Standing on the Shoulders of Giants: Contemplating a Standard National Curriculum for Surgical Training in Gynaecology

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Abstract

Surgical gynaecology is mostly taught in the operating room. Few training programs organize structured surgical skill laboratories, and even fewer conduct a formal, objective surgical proficiency assessment at the completion of training. Articles published in English between 1950 and 2008 that described surgical curricula for training outside the OR were sought using Medline and the key words "resident," "gynecology," and "surgery." In this review, examples of structured curricula from the disciplines of obstetrics and gynaecology and general surgery are provided. The key features of an effective curriculum are realism, valid assessment tools, retention of skill over time, transferability to real OR situations, and cost efficiency. Training models such as bench and video trainers and virtual reality simulators have been reliably shown to produce quantifiable improvement in skills that is transferable to surgical procedures in live patients. Training laboratories are expensive to develop and maintain but may be more cost-effective than training residents solely in the OR. Having a standard national curriculum for surgical skill enhancement remote from the OR is highly desirable. Frequent assessment of learning progress using validated tools should also be considered.

Résumé

La gynécologie chirurgicale est en grande partie enseignée en salle d'opération. Peu de programmes de formation organisent des laboratoires structurés portant sur les compétences en chirurgie; un encore moins grand nombre d'entre eux offrent une évaluation officielle et objective de la maîtrise chirurgicale à la fin de la formation. Nous avons mené des recherches dans Medline afin d'y trouver les articles, publiés en anglais entre 1950 et 2008, portant sur le curriculum de formation en chirurgie à l'extérieur de la salle d'opération, et ce, au moyen des mots clés « *resident* », « *gynecology* » et « *surgery* ». Dans le cadre de cette analyse, nous offrons des exemples de curriculum structuré issus de disciplines liées à l'obstétrique-gynécologie et à la chirurgie générale. Les caractéristiques clés d'un curriculum efficace sont le réalisme, l'utilisation d'outils d'évaluation valables, la rétention des compétences avec le temps, la transférabilité à des situations opératoires réelles et la rentabilité. Il a été démontré de façon fiable que des modèles de formation (tels que les formations au moyen de bancs d'essai et de vidéos, et le recours à des simulateurs de type « réalité virtuelle ») généraient une amélioration quantifiable des compétences qui peut être transférée aux interventions chirurgicales menées chez des patientes vivantes. Bien qu'il s'avère coûteux d'élaborer et d'assurer le maintien des laboratoires de formation, ceux-ci peuvent s'avérer plus rentables que le seul recours à la formation des résidents en salle d'opération. Il serait très souhaitable de pouvoir disposer d'un curriculum national standard pour l'amélioration des compétences chirurgicales à l'extérieur de la salle d'opération. L'évaluation fréquente de l'évolution de l'apprentissage au moyen d'outils validés devrait également être prise en considération.

Key Words: Surgical skill, curriculum, resident, gynaecology, surgical education

Competing Interests: None declared.

Received on February 19, 2008

Accepted on March 20, 2008

J Obstet Gynaecol Can 2008;30(8):684–695

INTRODUCTION

In an environment of rapidly evolving surgical techniques, an increasing emphasis on conservative management, dwindling resources for surgical mentoring, and heightened awareness of medico-legal aspects of care can adversely affect technical skill training for residents. Gynaecologists are trained mostly in the OR,[1] where resources can be scarce.[2] Surgical education of residents has therefore been referred to as "education by random opportunity."[3]

A survey of the 266 residency training programs in obstetrics and gynaecology in the United States established that only 29% of respondents used a formal teaching curriculum for surgical skills.[1] A survey of endoscopic skills instruction in Canadian obstetrics and gynaecology programs[2] revealed that 66% of programs used didactic lectures, 47% dry laboratories, and 52% wet laboratories. Only 18% of programs incorporated a formal skills assessment for their graduating residents. Most residents and program directors and the Society of Obstetricians and Gynaecologists of Canada consider endoscopic skills essential to the practice of modern gynaecology.[2] First- and second-level skills such as laparoscopic ovarian cystectomy, laparoscopic management of ectopic pregnancy, and total endometrial ablation are considered minimum requirements for practice.[4,5] Yet not all

residents feel comfortable performing these procedures. On a scale of increasing confidence from 1 to 5, 25.5% of graduating residents rated their level of confidence for cystectomy and ectopic pregnancy management as 1 to 3 and 54.4% rated their level for endometrial ablation as 1 to 3.[2]

