ORIGINAL ARTICLE

Surveillance of surgical training by detailed electronic registration of logical components

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Objective: To obtain detailed information about the degree of surgical trainee supervision and delegation of procedures in a subspecialised department.

Design: Operative procedures and their logical components were recorded in a database constructed in Microsoft Access. Information about operating surgeon and assistants and their grade was registered prospectively over 12 months.

Subjects and methods: A total of 1250 intermediate or major procedures were performed by eight consultants, one staff specialist, four senior registrars, three specialist registrars, and five registrars.

Main measure: Number of components performed by surgeons in each grade and the degree of supervision and delegation.

Results: Eight hundred and eighty five of the operations were elective, while 365 were done as emergency procedures. Emergency procedures were far more often done by surgeons in training than by a staff surgeon, while the opposite was true for elective operations. Out of 323 elective operations done by surgeons in training, 189 were done under supervision (58.5%), while 119 out of 276 emergency operations done by surgeons in training were supervised (43.1%; $p=0.0002$). One hundred and twenty eight of 638 (20%) open abdominal operations were done by the most junior surgeons, and yet they closed 36% of all abdominal wounds. Although the most junior surgeons only served as operating surgeons in 39 of 334 bowel operations (12%), they constructed 24% of all stomas, and 20% of all anastomoses. Registrars and specialist registrars never constructed stomas or anastomoses without supervision.

Conclusion: Detailed information about individual and general training and supervision was achieved by a simple registration. Significant additional information was obtained about the extent of delegation of components compared with standard registration of operative procedures.

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It is increasingly recognised that maintaining surgical training at a sufficient level is demanding,^{1–4} particularly in more recent years, where training has been shortened, and weekly working hours decreased.^{5–6} Moreover, the tendency towards increasing subspecialisation makes it difficult for many units to offer a broad spectrum of general surgical procedures to trainees, and many of the procedures performed are often done by consultants due to the high specialisation required. Although many procedures are indeed highly specialised, many of the logical components such as incision, closure, construction of anastomoses, etc are more general. Allowing surgeons in training the opportunity to perform these components could actually improve education, as recently suggested.⁷ There is no doubt that some units and some consultants focus more on education than others,⁸ but for a given unit or consultant, it may be impossible to obtain an objective measure of the training offered. Log books may be valuable for each individual trainee, but are far less suited for evaluating the extent and degree of practical training and delegation in a surgical unit. We have constructed an electronic database with registration of details of the surgical team involved in each procedure, and with information of who has performed each component of the operation also being recorded. The aim was to obtain detailed information about the degree of supervision and delegation. A tool like this could prove valuable when individual and general behaviour needs to be evaluated and discussed.

SUBJECTS AND METHODS

Unit

The surgical department is part of the University Hospital of Aarhus, serving a population of 300 000 people as primary

referral centre with colorectal and breast/endocrine surgery as specialties. For rarer conditions within these specialties, the department serves as a secondary (650 000 people) and tertiary referral centre (2 000 000 people). The consultants and staff specialists are either colorectal or breast/endocrine surgeons, but senior registrars, surgical specialist registrars, and registrars serve at both units. A total of 5/3 consultants serve the two units, respectively, and one staff specialist, four senior registrars, three specialist registrars, and five registrars are associated to the two units. A registrar is equivalent to a senior house officer in the UK (one to two years of training). Appointment as specialist registrar is 27 months in Denmark, and authorisation as specialist is obtained after another 24 months as senior registrar. The grade “senior registrar” still exists in Denmark, and surgeons in this position are equivalent to the most senior specialist registrars in the UK (more than two years of advanced training).

