovery in these patients.

INCREASINGLY, clinical researchers and healthcare providers have focused on measuring patients’ perceptions of the outcomes of care.1,2 Although satisfaction with anesthesia care in general is high,3–5 factors influencing satisfaction in neurosurgical patients are not known. Cranial neurosurgical patients report a higher rate of postoperative complications than the general surgical population.6,7 In addition, they may have unique cognitive or physical deficits postoperatively that affect the reliability and validity of measurement instruments.5 Spinal surgery patients have a high incidence of chronic pain preoperatively, which may affect their assessment of quality of recovery.8,9 Therefore, evaluation of neurosurgical patients’ perceptions of quality of recovery is warranted.

The QoR-40 score was developed by Myles et al.10,11 to measure quality of recovery from anesthesia. Forty questions in five dimensions are scored by patients on a five-point Likert scale. The minimum score (indicating poor quality of recovery) is 40, and the maximum score is 200. The QoR-40 score was reported to have acceptable psychometric properties in general surgical13 and cardiac surgical patients.12 The QoR-40 has not been independently validated nor has it been specifically tested in cranial or spinal neurosurgical patients.

Therefore, we measured the performance of the QoR-40 score and described quality of recovery in cranial surgery and spinal surgery patients. Spinal surgery patients were chosen as a comparison group because they are cared for by the same service as cranial surgery patients but have different preoperative and postoperative problems from both cranial and general surgery patients.11 We also sought to identify predictors of poor quality of recovery and postoperative pain.

Methods

With approval of the Human Research Ethics Committee of Royal Melbourne Hospital, all patients undergoing elective neurosurgical procedures who met the inclusion criteria were approached until 200 consenting patients were recruited. Patients were eligible for inclusion if they were (1) age 18 yr or older; (2) undergoing elective neurosurgery under general anesthesia; and (3) admitted to the hospital for at least 1 postoperative night. Patients were excluded if they were (1) added to the operating list on the day of surgery as an emergency; (2) unable to communicate in English because of a language barrier, an intellectual disability, dementia, or an altered conscious state; (3) not expected to cooperate or be available for postoperative interviews; (4) expected to be intubated at the time of the first postoperative interview; or (5) had a life-threatening condition (American Society of Anesthesiologists [ASA] physical status IV or V).

The characteristics of patients who were undergoing surgery on elective neurosurgery operating lists but...
were not recruited were noted, and the reasons for exclusion were recorded. Patients were excluded after recruitment if their surgery was cancelled on the day of recruitment and was never completed in the study period or if the patient withdrew from the study before any postoperative data were collected.

Data were collected preoperatively and on postoperative days 1, 2, 3, 30, and 90. The QoR-40 questionnaire and 100-mm visual analog scales for quality of recovery (VAS-QoR) and pain (VAS-Pain) were explained to patients, who completed them in the presence of the investigators preoperatively and on postoperative days 1, 2, and 3. Assistance in completing the questionnaire was provided if requested by the patient or offered if deemed necessary by the investigators. The questionnaire and scales were posted to patients for completion on days 30 and 90. If they were not returned within 1 week, the patient was contacted by telephone. Failure to return the questionnaire and scales triggered another attempt to contact the patient by phone.

The following data were collected from the patients and their medical records: age; sex; ASA physical status; extent, type, and duration of surgery; anesthetic maintenance agent; use of neuromuscular blockade, antiemetics, and analgesics; duration of postanesthesia care unit and hospital stay; and time and assistance required to make the follow-up period; mechanical ventilation any time during the follow-up period; further surgery for a neurosurgical condition or for the treatment of complications; new neurologic deficits occurring after surgery; the use of antiemetic medications (including dexamethasone); infection at any site; acute myocardial infarction; pulmonary embolism; and acute renal failure.

**Statistical Analyses**

All continuous data were first tested for normality. The distributions of age, duration of postanesthesia care unit stay, surgery, and admission were compared using two-sample Kolmogorov-Smirnov tests for equality of distribution functions. The distributions of sex, ASA physical status, site of surgery, and drug use were compared using chi-square tests or Fisher exact tests, where appropriate. QoR-40 scores in patients with and without neurologic deficits were compared using the Wilcoxon rank sum test.

The responsiveness of the QoR-40 score was assessed in the 143 patients with complete questionnaires. Relative changes in QoR-40 scores over time were calculated by comparing values to day 90 (“full recovery”). A significant difference from day 90 was defined by bootstrapping the relative change from day 90 on each day and determining that the 95% confidence intervals (CIs) of the bootstrapped mean did not include one. To further test for responsiveness, standardized response means were calculated by dividing the mean change in the score divided by the SD of the change. Standardized response means of 0.2, 0.5, and 0.8 correspond to small, medium, and large changes in QoR-40 scores.