The situation is of more concern with urogynaecologic procedures. A national survey of recent graduates and residency program directors in the United States shows significant differences in perceived competence with several common procedures.[6] For example, 63% of program directors felt that their recent graduates were able to perform a TVT procedure independently, but only 30% of the graduates themselves felt able to do so ($P \leq 0.001$). The TVT is a good example of a set of skills that are usually taught exclusively in the OR, with no model or practice opportunity other than in live patients. In many Canadian residency training centres, the assessment of proficiency in performing TVT consists of subjective faculty evaluations that are known to have poor reliability and modest validity.[7] This is true of many other gynaecologic procedures requiring different skill sets. There is no mandatory objective assessment of overall surgical skill, either outside or inside the OR, at entry into a residency program, during training, or at the time of graduation. Given the lack of national standards for surgical skill training and objective assessment, training opportunities can be disparate and residents may graduate with suboptimal surgical skills.

The objective of this review is to summarize reports describing curricula used for the training of residents in gynaecology and general surgery outside the OR, in order to stimulate discussion among obstetrician-gynaecologists about how to standardise and improve surgical training in Canada. For the purposes of this review, a curriculum is defined as a structured, systematic, practical training program that leads to a resident's acquiring a specific set of surgical skills in a safe unhurried environment outside the OR. Ultimately, these skills need to be transferable to procedures in the OR, where the residents can consolidate their ability to perform the surgical procedures outlined by the Royal College of Physicians and Surgeons of Canada as mandatory for gynaecologic practice.[8] In addition to transferability of skills, other key curricular components of surgical skill teaching are model fidelity or realism, validity and reliability of assessment, retention of skills over time, and overall cost.[9–11]

ABBREVIATIONS

MISTELS	McGill Inanimate System for Training and Evaluation of Laparoscopic Skills
MIST-VR	Minimally Invasive Surgical Trainer—Virtual Reality
OR	operating room
TVT	tension free vaginal tape procedure

METHODS

Medline was used to search the literature for articles published in English between 1950 and 2008. Two search strategies were used: the key words "resident" and "gynecology" were combined; the search was repeated with the key words "resident" and "surgery." Articles were retained if they described training outside the OR and one or more of the above key curricular components: skill transferability, realism, validated assessment tools, skill retention, and cost. The bibliographies of all retained articles were examined for additional articles of interest.

RESULTS

Two hundred ninety-nine abstracts were reviewed and 23 articles of interest were retrieved using the "gynecology" search strategy. Approximately one thousand abstracts were reviewed and 20 articles of interest were retrieved using the "surgery" search strategy. Studies are described below as they pertain to the curricular components. Details of the curricula for the training of gynaecology residents are shown in Table 1 and for the training of general surgery residents in Table 2. The studies shown in the Tables are arranged in chronological order, from earliest to most recent date of publication.

Skill Transferability to the Real OR Setting

An important concern facing surgical educators is to ensure that models used for instruction translate into skills that are useful and applicable in the OR setting.

Coleman and Muller[12] used real life OR situations to test their laparoscopy curriculum. They randomized gynaecology residents to either a four-week curriculum of video trainer or to no intervention and tested them using validated scales[13] and blinded examiners before and after intervention. At week 4, the intervention group showed a greater reduction than the control group in time to accomplish the tasks compared to baseline ($P < 0.001$) and a greater improvement from baseline in skill assessment on the global score ($P = 0.015$). The same study design was used by Scott et al.[14] in 22 general surgery residents randomized to the above intervention (video trainer drills) or to no instruction. An actual laparoscopic cholecystectomy and a validated global scale[13] were chosen for resident evaluation before and after intervention. Both studies concluded that training via video trainer improved performance in the OR.