Database

A data sheet was constructed for coding the procedures. Each procedure has a unique code (Nordic Classification of Surgical Procedures),⁹ and the surgeons involved are coded according to their role as operator, assistant, or second assistant. The grade of each individual surgeon is also recorded. The operating surgeon is requested on the sheet to indicate who has performed each component of the operation. The components are given in table 1. An indication is also given in the sheet whether the operation was an elective or an emergency procedure, and the time of start and end is also noted. All information was recorded in a self made database constructed in Microsoft Access 2000. Each individual sheet was evaluated in terms of completeness of registrations, and was classified

Table 1 Logical procedure components as listed in the procedure sheet

Abdominal	Laparoscopic	Breast endocrine
Incision	Establishing pneumoperitoneum	Incision
Organ palpation	Removal of appendix	Breast dissection
Wound closure	Other procedure	Dissection of the axilla
Mobilisation of bowel	Port site closure	Thyroid lobe dissection
Mobilisation of colonic flexure		Wound closure
Division of adhesions		
Division of mesentery		
Open appendectomy		
Construction of anastomosis		
Type of anastomosis		
Construction of stoma		

by the author as correct, having minor errors/missing information or having severe errors/missing information. All sheets with errors/missing values were returned to the operating surgeon for correction. The procedures were classified as open abdominal, laparoscopic, or breast/endocrine operations. Minor procedures such as incisions, wound revisions, perianal procedures and endoscopies were not registered. A procedure was defined as being supervised if the assistant had a higher grade than the operating surgeon.

Statistical considerations

Proportions were compared either by χ^2 test or by Fisher's exact test (2×2 tables). An unpaired Student's *t* test was used for comparison of the duration of operations. A *p* value ≤ 0.05 was considered significant. Values are given as mean (SD).

RESULTS

In total, 1250 operations were registered during a 12 month period beginning 1 January 2000. Of these, 586 were abdominal procedures, 223 laparoscopic (including 61 procedures converted to open surgery), and 441 breast/endocrine (table 2). Table 2 also shows the grade of the operating surgeon as registered on the sheet. Eight hundred (64%) of the sheets were correctly filled out, while 236 had minor errors/missing values (19%), and major errors/missing values were detected in 214 (17%). The number of errors were particularly pronounced for specialist registrars, while the staff specialist produced the highest percentage of correct sheets. Of the 1250 procedures, 885 were registered as elective cases, and 365 as emergency procedures. Emergency procedures were more

often done by surgeons in training (registrars, specialist registrars, and senior registrars) than by a staff surgeon (staff specialist or consultant), while the opposite was true for elective operations ($p < 0.0001$; fig 1A and B).

Narrowing this analysis to small bowel and colonic resections, a total of 176 operations belong to this category, with 61 of these being performed as an emergency procedure (34.7%). Only 18 (29.5%) of these emergency operations were carried out by a consultant or staff specialist, while the majority were performed by unsupervised senior registrars ($n=35$; 57.4%). In addition three emergency bowel resections were performed by specialist registrars where no surgeon with a higher grade than senior registrar was present. This increases the total number of emergency bowel resections performed by a surgical team, where the highest grade was senior registrar, to 38 procedures (62.3%). Out of 323 elective operations done by surgeons in training, 189 were done under supervision (58.5%), while 119 out of 276 emergency operations done by surgeons in training were supervised (43.1%; $p=0.0002$).

Logical components

Very often, well defined components of the procedures were handed over to junior surgeons to do under supervision. Table 3 shows the details for breast/endocrine operations. Registrars and specialist registrars did most of their breast and axilla dissections under supervision (registrars 100%; specialist registrars 93% and 100%, respectively). Senior registrars performed 39% of all breast dissections, and the majority of these (80%) were not supervised. Fifty per cent of all axilla dissections were carried out by consultants. A substantial percentage of breast/axilla procedures were done by consultants assisted by registrars and specialist registrars, who could have

Table 2 Groups of operations and numbers performed by surgeons in each grade

	Registrar (n=5)	Specialist registrar (n=3)	Senior registrar* (n=4)	Staff specialist (n=1)	Consultant (N=8)	Total
Thyroid	0	0	30 (25)	0	90 (75)	120
Parathyroid	0	0	1 (1)	0	70 (99)	71
Breast	20 (8)	30 (12)	104 (42)	0	96 (38)	250
Appendectomy	48 (32)	51 (34)	29 (19)	4 (3)	20 (13)	152
Bowel resection	3 (2)	33 (19)	69 (39)	17 (10)	54 (31)	176
Stomal closure	2 (4)	1 (2)	12 (22)	3 (5)	37 (67)	55
Colectomy, proctocolectomy, or restorative proctocolectomy	1 (2)	0	8 (17)	2 (4)	37 (77)	48
Low anterior resection and abdominoperineal resection	0	2 (2)	21 (19)	15 (14)	72 (65)	110
Miscellaneous	32 (12)	32 (12)	72 (27)	15 (5)	117 (44)	268
Total	106 (8)	149 (12)	346 (28)	56 (4)	593 (47)	1250

The numbers given in brackets are the percentage of the operations performed by surgeons in that grade.

