S1 Fig. Results from logistic regression.

Using the sample data, an iterative process (maximum likelihood) produces an estimated logistic regression equation of the form

$$logit(p) = \log_e \frac{p}{1-p} = a + b_1NRS + b_2A + b_3G + b_4BMI$$

(1)

where:

- $NRS$, $A$, $G$ and $BMI$ are the explanatory variables (Table 1 in the Methods section);
- $p$ is the estimated value of the true probability that a patient with a particular set of values for the explanatory variables has the outcome of interest, for example the patient moves appropriately;
- $a$ is the estimated constant term;
- $b_1$, $b_2$, $b_3$, and $b_4$ are the estimated logistic regression coefficients.

We can manipulate equation (1) to estimate the probability that a patient has the outcome of interest. After simplifying (as $A$, $G$ and $BMI$ proved to be of no influence), we first calculate for a patient with a particular $NRS$,

$$S = a + b_1NRS$$

(2)

Then, the probability that a patient has the outcome of interest is estimated as

$$p = \frac{e^S}{1+e^S}$$

(3)

and the probability that a patient does not have the outcome of interest as

$$1 - p = \frac{1}{1+e^S}$$

(4)

The probability $p$ decreases from one to zero, for $S$ decreasing from plus to minus infinity.

Noticeably, equation (3) shows that the probability $p=0.5$ for $S=0$ or $NRS = -a/b_1$. Table S3.1 lists the estimated constant terms and logistic regression coefficients.
Table S3.1. Results from the logistic regression model using the 11-points Numerical Rating Scale for movement-evoked pain as explanatory variable for each of the three dependent variables PO, NO, and PONO. Listed are constant term $a$ and logistic regression coefficient $b_1$ from equation (2), as well as the odds ratio (OR) with its 95% Wald confidence interval.

<table>
<thead>
<tr>
<th>Day after surgery</th>
<th>Dependent variable</th>
<th>$a$ (SE)</th>
<th>$b_1$ (SE)</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PO</td>
<td>4.1156  (0.0943)</td>
<td>-0.6039  (0.0166)</td>
<td>0.547 (0.529-0.565)</td>
</tr>
<tr>
<td></td>
<td>NO</td>
<td>4.7171  (0.1120)</td>
<td>-0.7773  (0.0197)</td>
<td>0.460 (0.442-0.478)</td>
</tr>
<tr>
<td></td>
<td>PONO</td>
<td>3.5161  (0.0871)</td>
<td>-0.6805  (0.0169)</td>
<td>0.506 (0.490-0.523)</td>
</tr>
<tr>
<td>2</td>
<td>PO</td>
<td>3.8677  (0.1243)</td>
<td>-0.5303  (0.0224)</td>
<td>0.588 (0.563-0.615)</td>
</tr>
<tr>
<td></td>
<td>NO</td>
<td>5.0953  (0.1651)</td>
<td>-0.7912  (0.0288)</td>
<td>0.453 (0.428-0.480)</td>
</tr>
<tr>
<td></td>
<td>PONO</td>
<td>3.4504  (0.1156)</td>
<td>-0.6220  (0.0224)</td>
<td>0.537 (0.514-0.561)</td>
</tr>
<tr>
<td>3</td>
<td>PO</td>
<td>3.4035  (0.1430)</td>
<td>-0.4578  (0.0275)</td>
<td>0.633 (0.600-0.668)</td>
</tr>
<tr>
<td></td>
<td>NO</td>
<td>5.3441  (0.2248)</td>
<td>-0.8378  (0.0402)</td>
<td>0.433 (0.400-0.468)</td>
</tr>
<tr>
<td></td>
<td>PONO</td>
<td>3.1292  (0.1364)</td>
<td>-0.5719  (0.0280)</td>
<td>0.564 (0.534-0.596)</td>
</tr>
</tbody>
</table>

PO, patient’s opinion on whether the pain is acceptable; NO, nurses’ observation on the patient’s ability to make appropriate movements; PONO, combined measure of PO and NO: is “acceptable pain” associated with “good appropriate movements” or not.

The values in Table S3.1 can be used to calculate $S$ (eq. 2) and the probabilities given in equations (3) and (4). For example, a patient has NRS=4 on day 1. The probability that this patient moves appropriately is 0.833, whereas the probability of not moving appropriately is 0.167. The odds of moving appropriately is $p/(1-p) = 0.833/0.167 = 4.99$. Alternatively, combining equations (3) and (4) yields $p/(1-p) = e^S = e^{4.7171-0.7773x_4} = 4.99$.

Although mathematically correct, we should not apply estimates on the probability scale to individual subjects like we did in the example. Each individual subject reporting NRS=4 either does or does not move appropriately. The estimated probabilities from a logistic regression model are best viewed as estimates of proportions in the underlying population. As a result, we better express the result for the example as: the estimated proportion of patients that move appropriately at NRS=4 is 0.833. A confidence interval for an estimated proportion can be calculated. We therefore refer to Hosmer and Lemeshow.†
The odds ratio (OR) in the example is calculated as follows. For an NRS=4, it is the estimated odds of moving appropriately for NRS=5 relative to the estimated odds of moving appropriately for NRS=4. As the odds with NRS=5 is $e^{4.7171-0.7773\times 5} = 2.30$, the OR = $2.30/4.99 = 0.46$. Alternatively, it can be shown that the OR $= e^{b_1} = e^{-0.7773} = 0.46$, as NRS increases by one unit. If the OR is equal to one, then the two odds are the same. An OR > 1 indicates an increased odds of moving appropriately, and an OR < 1 indicates a decreased odds of moving appropriately, as NRS increases by one unit.

A measure of the model’s ability to discriminate between those subjects who experience the outcome of interest versus those who do not is provided by the area under the Receiver Operating Characteristic (ROC) curve (Figure S3.1).†† It plots sensitivity (true positive fraction of subjects) versus 1-specificity (false positive fraction of subjects) at all possible cutoff points on the NRS. § The ‘optimal’ cutoff point is found where the vertical distance between the curve and the line of identity is maximal (Youden’s J-statistic).

![ROC curves for the dependent variables PO, NO and PONO for the three first postoperative days.](image)

Fig. S3.1. ROC curves for the dependent variables PO, NO and PONO for the three first postoperative days. The dashed line is the line of identity where the AUC = 0.5. The closer the ROC curve is to the upper left corner, the better NRS discriminates. Open circles are the points where Youden’s J-statistic is maximal for PONO.