The validity and reliability of the QoR-40 score were assessed in the 185 patients who completed the questionnaire on day 3. This day was chosen prospectively, based on our clinical experience that there should be good discrimination on this day between patients with good and poor recovery. The correlations between QoR-40 and VAS-QoR scores for cranial surgery patients and spinal surgery patients were tested using Spearman rank correlation (ρ; convergent validity). Differences between QoR-40 scores for men and women, for cranial and spinal patients, and for patients with good or bad recovery were tested using the Wilcoxon rank sum test. Good recovery was defined by the median of the VAS-QoR scores on day 3. Correlations between QoR-40 scores on day 3 and duration of hospital stay, duration of postanesthesia care unit stay, and the need for assistance to complete the questionnaire were tested using Spearman rank correlation (ρ; construct validity). Interdimension, dimension — total QoR-40, and item-to-item dimension correlations were tested using Spearman rank correlation (ρ) and Cronbach α. The dimension was included in the total QoR-40 score for the dimension — total QoR-40 correlations, but the item was excluded from the dimension for the item-to-item dimension correlations. Concordance between QoR-40 scores on days 2 and 3 and between the split halves of the QoR-40 was tested with Spearman rank correlation (ρ). Test-retest reliability was further assessed using intraclass correlation between days 2 and 3.

Impairment in quality of recovery on day 3 was defined by a QoR-40 less than 1 SD below the group mean for two or more dimensions or a global QoR-40 score less than 1 SD below the group mean. Relative changes in VAS-Pain scores over time were calculated by comparing values to day 0. Patients with a VAS-Pain score of zero on day 0 were excluded from this analysis (14% of patients). A significant difference from day 0 was defined by bootstrapping the mean change from day 0 on each day and determining that the 95% CIs of the bootstrapped mean did not include one. Univariate predictors of VAS-Pain scores were defined using generalized linear models. Significant factors (P < 0.1) were included in multivariate generalized linear regression models, and finally, parsimonious models were created.

All analyses were performed using Stata 6.0 (College Station, TX); P < 0.05 was considered statistically significant. Symmetric data are presented as mean ± SD; nonsymmetric data are presented as median (interquartile range) and counts as number (percent).
Results

Of the 453 patients who underwent surgery on elective operating lists during the study period, 200 were recruited. Eight recruited patients were later excluded from the study, leaving 192 patients in the cohort (fig. 1). Recruited patients were significantly younger (P = 0.003), had lower ASA physical status (P = 0.0001), and had a different spectrum of surgical procedures (P = 0.001) than excluded patients (more operations for benign intracranial tumors and spinal disorders; fewer operations for intracranial vascular and peripheral nerve disorders and cerebrospinal fluid shunts).

Of the 1,152 questionnaires that were administered to the 192 patients, 80 were not completed (48 cranial surgery and 32 spinal surgery; 7% of total). The missing questionnaires were confined to 49 patients (26 cranial surgery and 23 spinal surgery), leaving 143 patients who completed all six questionnaires (75% of total). The reasons for missing questionnaires were as follows: (1) dead (9 questionnaires); (2) too ill (22 questionnaires); (3) did not reply (45 questionnaires, mostly on days 30 and 90); and (4) missed (4 questionnaires).

The characteristics of the 192 patients are outlined in table 1. For cranial surgery patients, assistance in completing the questionnaire was required by 43% of patients preoperatively, 73% on postoperative day 1, 68% on postoperative day 2, 61% on postoperative day 3, 9% at 1 month, and 9% at 3 months. For spinal surgery patients, assistance in completing the questionnaire was required by 50% of patients preoperatively, 85% on postoperative day 1, 77% on postoperative day 2, 73% on postoperative day 3, 11% at 1 month, and 3% at 3 months. The median time taken to complete the questionnaire was 5 (5–10) min in both cranial and spinal surgery patients.