*A senior registrar is equivalent to a UK specialist registrar with > 2 years of advanced training.

Figure 1 Percentage of procedures performed by surgeons in different grade. (A) Elective procedures. (B) Emergency procedures. A senior registrar is equivalent to a UK specialist registrar with >2 years of advanced training.

benefited from the training. Looking at thyroid gland dissections, the majority were performed by consultants (79.5%), while these dissections were never carried out by registrars or specialist registrars. Senior registrars did most of their thyroid gland dissections under supervision (92%).

One hundred and twenty eight of 638 (20%) open abdominal operations were performed by the most junior surgeons (registrars and specialist registrars), and yet these young surgeons closed 36% of all abdominal wounds. Table 4 illustrates that the degree of supervision exceeded 80% for this component. Although registrars and specialist registrars only served as operating surgeons in 39 of 334 bowel operations (12%), they constructed 24% of all stomas ($n=52$), and 20% of all anastomoses ($n=60$) (table 4). It is worth noting that registrars and specialist registrars never constructed stomas or anastomoses without supervision. Senior registrars were also supervised heavily when constructing stomas and anastomoses (54% and 61% supervised, respectively). Mobilisation of colonic flexure by registrars or specialist registrars was always done under supervision, but only 23 of 160 flexures (15%) were taken down by registrars or specialist registrars (table 4). The splenic flexure, the most difficult to mobilise, was never taken down by a registrar, and only once by a specialist registrar. Thirteen splenic flexures were mobilised by senior registrars, whereas 30 of 44 splenic flexures (68%) were mobilised by a staff specialist or consultant. In 18 of

these 30 mobilisations, a specialist registrar or senior registrar was assisting.

Looking in detail on the column (table 4) where a consultant was registered as performing a procedure, it is clear that a high number of these were carried out with either another consultant or staff specialist as first assistant. There is still a fair number of procedures where their assistant was a junior surgeon, who could have benefited from performing the procedure. A more detailed analysis showed great variation between consultants in their willingness to let more junior colleagues carry out the procedures under their supervision (data not shown).

Almost half of all pneumoperitoneums were established by registrars or specialist registrars (100 of 203; 49%), and 74 of these were done under supervision. Of 56 pneumoperitoneums established by consultants, 31 (55%) were carried out with a registrar or specialist registrar as assistant. A total of 73 laparoscopic appendicectomies were performed, and 43 (59%) were done by a registrar or a specialist registrar. Thirty two (59%) of these were supervised. Senior registrars, the staff specialist, and consultants performed 30 laparoscopic appendicectomies with the assistance of a registrar or a specialist registrar in 24 (80%).

The mean duration of selected operations is shown in table 5. No significant difference in operating time was found for

Table 3 Breast/endocrine operations

	Registrar	Specialist registrar	Senior registrar*	Consultant	
Breast dissection					
Supervised operation	27 (100)	38 (93)	18 (20)		
Assistant registrar		2 (5)	38 (43)	41 (56)	
Assistant specialist registrar			14 (16)	17 (23)	
Assistant senior registrar			1 (1)	8 (11)	
Assistant consultant					
No assistant		1 (2)	18 (20)	7 (10)	
Total	27 (12)	41 (18)	89 (39)	73 (32)	230
Dissection of the axilla					
Supervised operation	5 (100)	11 (100)	14 (21)		
Assistant registrar			32 (48)	44 (54)	
Assistant specialist registrar			15 (22)	21 (26)	
Assistant senior registrar			2 (3)	9 (11)	
Assistant consultant				4 (5)	
No assistant			4 (6)	4 (5)	
Total	5 (3)	11 (7)	67 (41)	82 (50)	165
Thyroid gland dissection					
Supervised operation			33 (92)		
Assistant registrar			1 (3)	47 (34)	
Assistant specialist registrar			1 (3)	33 (24)	
Assistant senior registrar			1 (3)	59 (42)	
Assistant consultant					
No assistant				1 (1)	
Total	0	0	36 (20)	140 (80)	176

* A senior registrar is equivalent to a UK specialist registrar with > 2 years of advanced training.

