Decision-making and technical factors account for the learning curve in complex surgery

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ABSTRACT

Introduction The general public, the legal profession, patients and relatives expect best practice and have difficulty with the concept of a learning curve in surgical interventions. However, it is improbable that technical and innovative skills can be developed, or optimized, without some aspects of learning by experience and indeed ‘risk taking’.

Patients and Method A single surgeon experience with a novel, complex, surgical procedure for peritoneal malignancy is described and compared with recent literature reports on the surgical learning curve. In total, 100 of 242 (41%) patients referred underwent a laparotomy. The 100 were divided into three numerically equal groups of 33, 33 and 34 cases, and the proportions undergoing surgery, mortality and major morbidity rates for the three groups were analysed.

Results The numbers undergoing surgery were 33/54 (61%), 33/96 (34%) and 34/92 (37%). The mortality was 6/33 (18%), 1/33 (3%) and 1/33 (3%), and the major morbidity rates were 9/33 (27%), 2/33 (6%) and 0/34 (0%) in the three groups.

Conclusions The main components of the learning curve were considered to be decision-making and technical factors. A mechanism to reduce the surgical learning curve is suggested involving teamwork, and at least two experienced surgeons involved in all major surgical interventions. Decision-making and technical factors account for the learning curve in complex surgery.

Keywords decision-making, learning curve, surgery, technical factors

Introduction

It is generally considered essential that all doctors should participate in continuing medical education and continuous professional development. Whilst this rightly acknowledges that medical training is lifelong, doctors are nonetheless expected to be ‘experts’ at technical procedures, and the concept of a learning curve is frowned upon.

Surgery has traditionally been considered a technical craft, relying on manual dexterity to complete a series of defined steps. This simplistic viewpoint is outdated. It is now accepted that, in addition to manual skills, surgery involves informed decision-making and an ability to make and alter complex intraoperative decisions in response to unexpected findings and adverse events. Recognition of actual and impending problems and the wisdom to seek help and advice are crucial. Willingness to reflect and analyse, learn and teach from good, bad and sub-optimal outcomes are essential aspects of life as a surgeon in modern times.

This report analyses an individual learning curve experience in technically challenging, novel surgery undertaken by an already experienced colorectal surgeon. The purpose of this exercise was to ascertain what might be the important aspects of the learning curve in surgery and how this experience might be of benefit to a wider audience.

Patients and methods

An internationally recognized colorectal unit specializing in complex rectal cancer surgery, with a documented track record in surgical teaching and the delivery of high quality care, initiated a peritoneal malignancy treatment programme in 1994. The programme consists mainly of complex abdominal surgical procedures, with the addition of chemotherapy. The surgical strategy was to aim for complete macroscopic tumour removal (complete cytoreduction) combined with intraoperative, intraperitoneal chemotherapy. Complete cytoreduction entails a series of peritonectomy procedures.

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with resection of involved non-essential organs. This includes all or a combination of right hemicolectomy, greater and lesser omentectomy, splenectomy, partial or complete gastrectomy, cholecystectomy, peritoneal stripping of the right and left hemidiaphragm with Glisson capsulectomy of the liver, anterior resection of the sigmoid and rectum and oophorectomy and hysterectomy in females. If complete cytoreduction was impossible, predominantly due to a combination of gastric and extensive small bowel involvement, then maximum tumour removal (usually by an extended right hemicolectomy, omentectomy and commonly a splenectomy) was attempted.

Between January 1994 and October 2000, 242 patients with peritoneal malignancy were referred to the unit, and 169/242 (70%) had been assessed and considered for surgical intervention. Of the 169 assessed, a consecutive series of 100/169 (59%) underwent laparotomy, and the morbidity and mortality documented. The majority were patients with pseudomyxoma peritonei, although a small number were known cases of adenocarcinoma or abdominal mesothelioma.

### Results

The cohort of 100 consecutive cases was divided into three numerically similar sized groups of 33, 33 and 34 patients, and a comparative audit of the mortality and morbidity was performed. The initial 33 cases were performed between January 1994 and September 2000 (79 months). The next 33 underwent surgery between October 2000 and January 2002 (16 months) and the last 34 between February 2002 and October 2002 (9 months), reflecting a developing and expanding service. The proportion of patients undergoing surgery changed from two-thirds in the first group to one-third in the other groups (Table 1). Of the 100 patients, 65 had complete cytoreduction, 28 had maximum debulking and 7 were inoperable and had laparotomy and biopsy only. There were no differences between the three groups in the proportions having complete cytoreduction (22/33, 24/33 and 19/34, respectively), maximum debulking (8/33, 7/33 and 13/34, respectively) and laparotomy only (5/33, 2/33 and 2/34, respectively).