For cranial surgery patients, QoR-40 scores were significantly lower on days 1 and 2 than on day 90 but not preoperatively or on days 3 or 30. For spinal surgery patients, QoR-40 scores were significantly lower preoperatively and on days 1 and 2 than on day 90 but not on days 3 or 30 (fig. 2). Standardized response means were greater than 0.5 for the global score, physical comfort, physical independence, and pain dimensions in both cranial and spinal surgery patients, indicating medium to large changes in QoR-40 scores. Standardized response

Table 1. Demographic Characteristics of 192 Patients Included in Analysis

<table>
<thead>
<tr>
<th></th>
<th>Cranial Surgery (n = 100)</th>
<th>Spinal Surgery (n = 92)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td>52 ± 15 (22–81)</td>
<td>52 ± 16 (22–82)</td>
<td>0.9</td>
</tr>
<tr>
<td>Sex (male)</td>
<td>48 (48)</td>
<td>44 (48)</td>
<td>1.0</td>
</tr>
<tr>
<td>ASA physical status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>18 (18)</td>
<td>20 (22)</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>50 (50)</td>
<td>53 (58)</td>
<td>0.33</td>
</tr>
<tr>
<td>III</td>
<td>32 (32)</td>
<td>19 (20)</td>
<td></td>
</tr>
<tr>
<td>Premedication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>3 (3)</td>
<td>4 (4.5)</td>
<td>0.6</td>
</tr>
<tr>
<td>II</td>
<td>57 (57)</td>
<td>26 (28)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Intraoperative antiemetic (including dexamethasone)</td>
<td>4 (4)</td>
<td>7 (8)</td>
<td>0.2</td>
</tr>
<tr>
<td>Volatile anesthetic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>23 (23)</td>
<td>56 (61)</td>
<td>0.0001</td>
</tr>
<tr>
<td>II</td>
<td>96 (96)</td>
<td>90 (99)</td>
<td>0.5</td>
</tr>
<tr>
<td>PACU stay,* min</td>
<td>85 (55–165)</td>
<td>77 (30–420)</td>
<td>0.4</td>
</tr>
<tr>
<td>Patient-controlled analgesia</td>
<td>2 (2)</td>
<td>72 (78)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Duration of surgery, min</td>
<td>187 (30–795)</td>
<td>132 (40–460)</td>
<td>0.0007</td>
</tr>
<tr>
<td>Duration of admission, days</td>
<td>7 (1–29)</td>
<td>5 (1–83)</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Data are presented as mean ± SD (range) for symmetric data, median (range) for nonsymmetric data, and number (%) for categorical data. * n = 186 (6 patients admitted directly to the intensive care unit [cranial = 4; spinal = 2]).

ASA = American Society of Anesthesiologists.
means for the psychologic support and emotional state dimensions were small and did not change over time (tables 2 and 3).

The correlation between QoR-40 scores and VAS-QoR scores on day 3 was 0.50 for cranial surgery patients \((P < 0.0001)\) and 0.39 for spinal surgery patients \((P < 0.001)\). Patients with poor recovery (as defined by a VAS-QoR score < 74 [45% of patients]) had lower QoR-40 scores than patients with good recovery (cranial surgery patients: \(P < 0.0001\); spinal surgery patients: \(P = 0.0009\)), but QoR-40 scores for spinal surgery patients and cranial surgery patients (174 [160–182] vs. 177 [164–186]; \(P = 0.07\)) and for males and females (cranial surgery patients [174 [159–183] vs. 181 [168–190]; \(P = 0.05\); spinal surgery patients [168 [159–181] vs. 175 [163–183]; \(P = 0.37\)) were not significantly different. There was a significant negative correlation between QoR-40 on day 3 and duration of hospital stay (cranial surgery patients: \(r = -0.29; P = 0.004\); spinal surgery patients: \(r = -0.29; P = 0.005\)). For time taken to complete the questionnaire (cranial surgery patients: \(r = -0.34; P = 0.001\); spinal surgery patients: \(r = -0.23; P = 0.25\)) and duration of postanesthesia care unit stay (cranial surgery patients: \(r = -0.33; P = 0.001\); spinal surgery patients: \(r = 0.04; P = 0.67\)), there were differences between the two groups.

Values for internal consistency were as follows: dimension – global QoR-40 \(\alpha\): cranial patients = 0.95; spinal patients = 0.95; interdimension \(\alpha\): cranial patients = 0.97; spinal patients = 0.96. The dimension – global QoR-40 and interdimension correlation matrix are shown in table 4. The median item-to-own dimension correlation coefficients and Cronbach \(\alpha\) for each dimension were as follows: physical comfort (cranial surgery patients: \(r = 0.37; \alpha = 0.99\); spinal surgery patients: \(r = 0.40; \alpha = 0.99\)); physical independence (cranial surgery