Table 1. Curricula for gynaecology residents

Study	Evidence level	Course	Model realism	Description of curriculum	N	Randomized	Skills evaluation	Results	Skill transfer to OR	Skill retention	Cost analysis
Sammarco et al.[54] 1993	III	Endoscopy	Adequate Didactic, pelvic trainer	10-week course, twice during 4-year residency: didactic; instrumentation; pelvic trainer tasks; bench models	On-going	No	Written and practical tests	N/P	N/A	N/A	N/P
Letterie et al.[55] 1993	III	Laparoscopy	Adequate Didactic, pelvic trainer	4-year instruction plan tailored to resident level: didactic; reading lists; pelvic trainer	6	No	Subjective faculty evaluation at each level; resident allowed to progress to next level only if evaluation satisfactory	One resident failed to master first year skills and had restricted privileges in second year; he subsequently departed from the residency	Subjective assessment	N/A	N/P
Cundiff[20] 1997	II-3	Laparoscopy	Good Didactic, pelvic trainer, porcine model	7 weekly 4-hour sessions tailored to resident level: didactic, pelvic trainer, porcine model	18	No	Timing on pelvic trainer skills at first and sixth session, faculty assessment of pelvic trainer skill proficiency, self and faculty assessment of laparoscopic competency in real OR before and after training	All residents significantly improved timing on trainer skills (58-72% improved, P 0.04 to < 0.001) Faculty and residents reported improved resident laparoscopic competency at end of training (ns)	Subjective assessment	N/A	N/P
Milad et al.[44] 1998	III	Endoscopy	Good Didactic, pelvic trainer, animal model	Weekly endoscopy rounds; bench models for demonstration of electrosurgery, laser, laparoscopy and hysteroscopy; 4 half-day animal lab sessions performed twice during 4-year residency; individual animal lab access; year-round access to inanimate laparoscopic trainer	On-going	No	None	N/A	N/A	N/A	US$34544 annually
Goff et al.[21] 1999	II-3	Laparoscopy Open	Good Bench model, pelvic trainer, porcine model	Pretest, administered to all residents before each session: bench model and laparoscopic trainer tasks Instruction first year residents: didactic, pelvic trainer, porcine model (8 hours) Instruction second, third and fourth year residents: pelvic trainer (6 hours), porcine model (3 hours laparoscopy, 1 hour open tasks); 2 sessions per year	24	No	Timing of tasks, subjective faculty rating on scale of 1-3 on same tasks, written tests on surgical anatomy, suturing and laparoscopy	Significant improvements in peg placement ($P = 0.001$), incision suturing ($P < 0.001$) Subjective faculty rating significantly improved for incision suturing from first to second pretest ($P = 0.013$) Subjective faculty rating significantly improved for first year residents from first to second test ($P = 0.001$)	N/A	N/A	US$1800/ 4-hour pig session

continued

Table 1 Continued

Study	Evidence level	Course	Model realism	Description of curriculum	N	Randomized	Skills evaluation	Results	Skill transfer to OR	Skill retention	Cost analysis
Coleman et al.[12] 2002	I	Laparoscopy	Adequate Video trainer	4-week curriculum: Wks 1-5 timed video laparoscopic drills, baseline OR pretest. Wks 2 & 3-practice 5 video trainer drills for 30 minutes daily on 10 days. Wk 4-evaluation of 5 timed video laparoscopic drills, and second OR test. Comparison group did not do drills.	18	Yes	Validated Global Rating Scale on laparoscopic partial salpingectomy in real OR before and after intervention; blinded examiners (videotapes) Timing of videotrainer drills	Both groups significantly improved timed drill scores and intraoperative laparoscopic skills. Intervention group had greater % reductions in time from baseline (51% vs. 18%, $P < 0.0001$), improvement in global score (mean 4.9 points; $P = 0.015$; 95% CI 1–7.5)	Yes	No	N/P
Van Blaricom et al.[30] 2005	II-2	Hysteroscopy	Adequate Inanimate model	3-hour curriculum administered once yearly: 1-hour didactic session, 2-hour hands-on lab for practice with equipment and inanimate hysteroscopy uterine model	24 Control group of 24 residents	No	Pass fail, task specific checklist, validated Global Rating Scale, blinded and unblinded examiners	Trained residents did significantly better than untrained colleagues on global rating scale (mean 24.88 vs. 18.28, $P = 0.007$) and on checklist (average score 63% vs. 45%, $P = 0.001$)	N/A	N/A	Pelvic trainer US$407 Uterus $61 per 3 residents
Levine et al.[19] 2006	II-3	Laparoscopy	Good Lightly embalmed cadavers	5 half-days: Day 1-pretest using physical reality simulator tasks and cadaver suturing; port placement and dissection in female cadaver Day 2-adnexal laparoscopic surgery Day 3-further dissection and suturing Day 4-subtotal laparoscopic hysterectomy Day 5-further dissection, Burch procedure/paravaginal repair, post-test (same as pretest)	29	No	Timing and number of transferred beads; suture time (simulator); suture time (cadaver)	Significant decrease in bead transfer time (median decrease 38.5 s, $P = 0.02$); increase in number of transferred beads (median increase 2.5, $P = 0.001$); decrease in simulator suture time (median decrease 63.5 s, $P = 0.001$); decrease in cadaver suture times (median decrease 54.5 s, $P = 0.001$ and 53.5 s, $P < 0.001$)	N/A	N/A	US$2400 annually for whole program