The median operating time was 10 h (range 3–18) in the 65 complete cytoreductions and 6 h (range 2.5–12) in the 28 debulking procedures. The overall mortality in the whole series was 8/100 (8%), but this resulted from a rate of 6/33 (18%) in the first group versus 1/33 (3%) and 1/34 (3%) in the other groups (Table 1).

Technical failures such as anastomotic leakage and re-operation for bleeding were predominantly in the first group. There were four anastomotic leaks (three clinical requiring surgical intervention) in the first 33 (12%), one clinical leak in the second 33 (3%) and none in the last group (Table 1).

Significant intra-abdominal bleeding was detected in 11/100 (11%), and 6/11 required re-laparotomy for bleeding. Five of the six who required laparotomy for bleeding were in the first group, including one patient who had four further laparotomies to evacuate haematoma and control hepatic bleeding. The re-operation rate for bleeding was 5/33 (15%) in the first group compared with 1/33 (3%) in the second and none in the last (Table 1).

Other complications were infectious, in particular respiratory, urinary and wound infections, with a significant reduction in respiratory infections but little change in urinary or wound infections in the three groups.

### Discussion

The general public, the legal profession and patients have come to expect ‘best practice’ and ‘risk-free’ interventions. However, as Treasure points out, ‘there is a risk to being a patient’ and ‘our duty in providing health care is to get that risk to a minimum, while at the same time learning ourselves and training others’.

Much of the current thinking on the learning curve in the United Kingdom emanates from the Bristol Royal Infirmary Inquiry into mortality following paediatric cardiac surgery, with a chapter in the report entitled ‘Care in the Operating Theatre and the Learning Curve’. In this high-profile inquiry, there was general agreement that outcomes after interventional procedures improved with operator experience. However, there were no definitive conclusions as to the components of this so-called learning curve, whether it was inevitable or indeed whether it could be abolished or at the very least minimized in modern times. The then president of the Royal College of Surgeons of

### Table 1 Mortality and morbidity of patients undergoing surgery

<table>
<thead>
<tr>
<th>Group</th>
<th>Total referred</th>
<th>Number undergoing laparotomy (%)</th>
<th>Mortality number (%)</th>
<th>Number of re-operation for bleeding (%)</th>
<th>Anastomotic leakage number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>54</td>
<td>33 (61)</td>
<td>6/33 (18)</td>
<td>5 (15)</td>
<td>4 (12)</td>
</tr>
<tr>
<td>Group 2</td>
<td>96</td>
<td>33 (34)</td>
<td>1/33 (3)</td>
<td>1 (3)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Group 3</td>
<td>92</td>
<td>34 (37)</td>
<td>1/34 (3)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>
England reported in evidence to the inquiry that ‘College Council has agreed in debate, in discussion formally, that the term be expunged from medical literature’. The final report concluded that a learning curve in surgery should be a thing of the past and suggested that it had somehow been eradicated by ‘modern’ surgical training. While this is a laudable aim, common sense would suggest that all technical tasks have, and will always involve, a learning curve. It seems improbable that technical and innovative skills can be optimized without some aspects of learning by experience and indeed by ‘risk taking’. The real challenge, for surgery in particular, is to minimize the learning curve in established technical procedures to allow training and dissemination of expertise to flourish whilst maximizing patient care and outcome.

**Main finding of this study**

This study has documented a significant learning curve in complex novel surgery with reductions in mortality and morbidity, particularly after the first 33 cases. There appear to be two main components to the learning curve, namely decision-making and technical factors. The most obvious decision-making was in case selection, with 61, 34 and 37% of those referred undergoing laparotomy in the three groups, respectively. The main technical factors that undoubtedly formed a significant part of the learning curve were anastomotic failure and postoperative haemorrhage. These complications were markedly reduced in the second and third groups. However, it is impossible to estimate what proportion represents improved decision-making, either in case selection or in better intraoperative decisions.

The rarity of pseudomyxoma peritonei (PMP), the difficulty in defining and characterizing the condition and the complex surgery create many problems in establishing a treatment programme. The first case in this series was performed by an experienced surgeon (Paul Sugarbaker), assisted by the author, and all subsequent cases have been performed either by or under the direct supervision of the author. From April 2000, the unit has been designated a national centre for the assessment and treatment of PMP of appendiceal origin and supported by the National Specialist Commissioning Advisory Group (NSCAG), a subsidiary of the UK National Health Service (NHS) which commissions centralized assessment and treatment centres for rare diseases. National centre designation has resulted in increasing referrals and has provided a unique opportunity to assess and treat substantial numbers of cases annually.