### Table 2. Changes in QoR-40 Scores over Time in Cranial Surgery Patients

<table>
<thead>
<tr>
<th>QoR-40</th>
<th>Day 0</th>
<th>SRM</th>
<th>Day 1</th>
<th>SRM</th>
<th>Day 2</th>
<th>SRM</th>
<th>Day 3</th>
<th>SRM</th>
<th>Day 30</th>
<th>SRM</th>
<th>Day 90</th>
<th>SRM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>178 (19)</td>
<td>0.18</td>
<td>160 (19)</td>
<td>1.13</td>
<td>171 (19)</td>
<td>0.51</td>
<td>174 (19)</td>
<td>0.39</td>
<td>177 (17)</td>
<td>0.23</td>
<td>181 (18)</td>
<td></td>
</tr>
<tr>
<td>Physical comfort</td>
<td>52 (7)</td>
<td>0.22</td>
<td>47 (7)</td>
<td>0.96</td>
<td>51 (7)</td>
<td>0.46</td>
<td>51 (6)</td>
<td>0.39</td>
<td>53 (5)</td>
<td>0.19</td>
<td>54 (6)</td>
<td></td>
</tr>
<tr>
<td>Physical independence</td>
<td>23 (3)</td>
<td>0.07</td>
<td>14 (5)</td>
<td>1.74</td>
<td>18 (5)</td>
<td>0.95</td>
<td>20 (5)</td>
<td>0.68</td>
<td>22 (3)</td>
<td>0.40</td>
<td>23 (3)</td>
<td></td>
</tr>
<tr>
<td>Psychologic support</td>
<td>33 (3)</td>
<td>0.03</td>
<td>33 (3)</td>
<td>0.09</td>
<td>33 (3)</td>
<td>−0.12</td>
<td>33 (3)</td>
<td>−0.05</td>
<td>33 (3)</td>
<td>0.13</td>
<td>33 (3)</td>
<td></td>
</tr>
<tr>
<td>Emotional state</td>
<td>37 (7)</td>
<td>0.22</td>
<td>37 (6)</td>
<td>0.20</td>
<td>38 (6)</td>
<td>0.01</td>
<td>38 (6)</td>
<td>0</td>
<td>38 (6)</td>
<td>0.08</td>
<td>38 (7)</td>
<td></td>
</tr>
<tr>
<td>Pain</td>
<td>32 (4)</td>
<td>0</td>
<td>29 (4)</td>
<td>0.76</td>
<td>30 (5)</td>
<td>0.46</td>
<td>31 (5)</td>
<td>0.36</td>
<td>32 (4)</td>
<td>0.21</td>
<td>32 (3)</td>
<td></td>
</tr>
</tbody>
</table>

Scores are presented as mean (SD). SRM = standardized response mean = mean change in score divided by its SD, referenced to day 90 (“full recovery”). SRMs of 0.2, 0.5, and 0.8 correspond to small, medium, and large changes in quality of recovery (QoR)-40 scores, respectively.

### Table 3. Changes in QoR-40 Scores over Time in Spinal Surgery Patients

<table>
<thead>
<tr>
<th>QoR-40</th>
<th>Day 0</th>
<th>SRM</th>
<th>Day 1</th>
<th>SRM</th>
<th>Day 2</th>
<th>SRM</th>
<th>Day 3</th>
<th>SRM</th>
<th>Day 30</th>
<th>SRM</th>
<th>Day 90</th>
<th>SRM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>166 (17)</td>
<td>0.54</td>
<td>160 (15)</td>
<td>1.00</td>
<td>163 (19)</td>
<td>0.63</td>
<td>170 (18)</td>
<td>0.27</td>
<td>171 (19)</td>
<td>0.21</td>
<td>175 (20)</td>
<td></td>
</tr>
<tr>
<td>Physical comfort</td>
<td>51 (6)</td>
<td>0.58</td>
<td>48 (5)</td>
<td>1.09</td>
<td>49 (7)</td>
<td>0.76</td>
<td>52 (6)</td>
<td>0.44</td>
<td>53 (6)</td>
<td>0.27</td>
<td>54 (5)</td>
<td></td>
</tr>
<tr>
<td>Physical independence</td>
<td>21 (4)</td>
<td>0.30</td>
<td>13 (5)</td>
<td>1.71</td>
<td>17 (5)</td>
<td>0.88</td>
<td>19 (5)</td>
<td>0.58</td>
<td>20 (4)</td>
<td>0.49</td>
<td>22 (4)</td>
<td></td>
</tr>
<tr>
<td>Psychologic support</td>
<td>33 (2)</td>
<td>−0.47</td>
<td>33 (3)</td>
<td>−0.27</td>
<td>33 (4)</td>
<td>−0.13</td>
<td>33 (4)</td>
<td>−0.11</td>
<td>33 (4)</td>
<td>−0.08</td>
<td>32 (4)</td>
<td></td>
</tr>
<tr>
<td>Emotional state</td>
<td>34 (7)</td>
<td>0.33</td>
<td>38 (5)</td>
<td>−0.24</td>
<td>37 (6)</td>
<td>0</td>
<td>38 (6)</td>
<td>−0.28</td>
<td>36 (7)</td>
<td>0.09</td>
<td>37 (7)</td>
<td></td>
</tr>
<tr>
<td>Pain</td>
<td>27 (4)</td>
<td>0.71</td>
<td>27 (4)</td>
<td>0.66</td>
<td>37 (5)</td>
<td>0.53</td>
<td>28 (5)</td>
<td>0.34</td>
<td>29 (4)</td>
<td>0.07</td>
<td>30 (4)</td>
<td></td>
</tr>
</tbody>
</table>