N/A: not assessed; N/P: not provided; ns: not significant

Table 2. Curricula for general surgery residents

Study	Evidence level	Course	Model realism	Description of curriculum	N	Randomized	Skills evaluation	Results	Skill transfer to OR	Skill retention	Cost analysis
Melvin et al.[56] 1996	II-3	Laparoscopy	Good Box trainer Video trainer Porcine model	6-week course, total time 15-18 hours Week 1: didactic Weeks 2-5: box trainer, knot tying and suturing Week 6 (6 hours): animal lab	12	No	Task timing on bench tasks; performance in animal lab not objectively evaluated	Overall scores improved by 28.9%	N/A	N/A	N/P
Derossis et al.[57]1998	I	Laparoscopy	Adequate Box trainer (MISTELS)	Baseline testing, then 5 weekly practice sessions, retest. Comparison group did not do drills. No significant clinical exposure during study (residents on research year).	12	Yes	Task precision and timing	Intervention group significantly improved (baseline to final) for each task and for sum of all tasks ($P < 0.05$). Final total score for intervention group was 219 ± 14% of baseline ($P < 0.0001$) and for control group 162 ± 35% of baseline ($P = 0.07$)	N/A	N/A	N/P
Fried et al.[58] 1999	I	Laparoscopy	Adequate Box trainer (MISTELS)	Baseline testing MISTELS and porcine model; 5 weekly practice sessions on MISTELS; retest on MISTELS and porcine model. Comparison group did not do drills.	12	Yes	Task precision and timing, both in vitro and in vivo models	Intervention group significantly improved in vivo performance for cutting, clipping, mesh placement and suturing (5 of 7 tasks), as well as in total score ($P < 0.05$). Group B significantly improved in suturing (2 of 7 tasks) and in total score. Magnitude of improvement from baseline to final evaluation significantly greater for group A ($P < 0.05$).	No (transferability to porcine model)	N/A	N/P
Scott et al.[14] 2000	I	Laparoscopy	Adequate Video trainer	4 week curriculum: Wk 1 - 5 timed video laparoscopic drills, baseline OR pretest. Wk 2 & 3 - practice 5 video trainer drills for 30 minutes daily on 10 days. Wk 4 - evaluation of 5 timed video laparoscopic drills, and second OR test. Comparison group did not do drills.	22	Yes	Validated Global Rating Scale on laparoscopic partial salpingectomy in real OR before and after intervention; blinded examiners (videotapes). Timing of videotrainer drills	Intervention group showed greater improvement in time to complete each of the 5 videotrainer drills ($P = 0.001$ to 0.015) and a greater improvement from baseline in the global score ($P = 0.007$) on the laparoscopic cholecystectomy	Yes	No	N/P
Torkington et al.[34] 2001	II-2	Laparoscopy	Adequate Video instruction Box trainer	Pretest; 3-day laparoscopic training course; post-test immediately after course and at 3 weeks and 3 months later. Testing and intervention on all residents using the MIST Virtual Reality simulator.	13 Control group of 13 medical students	No	MIST-VR scoring	Intervention group had statistically significant improvements in 4 of 5 MIST-VR tasks ($P < 0.01$ to 0.05) at first post-test, 5 of 5 tasks at 3 weeks ($P < 0.001$ to 0.05) and 2 of 5 tasks at 3 months ($P < 0.05$). Control group: trend toward better performance.	N/A	Significant improvements maintained at 3 months for number of movements made and time taken to complete the MIST-VR task	N/P

