Time–motion analysis of operation theater time use during laparoscopic cholecystectomy by surgical specialist residents

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Abstract

Background: Data on man-machine interfaces in the operation theater are essential to the improvement of surgical efficiency. This study analyzed the activity of the operating team during laparoscopic cholecystectomy by surgical trainees.

Methods: The endoscopic image and overview of the operating room were recorded during 20 laparoscopic cholecystectomies performed by specialist residents. Time–motion analysis of the recorded tapes was performed.

Results: The median (interquartile range [IQR]) for theater time was 134 ± min (IQR, 52 min). The components of operative time for the surgeon were 26% for insertion of access ports and wound closure, 57% for intracorporeal endoscopic work, and 17% for instrument change. Only 52% of the scrub nurse time was related to the operation. Machine and video setup, adjustment of ancillary equipment together, and delivery of instruments and items requested by the surgeon and scrub nurse accounted for 13% of the circulating nurse time.

Conclusions: With the current nonergonomic theater design and structure, a significant proportion of theater time during routine uncomplicated laparoscopic surgery is used for nonoperative functions. The study highlights the need for improved ergonomic design, integrated bus operating systems under the control of the surgeon, and multifunctional laparoscopic instruments.

Key words: Time–motion analysis — Laparoscopic cholecystectomy — Theater time — Specialist surgical residents

Optimum management of operation theater time has become a key concern of the National Health Service because of lengthy waiting lists and financial constraints. Objective information on theater time use is necessary for efficient surgical performance, increased safety, and accommodation of supervised surgical operative training.

Efficiency entails appropriate use of manpower, facilities, and equipment to achieve the ideal operative care because operating room time constitutes a significant part of the cost for surgical treatment. This applies especially to short-stay laparoscopic surgery, (e.g., laparoscopic cholecystectomy [LC]), for which 60% of hospital costs are incurred while the patient is in the operating room [14]. In addition, complications often can be traced to errors that occur in the operating room. Besides increased suffering, complications add considerably to treatment costs.

Time–motion studies examine the actions of the operating team to identify the ideal motion patterns conducive to optimal task execution. The use of motion and time study has brought many benefits to a range of industries, hence its appeal especially to the manufacturing sector of the economy. Although less often used in health care services, it can confer similar benefits for such services, especially operative surgery, in which time–motion studies may identify unproductive activities and inefficient communication between theater staff and provide information for improving operating room layout and equipment design [9]. The objectives of the current descriptive study were to analyze the use of theater time, the activity of the operating team, and the nature of instrument use during a common laparoscopic operation.

Materials and methods

Patients

For this study, 20 consecutive patients with symptomatic gallstone disease were consented to participate. All the operations were performed in the main theater suite at Ninewells Hospital.
Operation

Laparoscopic cholecystectomy was selected for this study because it is a common operation worldwide [13], it incorporates standard laparoscopic techniques, and it exemplifies the complex interaction between conventional operating room design and evolving surgical operative technology. Therefore, LC can be regarded as a marker laparoscopic operation such that the results of the study can be applied to a wide range of routine laparoscopic operations. A standard technique for LC was used [10].

Procedure

External video recording of the operating room and a video record of the endoscopic image were obtained for each operation. The audio and video records of the operating team (surgeons, scrub and circulating nurses) activity and the layout of theater equipment were obtained with external video camera (Sony CCD-TR427E,Tokyo, Japan, autofocus with a 0.5x super wide-angle lens). The camera was mounted at a height of 192 cm and at a distance of 306 cm from the foot of the operating table. This position was selected because it allowed the camera to capture most of the movements around the operating table. Activities at the time of surgery, which were outside the field of the video camera, were recorded directly by the clinical research fellow.

The external video recording started when the anesthetized patient was brought into the operating room and ended when the patient was transferred out of the operating room. The internal video recording was obtained using an SVHS videocassette recorder (Matsushita Electric Industry Company, Osaka, Japan) for the entire operation from the first insertion of the laparoscope. A record also was kept of the operative team (surgeon, camera operator, assistant, scrub nurse, and circulating nurse) for each operation included in the study. The members of the theater staff were not informed about the objectives and end points of the study.