Scores are presented as mean (SD). SRM = standardized response mean = mean change in score divided by its SD, referenced to day 90 (“full recovery”). SRMs of 0.2, 0.5, and 0.8 correspond to small, medium, and large changes in quality of recovery (QoR)-40 scores, respectively.

### Table 4. Dimension – Global QoR-40 Correlations and Interdimension Correlations

<table>
<thead>
<tr>
<th>QoR-40</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cranial patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Physical comfort ((n = 12))</td>
<td>0.86</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>2. Physical independence ((n = 5))</td>
<td>0.68</td>
<td>0.46</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3. Psychologic support ((n = 7))</td>
<td>0.48</td>
<td>0.33</td>
<td>0.31</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>4. Emotional state ((n = 9))</td>
<td>0.90</td>
<td>0.74</td>
<td>0.52</td>
<td>0.44</td>
<td>—</td>
</tr>
<tr>
<td>5. Pain ((n = 7))</td>
<td>0.56</td>
<td>0.43</td>
<td>0.33</td>
<td>0.01*</td>
<td>0.42</td>
</tr>
<tr>
<td>Spinal patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Physical comfort ((n = 12))</td>
<td>0.82</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>2. Physical independence ((n = 5))</td>
<td>0.51</td>
<td>0.25</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3. Psychologic support ((n = 7))</td>
<td>0.55</td>
<td>0.33</td>
<td>0.14*</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>4. Emotional state ((n = 9))</td>
<td>0.84</td>
<td>0.65</td>
<td>0.28</td>
<td>0.51</td>
<td>—</td>
</tr>
<tr>
<td>5. Pain ((n = 7))</td>
<td>0.60</td>
<td>0.39</td>
<td>0.11*</td>
<td>0.24</td>
<td>0.38</td>
</tr>
</tbody>
</table>

\(P < 0.05\) for all coefficients except * \(P > 0.05\).

QoR = quality of recovery.
Table 5. Univariate Predictors of Poor Recovery on Day 3

<table>
<thead>
<tr>
<th>Predictor of Poor Recovery</th>
<th>Cranial Patients</th>
<th>Spinal Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td>0.97 (0.94–1.01)</td>
<td>1.0 (0.97–1.04)</td>
</tr>
<tr>
<td>Sex (female vs. male)</td>
<td>1.17</td>
<td>0.82</td>
</tr>
<tr>
<td>ASA physical status (III vs. I/II)</td>
<td>2.05 (0.64–6.65)</td>
<td>0.88 (0.30–2.58)</td>
</tr>
<tr>
<td>Intraoperative antiemetic (yes vs. no)</td>
<td>0.54 (0.14–2.09)</td>
<td>1.98 (0.59–6.62)</td>
</tr>
<tr>
<td>Volatile anesthetic (yes vs. no)</td>
<td>0.37</td>
<td>0.27</td>
</tr>
<tr>
<td>Duration of surgery, h</td>
<td>0.87</td>
<td>0.34</td>
</tr>
<tr>
<td>Complications on days 1–3, n</td>
<td>0.73 (0.19–2.89)</td>
<td>0.44 (1.35–0.32)</td>
</tr>
<tr>
<td>Duration of hospital stay, days</td>
<td>1.40 (1.1–1.78)</td>
<td>1.35 (0.98–1.85)</td>
</tr>
<tr>
<td>Assistance with questionnaire (yes vs. no)</td>
<td>1.45 (0.87–2.41)</td>
<td>1.09 (0.91–1.30)</td>
</tr>
<tr>
<td>Time to complete questionnaire, min</td>
<td>0.15</td>
<td>0.35</td>
</tr>
<tr>
<td>PCA (yes vs. no)</td>
<td>2.21 (0.86–10.66)</td>
<td>0.32</td>
</tr>
<tr>
<td>VAS-Pain on day 3 (10 mm)</td>
<td>1.29 (1.05–1.59)</td>
<td>1.05 (1.02–1.08)</td>
</tr>
<tr>
<td>VAS-Pain on day 3 (10 mm)</td>
<td>0.02</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Complications on days 1–3, n</td>
<td>2.47 (1.37–4.46)</td>
<td>1.37 (0.80–2.34)</td>
</tr>
<tr>
<td>Complications on days 1–3, n</td>
<td>0.003</td>
<td>0.25</td>
</tr>
<tr>
<td>Complications on days 1–3, n</td>
<td>1.11 (0.98–1.26)</td>
<td>1.00 (0.94–1.06)</td>
</tr>
<tr>
<td>Complications on days 1–3, n</td>
<td>0.09</td>
<td>0.92</td>
</tr>
<tr>
<td>Assistance with questionnaire (yes vs. no)</td>
<td>4.20 (0.89–19.89)</td>
<td>1.69 (0.44–6.52)</td>
</tr>
<tr>
<td>Assistance with questionnaire (yes vs. no)</td>
<td>0.07</td>
<td>0.45</td>
</tr>
<tr>
<td>Time to complete questionnaire, min</td>
<td>1.00 (0.97–1.04)</td>
<td>1.15 (0.97–1.35)</td>
</tr>
<tr>
<td>Time to complete questionnaire, min</td>
<td>0.99</td>
<td>0.11</td>
</tr>
</tbody>
</table>