**What is already known on this topic**

Cytoreductive surgery and intraperitoneal chemotherapy are a relatively novel treatment strategy for peritoneal malignancy. It involves complex surgery, with major morbidity and mortality. Major morbidity rates range from 25 to 35% and mortality from 1.5 to 12%. There have been no prior reports addressing the learning curve in this complex surgery, although in Sugarbaker’s experience, a mortality rate of 5% and morbidity of 35% reported in 1996 were reduced to 1.5 and 27%, respectively, in an update with an expanded series in 1999.

There have been many reports in the literature regarding the learning curve in surgical interventions. Most have been institutional learning curves, though some have reported the outcomes for individual surgeons. Thus, Watson et al. reported the highest complication rates in laparoscopic fundoplication in the first 20 cases of an individual surgeon (particularly the first five) and in the first 50 cases in an institution. Lo et al. arbitrarily divided 100 right-lobe living-donor liver transplants into two groups of 50 and noted less complications in the second 50. They also noted a change in the indications for transplant and introduced multiple changes in operative technique in the second 50. Bridgewater et al. found no significant differences in mortality rates after coronary artery bypass grafts between newly appointed and established surgeons. However, they noted a reduction in mortality rates for the newly appointed surgeons from 2.2% in the first year to 1.2% in the fourth year.

**What this study adds**

Most previous publications have focused predominantly on procedure times and hospital stay, as markers of the learning curve and few have attempted to analyse major morbidity and mortality as the main components. This article reports the experience of a single surgeon undertaking complex surgery, with an average operating time in excess of 10 h, in patients having complete tumour removal. This surgical intervention has been well documented to have high morbidity and mortality rates. Using morbidity and mortality as markers of the learning curve, this study suggests that there are two main components not previously alluded to in other studies, namely decision-making and technical factors.

Ongoing experience has resulted in further improvements, with only one postoperative death in the subsequent 100 cases. Nevertheless, occasional adverse events do still occur. In the subsequent 100 cases, there were four re-operations (two for intestinal fistula and two for haemorrhage), but three of the four occurred in three consecutive patients in late 2004.

**Limitations of the study**

The number of patients in this study is small, the time interval is long and the results take no account of other factors such as institutional experience and improvements in anaesthetic
care. However, the main factors analysed here involved decision-making by the author and technical complications attributable to the author as the leader of the surgical team.

Conclusions
A former surgical trainer and mentor remarked that in an established surgical practice ‘there is a ghost in every bed’ and that fortunately ‘surgeons get long lives and short memories’ (S. O’Domhnaill, personal communication). These are two sobering philosophies and, though somewhat contradictory in nature, are fundamentally accurate observations that guide and influence the learning and practice of major surgical interventions. We recall adverse outcomes and change our practice often on the basis of a single or a small number of adverse events. For example, in this series, the high early leakage rate, together with a detailed analysis of a small number of reports in the literature, led to the institution of a policy of proximal stomal defunctioning of all patients in the second two groups who underwent anterior resection and colorectal reconstruction. Similarly, the adverse outcomes associated with intra-abdominal bleeding have resulted in meticulous attention to haemostasis before abdominal closure.

The concept of a ‘short memory’ is probably crucial to allow surgeons to continue to operate when occasional adverse outcomes occur. A random sequence of adverse outcomes, even in the context of a much larger group of successful outcomes, such as recent events in our unit in 2004, can render even an experienced surgeon paralysed with fear and self-doubt. The real issue is how to cope with occasional failures and how to minimize the consequences of adverse events with potentially serious outcomes, in terms of both patient morbidity and patient mortality. One mechanism is to operate in teams, with at least two experienced trained surgeons available for complex high-risk procedures. This is now our preferred practice both in complex colorectal surgery and in surgery for peritoneal malignancy.

This approach benefits both patients and surgeons. Teamwork facilitates training and experience, minimizes the learning curve and should now be routine practice for all complex or novel interventional procedures. The development and application of any beneficial interventional procedure involves a learning curve with a determination to succeed and the courage to fail. All surgeons are interventionists and, in addition to knowledge, training and skill, require support in dealing with adverse outcomes; support that can only come from within the profession within the context of team efforts.

References