Is Laparoscopic Colorectal Surgery Less Invasive than Classical Open Surgery?

Quantitation of Physical Activity Using an Accelerometer to Assess Postoperative Convalescence

Y. Inoue
T. Kimura
H. Noro
M. Yoshikawa
M. Nomura
T. Yumiba
E. Taniguchi
S. Ohashi
S. Souda
H. Matsuda

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1 Department of Surgery, Nissay Hospital, 6-3-8 Itachibori, Nishi-Ku, Osaka City, Osaka 550-0012, Japan
2 Department of Surgery, Osaka Graduate School of Medicine, Osaka, Japan
3 Department of Surgery, Osaka Central Hospital, Osaka, Japan

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Abstract

Background: With the technical advances of recent years, the number of operative manipulations in the abdominal cavity by laparoscopic surgery is now considered to be the same as that using classical open surgery. The question has been raised whether laparoscopic colorectal surgery with lymphadenectomy improves the recovery compared to open surgery.

Methods: We compared patients’ physical activity for 7 days postoperatively as measured with an accelerometer between laparoscopic-assisted colorectal resection (LAC, n = 32) and classical open colorectal surgery (OC, n = 30).

Results: Physical activity expressed as cumulative acceleration was significantly higher in the LAC than in the OC group on each postoperative day. The recovery time, defined as the day on which the cumulative acceleration recovered to 90% of the preoperative level, was significantly shorter (p < 0.05) in the LAC (3.4 ± 1.2 days) than in the OC group (6.8 ± 1.7 days).

Conclusion: Our results showed that the duration of convalescence with LAC was significantly shorter than that with the OC procedure. Laparoscopic colorectal surgery appears to allow an earlier recovery after the operation than the classical open procedure, and it is less invasive as assessed by convalescence.

Key words: Accelerometer — Physical activity — Laparoscopic colorectal surgery — Postoperative recovery

A laparoscopic approach to the surgical treatment of gastrointestinal disease has generally been used to achieve less postoperative pain, immediate ambulation, shorter postoperative ileus, earlier initiation of oral intake, a reduced hospital stay, a quick return to normal activities, and improved cosmetic results [5]. These benefits have been demonstrated for laparoscopic cholecystectomy [8]. However, whether the laparoscopic approach to the resection of colorectal cancer has the same benefits is controversial because the presence of an anastomosis and an almost equal number of operative manipulations in the abdominal cavity, such as regional lymphadenectomy, as for an open procedure may prevent early oral food intake and a rapid recovery after the operation [6]. Thus, it has been difficult to demonstrate the benefits of laparoscopic approaches to colorectal cancer using only the currently available clinical parameters, such as the day of first mobilization, the day of initial food intake, the length of postoperative hospital stay, and the time it takes to attain rehabilitation to the preoperative level of social life. These parameters are not only dependent on the physician’s directions but also affected both by the patient and by a variety of social conditions.

On the view that the immediately recognizable clinical benefits of laparoscopic colorectal surgery reflect an earlier recovery in physical activity, we conducted this study to evaluate postoperative recovery by measuring the physical activity of patients using an acceleration sensor [1], a device for the accelerometric measurement of body movements [12].

Patients and methods

Among the colorectal cancer patients surgically treated between June 1998 and July 2002, 71 who gave informed consent to wear an accel-
erometer were studied. Patients with preoperative complications that might have resulted in complicated postoperative management and an altered convalescence response, such as cardiovascular, pulmonary, hepatic, and renal dysfunction, were excluded. Five patients who developed postoperative complications up to postoperative day (POD) 8, such as wound infection (5 patients) and anastomotic dehiscence (2 patients), were also excluded because these complications would likely affect their recovery. Two additional cases were excluded because their laparoscopic procedures were converted to open surgery.

Finally, data from 62 patients (36 men and 26 women; age, 46–72 years) were analyzed in this study (Table 1). The selection process was not randomized, but all patients with colorectal cancer deemed surgically resectable (stages I–III) were considered candidates for either arm of this study. The classical open surgery and the principles of the laparoscopic approach were thoroughly explained, and each patient was allowed to choose the initial approach for his or her resection. The patients were comparable in age, sex, and the staging of their tumors. Thus, the study is a nonrandomized but equally representative prospective trial.