Data are presented as odds ratio (95% confidence interval) and P value.
ASA = American Society of Anesthesiologists; PCA = patient-controlled analgesia; VAS = visual analog scale.

In cranial surgery patients, VAS-Pain scores were greater than preoperative values on all postoperative days except day 90, whereas for spinal surgery patients, VAS-Pain scores were not significantly different from preoperative values on any postoperative day.

There was significant concordance between QoR-40 scores on days 2 and 3 (cranial surgery patients: ρ = 0.78; P < 0.0001; spinal surgery patients: ρ = 0.62; P < 0.0001), and the intraclass correlation coefficient was 0.78 (95% CI: 0.64–0.92) for cranial surgery patients and 0.49 (95% CI: 0.20–0.79) for spinal surgery patients. There was also significant split half correlation (cranial surgery patients: ρ = 0.57; P < 0.0001; spinal surgery patients: ρ = 0.68; P < 0.0001).

There was no significant difference in quality of recovery between cranial and spinal surgery patients (odds ratio: 1.12 [95% CI: 0.52–2.43]; P = 0.77). Univariate predictors of poor quality of recovery on day 3 are reported in table 5. In cranial surgery patients, VAS-Pain scores (odds ratio: 2.25 [95% CI: 1.49–5.50; P = 0.002] and the number of complications on days 1–3 (odds ratio: 1.40 [95% CI: 1.09–1.80; P = 0.008] predicted poor quality of recovery in multivariate analyses. In spinal surgery patients, VAS-Pain score (odds ratio: 1.70 [95% CI: 1.28–2.25; P < 0.001] was the only predictor of poor quality of recovery in multivariate analyses.

Cranial surgery patients and spinal surgery patients exhibited different patterns of VAS-Pain scores over
time, but there was no significant difference between them on day 1 ($P = 0.35$). Median preoperative VAS-Pain scores were 3 (95% CI: 2–5) in cranial surgery patients and 51 (95% CI: 47–58) in spinal surgery patients (fig. 3). For cranial surgery patients, VAS-Pain scores were greater than preoperative values on all postoperative days except day 90, whereas for spinal surgery patients, VAS-Pain scores were not significantly different from preoperative values on any postoperative day. Univariate predictors of high VAS-Pain scores are presented in table 6.

Nineteen percent of cranial surgery patients reported nausea or vomiting at the preoperative interview, 64% on day 1, 42% on day 2, 32% on day 3, 25% on day 30, and 27% on day 90. For spinal surgery patients, the percentages were 26%, 55%, 48%, 36%, 26%, and 21%, respectively. The rate of postoperative nausea and vomiting (PONV) on day 1 was not different between the cranial surgery and spinal surgery groups (odds ratio: 0.68 [95% CI: 0.38–1.24]; $P = 0.21$).

Twenty-four cranial surgery patients (24%) and 13 spinal surgery patients (14%) reported postoperative neurologic deficits. Of the cranial surgery patients with deficits, 19 had transient deficits, and 5 had deficits that persisted to day 90. Of the spinal surgery patients with deficits, 12 had transient deficits, and 1 had a deficit that persisted to day 90. The presence of a neurologic deficit after day 3 was a significant predictor of poorer quality of recovery (table 7).