continued

Table 2 Continued

Study	Evidence level	Course	Model realism	Description of curriculum	N	Randomized	Skills evaluation	Results	Skill transfer to OR	Skill retention	Cost analysis
Hamilton et al.[59] 2001	I	Laparoscopy	Adequate Video, CD-ROM, inanimate model	Baseline laparoscopic hernia repair; training via interactive CD-ROM, detailed instructional video and rubber simulator (10 separate 30-minute sessions over a 2-week period; post-test laparoscopic hernia repair. Control group no practice outside the operating room.	21	Yes	Validated Global Rating Scale	Improvement significantly greater in intervention group in 5 of 8 global scale assessment areas as well as the composite score ($P < 0.05$).	Yes	N/A	N/P
Seymour et al.[17] 2002	I	Laparoscopy	Adequate MIST-VR	Training sessions with experienced surgeons using MIST-VR until desired competency achieved; posttest consisted of laparoscopic cholecystectomy. Control group no practice outside the operating room. Independent reviewers blinded to resident status.	16	Yes	Task timing; non validated scale assessing surgical skill	Gallbladder dissection 29% faster for intervention residents (ns). Mean errors 6X less likely to occur in trained group (1.19 vs. 7.38 errors per case, $P < 0.008$).	Yes	N/A	N/P
Lin et al.[22] 2003	II-3	Laparoscopy	Good Animal lab, preoperative tutorial, feedback	Animal lab sessions concentrated on acquisition of specific skills; preoperative tutorials with mentors to discuss operative strategy during laparoscopic colectomy; videos and books as teaching aids; postoperative feedback. Annual results compared to results from baseline year.	6	No	Operative time, conversion rate to open, hospital length of stay.	No statistical differences in operative time over the 3 years; length of hospital stay after surgery less than 5 days by year 3; conversion rate to open colectomy decreased from 30% in year 1 to 14% in year 3	Assumed	N/A	N/P
Anastakis et al.[23]2003	II-3	Different surgical procedures (eg, bone biopsy, vascular anastomosis etc.)	Good Animal lab,fresh cadavers, bench models	Biweekly 2-hour sessions, 2 year curriculum; training in many different individual basic operative procedures. Testing performed via cadaver based assessment of technical skills at least 2 years from curriculum introduction.	19 Historical control group of 31 residents	No	Checklist Validated Global Rating Scale	No statistically significant differences between intervention and historical control group.	N/A	Training on a procedure in isolation, in the lab, does not improve performance on the same procedure 2 years later	N/P
Grantcharov et al.[16]2004	I	Laparoscopy	Adequate MIST-VR	Pretest: laparoscopic cholecystectomy; training on MIST-VR; post-test within 14 days of pretest: laparoscopic cholecystectomy. Control group no training. 2 independent blinded observers for intraoperative assessment	16	Yes	Validated Global Rating Scale	Intervention group performed laparoscopic cholecystectomy significantly faster than control group ($P = 0.021$). Trained group significantly greater improvement in error ($P = 0.003$) and economy of movement ($P = 0.003$)	Yes	N/A	N/P