Laparoscopic resection was accomplished in 32 patients [laparoscopic-assisted colorectal (LAC) group] and 30 patients were treated with a classical open procedure [open colorectal surgery (OC) group]. Table 2 lists the operative procedures and Table 3 the postoperative course for each patient. The mean operative time for the LAC group was 199.3 ± 32.8 min and for the OC group was 186.4 ± 48.1 min. There was no significant difference between them. However, there was a significant difference in intraoperative bleeding between the LAC and OC groups. The total length of the skin incision, including the incisions for drainage and the insertion of trocars, was significantly longer for the OC group than for the LAC group (OC, 21.5 ± 4.8 cm; LAC, 8.4 ± 1.5 cm; p < 0.01).

Postoperative care

During the 24-h postoperative period, analgesia was administered via an epidural tube. Thereafter, pain control was accomplished with intravenous agents or suppositories as needed, in accordance with patient complaints. The severity of pain was assessed by the patient using a visual analog scale (VAS) of pain (0, no pain; 10, worst imaginable pain) at rest, during coughing, and during walking every day until POD 7 [7].

The day after the operation, the nasogastric tube was removed and all patients were encouraged to get out of bed. In both groups, an intrabdominal drainage tube was kept in place until 2 days after resumption of oral food intake. The postoperative initiation of oral food intake was carried out the day after the first flatus was confirmed. The day of discharge was determined by the surgeon after negotiating with the patient and was based on indications such as having no tubes, tolerating a regular diet, being positive for bowel movement, having a clean wound, and being ambulatory.

Measurement of physical activity

The cumulative acceleration of body movement was measured using an accelerometer [Active Tracer AC-301 (ACT); Fig. 1, left], and the generated data were used as a parameter for estimating the postoperative recovery of physical activity. The ACT is a device that continuously measures the gravitational acceleration of body movement by built-in acceleration sensors and hence allows a quantitative evaluation of integrative physical activity [11]. The built-in sensors detect accelerations triaxially in vertical, bilateral, and anteroposterior directions so that body movements are measured in terms of gravity. The sensors for the respective directions generate voltages proportional to the accelerations imposed. The generated voltages are then amplified via an amplifier, and the analog signals thereof are converted to digital signals that represent the extent of the acceleration. An ACT device measuring 56 × 83 × 16 mm and weighing 100 g was attached to the right ankle of each patient (Fig. 1, right).

Each patient was given a verbal explanation of the measurement, and the ACT device was attached 2 days prior to the operation. Except during bathing, the patient wore the device continuously, even in bed, and measurement was continued until POD 7. The rationale for attaching the ACT to the right ankle was that the patient would not forget to wear it when he or she got into or out of bed. If the ACT was worn on the waist, we believed that patients would take it off to be more comfortable in bed. The measurement results were obtained on POD 8 and analyzed on a computer using Microsoft Excel. The measurements obtained during the 24-h prior to surgery were taken as preoperative values. The data were then collected in consecutive 24-h periods up to POD 7, starting at 12:00 p.m. on the day after the operation; these postoperative values were expressed as a percentage of the preoperative value. To assess the duration of recovery quantitatively, we used a parameter called recovery time, defined as the number of days required for restoration to more than 90% of the preoperative value. The recovery times determined for individual patients were compared according to the surgical procedure used.

Table 1. Patient demographics

<table>
<thead>
<tr>
<th>Group</th>
<th>LAC</th>
<th>OC</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>32</td>
<td>30</td>
</tr>
<tr>
<td>Age, years (mean ± SD)</td>
<td>61.4 ± 14.3</td>
<td>60.4 ± 15.2</td>
</tr>
<tr>
<td>Male/female</td>
<td>18/14</td>
<td>18/12</td>
</tr>
<tr>
<td>Stage (TNM, UICC 1997)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>21</td>
<td>18</td>
</tr>
<tr>
<td>II</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>III</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Operative time (min)</td>
<td>199.3 ± 32.8</td>
<td>186.4 ± 48.1</td>
</tr>
<tr>
<td>Intraoperative blood loss (ml)</td>
<td>128.4 ± 35.6</td>
<td>563.7 ± 129.7*</td>
</tr>
<tr>
<td>Length of skin incision (cm)</td>
<td>8.4 ± 1.5</td>
<td>21.5 ± 4.8*</td>
</tr>
</tbody>
</table>