Table 4 Abdominal operations

	Registrar	Specialist registrar	Senior registrar*	Staff specialist	Consultant	
Abdominal incision						
Supervised operation	54 (87)	84 (78)	77 (43)	12 (39)		
Assistant registrar	1 (2)	5 (5)	68 (38)	6 (19)	47 (22)	
Assistant specialist registrar			28 (15)	7 (23)	33 (15)	
Assistant senior registrar			5 (3)	5 (16)	59 (27)	
Assistant staff specialist					33 (15)	
Assistant consultant					41 (19)	
No assistant	7 (11)	19 (18)	3 (2)	1 (3)	4 (2)	
Total	62 (10)	108 (18)	181 (30)	31 (5)	217 (36)	599
Wound closure						
Supervised operation	94 (92)	104 (81)	101 (57)	18 (38)		
Assistant registrar	1 (1)	5 (4)	48 (27)	15 (32)	41 (23)	
Assistant specialist registrar			18 (10)	5 (11)	31 (18)	
Assistant senior registrar			4 (2)	5 (11)	33 (19)	
Assistant staff specialist					25 (14)	
Assistant consultant					41 (23)	
No assistant	7 (7)	19 (15)	5 (3)	4 (9)	5 (3)	
Total	102 (16)	128 (20)	176 (28)	47 (7)	176 (28)	629
Mobilisation of flexure						
Supervised operation	4 (100)	19 (100)	25 (42)	4 (31)		
Assistant registrar			23 (38)	6 (46)	12 (19)	
Assistant specialist registrar			10 (17)	2 (15)	19 (30)	
Assistant senior registrar			1 (2)	1 (8)	15 (23)	
Assistant staff specialist					8 (13)	
Assistant consultant					9 (14)	
No assistant			1 (2)		1 (2)	
Total	4 (3)	19 (12)	60 (38)	13 (8)	64 (40)	160
Construction of stoma						
Supervised operation	18 (100)	34 (100)	39 (54)	17 (71)		
Assistant registrar			23 (32)	5 (21)	14 (21)	
Assistant specialist registrar			8 (11)	0	8 (12)	
Assistant senior registrar			1 (1)	2 (8)	21 (31)	
Assistant staff specialist					8 (12)	
Assistant consultant					15 (22)	
No assistant			1 (1)		1 (1)	
Total	18 (8)	34 (16)	72 (33)	24 (11)	67 (31)	215
Anastomoses						
Supervised operation	14 (100)	46 (100)	48 (61)	12 (41)		
Assistant registrar			20 (25)	12 (41)	32 (24)	
Assistant specialist registrar			7 (9)	2 (7)	28 (21)	
Assistant senior registrar			3 (4)	3 (10)	28 (21)	
Assistant staff specialist					21 (16)	
Assistant consultant					26 (19)	
No assistant			1 (1)		0	
Total	14 (5)	46 (15)	79 (26)	29 (10)	135 (45)	303

*A senior registrar is equivalent to a UK specialist registrar with >2 years of advanced training.

colonic resections and mastectomies when performed by consultants or by trainees. Hemithyroidectomies were done significantly faster by consultants than by senior registrars.