Data analysis

The external video recordings were analyzed to determine the time that the patients spent in the operating room for the activity of the operative team (activity by the surgeon, scrub nurse, and circulating nurse during the operation). The internal video recording was analyzed to identify the pattern of instrument use by the surgeon (type of instrument, duration of use, frequency of exchange). Each operation was graded for the degree of difficulty according to preset criteria [5]. The theater time, from induction of anesthesia to cleaning of the instruments after the operative procedure, was divided into six periods. The surgeon’s work time was analyzed in terms of three components: intracorporeal and extracorporeal execution time and instrument exchange time (Table 1). The latter included the type of instruments, duration of use, and frequency of instrument exchange. A complete record of the surgeon’s verbal instructions for adjustments to ancillary equipment and requests for instruments was obtained.

The motion and time analysis for the scrub nurse included preparing instruments, handing instruments to the surgeon, and following the progress of the operation on the monitor. The motion and time analysis for the circulating nurse included the adjustment of video imaging and ancillary equipment and the supply of instruments as requested by the surgeon or scrub nurse.

Because the data obtained by the study were not normally distributed, the comparison was expressed as medians and interquartile range (IQR), and nonparametric tests (Kruskal-Wallis one-way analysis of variance and Mann-Whitney U test) were used in the analysis. The significance level was set at 5%.

Results

This study involved 4 consultants, 4 specialist residents, 1 senior house officer, 11 scrub nurses, and 13 circulating nurses. The principal surgeon was a specialist resident in 19 cases and a consultant in 1 case. The camera operator was a consultant in 8 cases, a specialist resident in 7 cases, and a senior house officer in 5 cases. In terms of difficulty, four operations were classified as grade 1, nine as grade 2, and seven as grade 3.

Table 1. Definitions of operating theater time

<table>
<thead>
<tr>
<th>Description</th>
<th>Time (min)</th>
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<tr>
<td>Anesthetic induction time</td>
<td>Period spent in the anesthesia room</td>
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<tr>
<td>Surgical preparation time</td>
<td>Period between arrival of patient in operating room and start of skin preparation</td>
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<tr>
<td>Operative setup time</td>
<td>Interval between skin preparation and first skin incision</td>
</tr>
<tr>
<td>Operative time</td>
<td>Time from first incision to last skin suture</td>
</tr>
<tr>
<td>Recovery time</td>
<td>Interval between end of operative time and exit of patient from theater</td>
</tr>
<tr>
<td>Instrument cleaning time</td>
<td>Time spent by nurse cleaning instruments before sterilization</td>
</tr>
<tr>
<td>Intracorporeal surgical time</td>
<td>Time that the surgeon performed tasks inside the abdominal cavity</td>
</tr>
<tr>
<td>Extracorporeal surgical time</td>
<td>Time that the surgeon performed tasks outside the laparoscopic field such as trocar insertion and closing of incisions</td>
</tr>
<tr>
<td>Instrument exchange time</td>
<td>Time from when the tip of the instrument entered the cannula until the tip of the other or the same instrument protruded from the cannula</td>
</tr>
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</table>

The surgeons’ intracorporeal and extracorporeal execution times were 46 min (IQR, 28.81 min) and 21 min (IQR, 14.7 min), respectively, whereas the time for instrument change by surgeons was 11 min (IQR, 8.11 min). The proportions of time spent were 55% for intracorporeal work, 23% for extracorporeal functions, 13% for instrument exchange, 8% for intraoperative cholangiogram, and 1% for camera cleaning.

The motion and time analysis for the scrub nurse included preparing instruments, handing instruments to the surgeon, and following the progress of the operation on the monitor. The motion and time analysis for the circulating nurse included the adjustment of video imaging and ancillary equipment and the supply of instruments as requested by the surgeon or scrub nurse.

Because the data obtained by the study were not normally distributed, the comparison was expressed as medians and interquartile range (IQR), and nonparametric tests (Kruskal-Wallis one-way analysis of variance and Mann-Whitney U test) were used in the analysis. The significance level was set at 5%.

Activity of the operative team

Surgeon

The medians for the frequency of the surgeon’s instructions were 7 (IQR, 3) for adjusting machine and equipment setups and 29 (IQR, 15) for obtaining instruments, and with no significant difference between surgeons for either machine and equipment adjustment requests (p = 0.29) or instrument requests (p = 0.4). The surgeons’ intracorporeal and extracorporeal execution times were 46 min (IQR, 28.81 min) and 21 min (IQR, 14.7 min), respectively, whereas the time for instrument change by surgeons was 11 min (IQR, 8.11 min). The proportions of time spent were 55% for intracorporeal work, 23% for extracorporeal functions, 13% for instrument exchange, 8% for intraoperative cholangiogram, and 1% for camera cleaning.

Scrub nurse

The medians for the frequency of preparing and handing instruments by the scrub nurse was 28 min (IQR, 21)