Table 6. Univariate Predictors of VAS Pain Scores on Day 1

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Cranial</th>
<th>Spinal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr (yrs)</td>
<td>−0.04 (−0.08 to −0.02)</td>
<td>−0.04 (−0.07 to −0.01)</td>
</tr>
<tr>
<td>Sex (female vs. male)</td>
<td>0.04</td>
<td>0.03</td>
</tr>
<tr>
<td>ASA physical status (III vs. I/II)</td>
<td>0.88 (−0.29 to 2.05)</td>
<td>0.47 (−0.60 to 1.55)</td>
</tr>
<tr>
<td>Intraoperative antiemetic (yes vs. no)</td>
<td>−0.28 (−1.54 to 0.99)</td>
<td>−1.23 (−2.54 to 0.07)</td>
</tr>
<tr>
<td>Volatile anesthetic (yes vs. no)</td>
<td>−0.02 (−1.21 to 1.71)</td>
<td>0.17 (−1.03 to 1.37)</td>
</tr>
<tr>
<td>Duration of surgery, h</td>
<td>0.30 (−1.11 to 1.69)</td>
<td>−0.25 (−1.35 to 0.86)</td>
</tr>
<tr>
<td>PACU stay, h</td>
<td>−0.19 (−0.43 to 0.06)</td>
<td>−0.19 (−0.43 to 0.06)</td>
</tr>
<tr>
<td>PCA (yes vs. no)</td>
<td>0.06 (−0.25 to 0.14)</td>
<td>0.06 (−0.25 to 0.14)</td>
</tr>
<tr>
<td>Postoperative antiemetic (yes vs. no)</td>
<td>0.94 (−3.27 to 5.15)</td>
<td>1.82 (0.57 to 3.07)</td>
</tr>
<tr>
<td>Postoperative nausea and vomiting (yes vs. no)</td>
<td>0.07 (−1.24 to 1.38)</td>
<td>0.67 (−0.40 to 1.74)</td>
</tr>
<tr>
<td>Duration of hospital stay, days</td>
<td>2.41 (1.24 to 3.59)</td>
<td>1.08 (0.005 to 2.16)</td>
</tr>
</tbody>
</table>

Data are presented as coefficient (95% confidence interval) and P value.

ASA – American Society of Anesthesiologists; PCA – patient-controlled analgesia; VAS – visual analog scale.

required reintubation 2 days after cerebral aneurysm clipping. This patient also had acute myocardial infarction at this time. No patient required further surgery in the first 3 postoperative days. Thirteen patients reported that further surgery had been required by 1 or 3 months (original operations: brain tumor = 5; cerebral aneurysm clipping = 2; microvascular decompression = 1; spinal surgery = 5). Twenty patients (10%) reported infections at 1 and 3 months postoperatively. Seven patients reported chest infections; six reported wound infections, and four reported cannulation site infections. Six patients reported infection at other sites.

Seven patients died during the study period (3.6%). Six patients with primary or metastatic brain tumors and one with metastatic thoracic spinal disease died as a result of

Table 7. Postoperative Neurologic Deficits and Quality of Recovery

<table>
<thead>
<tr>
<th>QoR-40</th>
<th>Cranial Surgery</th>
<th>Spinal Surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1 n = 12</td>
<td>166 (154–170)</td>
<td>162 (150–172)</td>
</tr>
<tr>
<td>Day 2 n = 13</td>
<td>173 (142–182)</td>
<td>174 (160–183)</td>
</tr>
<tr>
<td>Day 3 n = 10</td>
<td>161 (152–175)</td>
<td>177 (165–186)</td>
</tr>
<tr>
<td>Day 30 n = 13</td>
<td>168 (157–179)</td>
<td>182 (171–189)</td>
</tr>
<tr>
<td>Day 90 n = 12</td>
<td>175 (168–181)</td>
<td>187 (176–195)</td>
</tr>
<tr>
<td>Day 1 n = 3</td>
<td>161 (153–170)</td>
<td>159 (149–170)</td>
</tr>
<tr>
<td>Day 2 n = 7</td>
<td>159 (150–162)</td>
<td>163 (148–179)</td>
</tr>
<tr>
<td>Day 3 n = 4</td>
<td>166 (155–171)</td>
<td>174 (160–182)</td>
</tr>
<tr>
<td>Day 30 n = 3</td>
<td>156 (150–157)</td>
<td>175 (161–184)</td>
</tr>
<tr>
<td>Day 90 n = 4</td>
<td>160 (142–169)</td>
<td>181 (163–190)</td>
</tr>
</tbody>
</table>

Data are presented as median (interquartile range).
their disease between 1 and 3 months postoperatively. A 75-yr-old woman undergoing lumbar laminectomy died of a cardiac arrhythmia 10 weeks after surgery.