DISCUSSION

The present study shows that substantial information about operating activity can be obtained by recording details of each procedure in a simple database. This enables trainers and trainees to evaluate training and supervision in greater detail

than previously described, and it may be used for setting and maintaining standards of training. There are important limitations to the database that should be kept in mind when the results of this study are interpreted. First of all, acquisition of competence was not assessed, although this is possible.¹⁰⁻¹² Preoperative risk factors, patient outcome, and complications were not registered in the database, and it is therefore not possible to discuss if patient outcome was adversely affected in trainee supervised and unsupervised procedures. For all trainers these are crucial concerns whenever a procedure is handed over to junior colleagues, and such a correlation could accordingly have been justified.

With increasing subspecialisation and complexity of many surgical procedures, more detailed knowledge of the extent of training of logical components seems essential,⁷ because a substantial part of early training in these units will inevitably be achieved as bricks in a puzzle. Training policy and evaluation should therefore focus more on these components. The importance of new thinking in training is more relevant than ever, as weekly working hours are being reduced in many European countries. Log books are recommended for documentation of

Table 5 Mean (SD) duration of selected operations (hours)

	Consultants	Junior surgeons	p Value
Right hemicolectomy	1:43 (0:05) [7]	1:53 (0:03) [12]	NS
Sigmoid resection	1:35 (0:03) [10]	2:11 (0:07) [39]	NS
Radical mastectomy	2:17 (0:03) [48]	2:36 (0:07) [40]	NS
Hemithyroidectomy	1:50 (0:03) [44]	2:18 (0:03) [28]	0.024

The number of operations performed are shown in square brackets.

training in many countries,¹³ but they may provide insufficient information,⁷ and the information is not readily summarised and evaluated. It has previously been shown that electronic registration of surgical activity can be used efficiently to assess training.^{14–15} It is difficult in the literature, though, to find objective data on the supervision given by senior registrars and registrars to less experienced colleagues, a training that at least in Scandinavian countries is very important.

The high number of elective procedures performed by consultants reflects the fact that the unit is highly specialised, and that few procedures can be done completely by the youngest surgeons. Only 106 of 1250 annual procedures were done by one of the five registrars, and this is most definitely insufficient for young surgeons, who are about to qualify for advanced training. It is a warning that a tendency towards subspecialisation may severely affect the training being offered to junior surgeons. Having said this, it is important to pay attention to tables 3 and 4, where evidence is found that the majority of components performed by registrars and specialist registrars were done under supervision. There is no doubt that supervision is crucial in surgical training, and this will prove to be a mainstay in future training as training hours are shortened.⁴ Also important, and stressing the benefits of a detailed registration, is the fact that a substantial number of components (like incision, wound closure, creation of a stoma, and anastomosis) were actually performed by the youngest surgeons, even though a more senior colleague was registered as having performed the operation.

For all trainees, the fraction of elective operations done under supervision amounted to approximately 85% (fig 1A), which is far more than what has previously been reported from a district general hospital in the UK.¹⁶ In an audit from three large regions in the UK, the supervision of elective large bowel cancer surgery was also far from what was observed in the present study.¹⁷ Emergency colonic resections are often more demanding than elective cases, and these procedures were done to a much higher extent by unsupervised trainees than were the elective cases. This paradox has also been reported in the UK.^{16–17}

Establishing pneumoperitoneum and insertion of trocars are procedures that may be hazardous,^{18–19} and careful supervision is imperative during early laparoscopic training. A high degree of supervision was evident in the present study with 70% of all pneumoperitoneums being established by registrars or specialist registrars under supervision. Supervised experience could have been achieved in another 31 procedures, but a number of the laparoscopic procedures were repair of incisional and parastomal hernias, and these operations were not considered suitable for training. A fair fraction of laparoscopic appendicectomies were performed by registrars and specialist registrars, but it is surprising that consultants and the staff specialist performed as many as 30 of these procedures with a registrar or specialist registrar as assistant. This only happened in eight out of 91 open appendicectomies.

Modern surgical units face increasing demands of productivity and cost effectiveness, arguments that are often presented when concern about surgical training is being debated. Although it is possible that specialist registrars were offered the simplest cases to operate on, it was found that only hemithyroidectomies were of significantly longer duration when performed by senior registrars rather than by consultants, whereas mastectomies and colonic resections were done almost as quickly by trainees as by consultants (table 4). It has been shown in another study, however, that trainees required 50%–75% more operating time than consultants, and it would require substantial economic funding to increase the number of operations performed by trainees.⁵

Key points

- Electronic registration of logical components of surgical procedures provides detailed information about supervision and delegation.
- The information can be used for assessing both individual and general performance.
- In a subspecialised surgical unit, a significant number of more general components can be performed by surgeons in training, although they may not be capable of performing the whole procedure.