LAC, laparoscopic-assisted colorectal surgery; OC, open colorectal surgery

* p < 0.05 vs LAC

Table 2. Operative procedures

<table>
<thead>
<tr>
<th>Procedure</th>
<th>LAC</th>
<th>OC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ileorectal resection</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Right hemicolectomy</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Transverse colectomy</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Left hemicolectomy</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Sigmoidectomy</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>High anterior resection of the rectum</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td>30</td>
</tr>
</tbody>
</table>

LAC, laparoscopic-assisted colorectal surgery; OC, open colorectal surgery

Table 3. Postoperative outcome

<table>
<thead>
<tr>
<th>Procedure</th>
<th>LAC</th>
<th>OC</th>
</tr>
</thead>
<tbody>
<tr>
<td>First mobilization (days)</td>
<td>1.1 ± 0.4</td>
<td>1.3 ± 0.5</td>
</tr>
<tr>
<td>Time to pass flatus (days)</td>
<td>3.2 ± 0.6</td>
<td>4.5 ± 0.5*</td>
</tr>
<tr>
<td>First bowel movement (days)</td>
<td>3.8 ± 0.7</td>
<td>4.8 ± 0.7**</td>
</tr>
<tr>
<td>Time to restart oral intake (days)</td>
<td>4.2 ± 1.1</td>
<td>5.8 ± 1.1*</td>
</tr>
<tr>
<td>Duration of postoperative hospital stay (days)</td>
<td>15.9 ± 8.3</td>
<td>26.4 ± 9.8*</td>
</tr>
<tr>
<td>Analgesic requirement (No. of administrations)</td>
<td>1.8 ± 1.1</td>
<td>5.2 ± 3.1*</td>
</tr>
</tbody>
</table>

LAC, laparoscopic-assisted colorectal surgery; OC, open colorectal surgery

Data expressed as mean ± SD

* p < 0.05 vs LAC
Statistical analysis

Data are expressed as mean ± standard deviation (SD). The statistical significance of any observed differences was evaluated using the computer software StatView-J 4.11 (Abacus Concepts), and differences between the two groups were assessed for significance using the Student's unpaired t-test.

Results

Outcome in the postoperative course

The average requirement for postoperative analgesia was significantly less for the LAC (1.8 ± 1.1 times) than for the OC (5.2 ± 3.1 times) group. The VAS with resting, coughing, and walking was gradually decreased but not significantly different between the two groups on each postoperative day (Fig. 2). All patients were managed using a protocol in which ambulation was encouraged on POD 1. The first day of mobilization was not different between the LAC (1.1 ± 0.4 days) and OC (1.3 ± 0.5 days) groups. The time to pass flatus and the day of the first bowel movement, parameters that indicate the recovery of bowel function, were significantly sooner in the LAC group than in the OC group. The day of initial food intake was also significantly different (LAC, 4.2 ± 1.1 days; OC, 5.8 ± 1.1 days). Postoperative hospital stay was significantly longer for the OC group (26.4 ± 9.8 days) than for the LAC group (15.9 ± 8.3 days).

ACT measurement data

The actual ACT data obtained are highlighted in Fig. 3, in which a representative course from each group is shown. The LAC patient displayed physical activities similar to those of the preoperative level on the second day after the operation and recovered to the preoperative level by POD 3 or 4. In contrast, the OC patient required 6 or 7 days to return to the preoperative level of activity, showing an obvious difference from the LAC case. Moreover, the LAC patient recovered to a preoperative pattern of physical activity (i.e., the daytime value was high and the nighttime value low) more rapidly than the OC patient.