Discussion

The patients recruited for this study represent the healthiest 44% of patients undergoing operations on elective neurosurgery lists in our hospital, and therefore, the ability of our results to be generalized is limited. The response rates were acceptable, especially when postoperative pain, neurologic deficits, and terminal illness were taken into account. However, the majority of our patients needed assistance to complete the questionnaire, perhaps because of the nature and severity of their illness, whereas previous studies reported a high rate of completion by patients. The QoR-40 score still performed well under these conditions.

The QoR-40 score was responsive to changes in the health status of cranial and spinal neurosurgical patients. The physical independence dimension was most responsive to acute changes during hospital admission in both groups. However, the psychologic support and emotional state dimensions demonstrated very little change over time. This may indicate sustained care in the hospital, an unwillingness to reveal personal concerns as opposed to physical concerns, or insufficient responsiveness of the instrument. The responsiveness of the QoR-40 score may have been greater if more emergency patients had been included. On the other hand, responsiveness may have been reduced by the fact that all patients were nursed in a neurosurgical high-dependency unit, where their care may have been more uniform than in a diverse group of patients. Overall, our results for responsiveness are consistent with previous reports.

There is no accepted criterion that can serve as a definitive standard of quality of recovery. Therefore, following the lead of previous investigators, we chose to compare the QoR-40 to a visual analog scale representing global quality of recovery. Convergent validity was somewhat less than previously reported, although still statistically significant. However, construct validity was good with poorer recovery demonstrated in those having longer duration of hospital stay and those having more trouble completing the questionnaire. The reliability of the QoR-40 score was good, and coefficients were comparable to the results obtained in previous studies. The physical comfort and emotional state dimensions were the most highly correlated. Our item-to-item correlations, test-retest reliability, intraclass correlation, and split-half correlation were statistically significant but were not as strong as those reported in general surgery patients. Overall, the performance of the QoR-40 score was similar in cranial surgery and spinal surgery patients, compared favorably to previous studies in general and cardiac surgical patients, and is therefore suitable to assess the effect of interventions in neuroanesthesia research.

Cranial and spinal surgical patients exhibited different patterns of recovery and complications. Cranial surgery patients enjoyed good health status preoperatively, suffered significant pain and PONV in the first few postoperative days, and then recovered to preoperative health status relatively rapidly. However, they reported a significant incidence of transient and persistent neurologic deficits, which, if present, adversely affected their quality of recovery. Spinal surgery patients had relatively poor health status preoperatively. Therefore, as a group, spinal patients were qualitatively different from cranial surgery and general surgery patients. They also experienced significant pain and PONV in the first few postoperative days. However, although health status improved above preoperative levels by day 90, these patients had significant residual pain.

Inadequate treatment of postoperative pain may result in adverse physical and psychologic outcomes and decreased patient satisfaction. The postoperative pain experienced by cranial surgery patients in our study was relatively short-lived but was nevertheless of moderate severity. Postoperative pain in craniotomy patients is widely perceived as being undertreated. Codeine phosphate remains in widespread use, despite studies documenting its inadequacy and the safety and efficacy of nurse-administered and patient-administered morphine. A thorough evaluation of other treatment options for postcraniotomy pain (such as tramadol, nonsteroidal antiinflammatory drugs, cyclooxygenase II inhibitors, and paracetamol) has not occurred.

Spinal surgery patients reported similar pain scores to cranial surgery patients, but their pain was more persistent. Nevertheless, QoR-40 scores continued to improve postoperatively in spinal surgery patients. The primary aim of spinal surgery is to prevent permanent nerve root or spinal cord damage from prolapsed intervertebral discs or arthritic change. Surgery is not always able to relieve pain (particularly back pain) or restore function, and spinal surgery patients generally score lower on measures of quality of life and have lower functional capacity and higher rates of depression than other patients.

The development of complications can adversely affect patients’ perceptions of quality of recovery. The number of complications (including PONV) experienced by day 3 predicted poor quality of recovery on day 5 in cranial surgery patients in this study. Neurologic deficits were common, and possibly expected, in the first three postoperative days and were not specifically associated with lower QoR-40 scores in either group. However, deficits that persisted past 30 days were associated with...
a poorer perception of quality of recovery in cranial surgery and spinal surgery patients.

In conclusion, our data indicate that the QoR-40 score was responsive, valid, and reliable in cranial surgery and spinal surgery patients. Therefore, the QoR-40 score is suitable to assess the effect of interventions in neuroanesthesia that are aimed at improving the quality of recovery and improving patient satisfaction with care.

The authors thank the staff of the Melbourne Neuroscience Centre at the Royal Melbourne Hospital for their encouragement and cooperation.

References