In conclusion, the present study shows that it is possible to obtain detailed information of general and individual performance and delegation of surgical procedures, and about the degree of supervision. Detailed information about the performance of logical components provided a foundation for evaluating the extent of training in these components. A database like the present could constitute a valuable tool for improving surgical training, and also for credentialing components when they are being performed by trainees, who were not registered for having performed the whole procedure.

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REFERENCES

- 1 Jones PF. Surgical training: a report to the Association of Surgeons of Great Britain and Ireland. *Br J Surg* 1991;**78**:1156–8.
- 2 Varghese D, Patel H, Varghese A. Surgical training for the next millennium. *Hosp Med* 1999;**60**:210–11.
- 3 Taffinder N. Better surgical training in shorter hours. *J R Soc Med* 1999;**92**:329–31.
- 4 Collins C. Surgical training, supervision, and service [editorial; comment]. *BMJ* 1999;**318**:682–3.
- 5 Crofts TJ, Griffiths JM, Sharma S, et al. Surgical training: an objective assessment of recent changes for a single health board [see comments]. *BMJ* 1997;**314**:891–5.
- 6 Pickersgill T. The European working time directive for doctors in training. *BMJ* 2001;**323**:1266.
- 7 Shields R, Macleod DA, Porter RW. Surgical training. Structured training is now being used [letter; comment]. *BMJ* 1997;**315**:125.
- 8 Dikki PE, Crofts TJ, Nixon SJ, et al. Consultant supervision of surgical trainees: an objective assessment of how much actually occurs. *Ann R Coll Surg Engl* 1999;**81**:73–5.
- 9 NOMESCO. *Classification of surgical procedures*. Version 1.3. Copenhagen: NOMESCO, 1999.
- 10 Martin JA, Regehr G, Reznick R, et al. Objective structured assessment of technical skill (OSATS) for surgical residents. *Br J Surg* 1997;**84**:273–8.
- 11 Faulkner H, Regehr G, Martin J, et al. Validation of an objective structured assessment of technical skill for surgical residents. *Acad Med* 1996;**71**:1363–5.
- 12 Scott DJ, Valentine RJ, Bergen PC, et al. Evaluating surgical competency with the American Board of Surgery In-Training Examination, skill testing, and intraoperative assessment. *Surgery* 2000;**128**:613–22.
- 13 Galasko C, Mackay C. Unsupervised surgical training. Logbooks are essential for assessing progress [letter; comment]. *BMJ* 1997;**315**:1306–7.
- 14 Milne AA, Griffiths JM, Aitken RJ, et al. Comparative assessment of surgical training using objective criteria. *Ann R Coll Surg Engl* 1996;**78**:177–9.
- 15 Potter MA, Griffiths JM, Aitken RJ, et al. An objective assessment of surgical training. *Ann R Coll Surg Engl* 1996;**78**:11–3.
- 16 O'Leary DP, Collins CD. Analysis of a year's general surgical activity in a district general hospital. *Ann R Coll Surg Engl* 1994;**76**:176–81.
- 17 Aitken RJ, Thompson MR, Smith JA, et al. Training in large bowel cancer surgery: observations from three prospective regional United Kingdom audits [see comments]. *BMJ* 1999;**318**:702–3.
- 18 Usal H, Sayad P, Hayek N, et al. Major vascular injuries during laparoscopic cholecystectomy. An institutional review of experience with 2589 procedures and literature review. *Surg Endosc* 1998;**12**:960–2.
- 19 Ahmad SA, Schuricht AL, Azurin DJ, et al. Complications of laparoscopic cholecystectomy: the experience of a university-affiliated teaching hospital. *J Laparoendosc Adv Surg Tech A* 1997;**7**:29–35.