The postoperative restorative progress of mobility, expressed as the percentage of the preoperative 24-h cumulative acceleration value, was also compared (Fig. 4). Patients in the LAC group recovered physical activity 35% of the preoperative level by POD 1, 78% by POD 2, and reached the preoperative level on POD 3. In the OC group, the recovery was approximately 15% of the preoperative level on POD 1, approximately 32% on POD 2, and thereafter improved gradually to 70% at POD 6 or 7. There were significant differences between the LAC and OC groups on each postoperative day.

Intergroup comparisons were also made for the recovery time, defined as the number of days required for
the cumulative acceleration per 24-h recovery to reach more than 90% of the preoperative level (Fig. 5). The recovery time was significantly shorter in the LAC group (3.4 ± 1.2 days) compared to the OC group (6.8 ± 1.7 days).

Discussion

The accelerometer continuously measures a patient’s spontaneous body movements. The ACT has been used in a variety of studies to investigate the relationship between blood pressure or heart rate and physical activity [4], analyze the behavioral patterns in mentally retarded individuals [3], assess the effects of medication on sequelae in cerebral infarction [10], and assess the physical activity in patients with chronic obstructive lung disease [9]. We have previously reported the applicability of the ACT for assessing the postoperative recovery of physical activity for patients undergoing gastric surgery [2].

As seen in Fig. 2, the frequency and strength of an individual’s spontaneous body movement can be tracked by observing the cumulative acceleration per hour, which is measured continuously from the time prior to the procedure to POD 7. These results are considered to be a quantitative assessment of recovery, which can otherwise be a relatively vague impression based on the conventional evaluation of a patient’s recovery status in clinical practice. Using this quantitative parameter, our findings indicate that the postoperative recovery status of physical activity is higher after LAC than after OC.

For a quantitative comparison of the results among groups receiving different surgical treatments, the 24-h value of acceleration was used. Because the absolute value of the acceleration of physical activity varies among individuals, an evaluation was conducted that compared the acceleration to the preoperative 24-h value for each patient (%). Age and male/female ratio were not different between the groups. The LAC group exhibited significantly higher cumulative acceleration values from POD 1 through POD 7 compared to the OC group, thus providing quantitative evidence that patients receiving the LAC procedure showed higher physical activity over time following the operation.

The obtained data were further analyzed by determining the recovery time, defined as the number of days required for recovery to more than 90% of the preoperative physical activity level, to clarify the duration of the postoperative period required to restore physical activity to the preoperative level. The LAC group showed a recovery to more than 90% of the preoperative physical activity level within 3 days postoperatively, whereas this duration was 6 or 7 days in the OC group. This finding suggests that the greater the degree of surgical stress, the longer the duration required for the restoration of physical activity to the preoperative level. With the conventional evaluation parameters, it had been impossible to assess the postoperative time required to attain recovery in physical activity to the preoperative level. However, the ACT is an objective parameter that appears to be useful for quantitatively expressing the postoperative recovery status.

It is also necessary to consider a variety of factors that could restrict mobilization in postoperative patients. In a previous report, we indicated that a difference in the drainage method influenced postoperative physical activity. However, in this study there were no differences in the drainage method between the LAC and OC groups. It is also important to consider the patient’s susceptibility to pain sensation. In this study, we managed all the postoperative cases by controlling pain via the epidural route during the first 24 h postoperatively and by the use of analgesic agents as required thereafter. Although there were no differences in the estimation of pain by patients using a VAS, the frequency of administered analgesia was significantly higher in the OC group than in the LAC group. We believe that postoperative pain strongly influenced the intergroup differences in recovery of physical activity, but other inflammatory factors, such as the response in
cytokine and endocrine related to the invasiveness of the procedure, may have also affected these results.

In conclusion, to clinically test whether endoscopic surgery is less invasive than conventional open surgery, we assessed the postoperative recovery status by measuring the acceleration in physical activity as a parameter of recovery. The data obtained indicated that the measurement of acceleration quantitatively expressed changes in the postoperative physical activity and the time to attain postoperative recovery, which varied according to the extent of surgical intervention. Furthermore, assessment of postoperative recovery status suggested that endoscopic surgery is less invasive than open surgery, based on the hastened postoperative recovery in physical activity.

References