continued

Table 2 Continued

Study	Evidence level	Course	Model realism	Description of curriculum	N	Randomized	Skills evaluation	Results	Skill transfer to OR	Skill retention	Cost analysis
Scheeres et al.[24] 2004	II-3	Laparoscopy	Good Didactic Animal lab	Pretest; training 6 half-day sessions weekly; post-test immediately after and 6 months after the course; testing by blinded observer on laparoscopic fundoplication (porcine model)	12	No	Timing, intraoperative performance score	Overall performance score 35.7 ± 2.5 for pretest, improved to 16.5 ± 1.2 ($P < 0.05$) immediately after the course and 23.7 ± 5.1 ($P < 0.05$) at 6 months.	NO – transfer-ability to porcine model	Significant retention of skills on porcine model at 6 months, including trocar insertion and fundoplication	US$860.00/ resident/yr
Stefanidis et al.[35] 2005	II-3	Laparoscopy	Adequate Video trainer MIST-VR	Pretest; sequential training via 12 MIST-VR and 5 video trainer tasks until proficiency achieved; "test" at proficiency, "post-test" at 13.2±11.8 days and "retention test" at 7.0±4.0 months; testing via one representative MIST-VR and one representative video trainer task	14	No	MIST-VR scoring, timing	MIST-VR scores: test at proficiency 59% improvement from baseline ($P < 0.001$); posttest 55% skill retention compared to proficiency ($P < 0.01$); retention 0% deterioration compared to post-test Video trainer scores: test at proficiency 56% improvement from baseline ($P < 0.001$); post-test 83% skill retention compared to proficiency ($P < 0.01$); retention 3% deterioration compared to post-test	N/A	Significant retention of skills demonstrated for one academic year	N/P
Berg et al.[45] 2007	III	Open Laparoscopy	Good Didactic Bench model Box trainer Porcine model	Didactic session and skills modules: 4 open and 5 laparoscopic, combination of inanimate (bench) models, box trainers and animal labs	ongoing	No	None	N/A	N/A	N/A	US$982/ resident/yr

N/A: not assessed; N/P: not provided; ns: not significant

The use of the MIST-VR simulator is described in general surgery training. This tool simulates a range of laparoscopic tasks using instruments passed through mechanical tracking devices that record instrument position data during the performance of different tasks. The simulator provides information regarding task completion time, number of movements performed, distance travelled, economy of movement and number of errors in task completion. The transferability of skills to the OR after MIST-VR simulator training has been demonstrated in several randomized controlled trials.[15–17]

Realism of Models

The ability to perform well in the OR depends on the surgeon's ability to create a 3-D picture using multisensory landmarks, to retrieve previously stored sensory information and to concentrate on essential detail.[18] In addition to exercising manual dexterity through basic skill drills, successful training models need to reproduce real OR situations.

Human cadavers and anaesthetized animals provide the most realistic training models. The light embalming cadaver technique preserves the colours and textures of the living body for up to six weeks.[19] Anaesthetized animals have the advantage of bleeding tissues which can provide instant feedback on surgical mistakes. Levine et al.[19] demonstrated significant improvement in the surgical skills of 29 obstetrics and gynaecology residents using lightly embalmed cadavers; the training program involved simulator tasks and cadaver dissection over five days. Surgical skills were tested by timing and dexterity in different tasks using both simulators and cadavers before and after intervention. Cundiff[20] studied the surgical performance of 18 first, third and fourth year obstetrics and gynaecology residents. The curriculum, comprising didactic sessions, pelvic trainer instruction, and a porcine model, was administered over seven condensed four-hour weekly sessions. All residents improved operating times in pelvic trainer skills, and faculty assessment of resident proficiency in the OR after the program showed an upward trend. The curriculum accommodated educational needs of residents at different stages of training. However, some of the laparoscopic tasks for the porcine model, involving the upper abdomen, were not relevant to gynaecology resident training. Goff et al.[21] also described the integration of a porcine model for obstetrics and gynaecology resident instruction in open and laparoscopic procedures. Twenty-four second, third and fourth year residents participated in didactic lectures, laparoscopic video training and animal laboratory, with pre- and post-testing. Close supervision was provided and tasks were tailored to resident level. Video trainer tasks were evaluated and resident performance was rated by faculty. Timing of tasks improved at all resident levels. Only the first year residents showed significant improvement between the first and second faculty ratings (median rating of 1.00 to 2.00, $P = 0.01$).

Lin et al.[22] described the use of a porcine model to improve the surgical skills of general surgery residents. These authors evaluated subsequent performance on actual laparoscopic colectomies by recording operative time, conversion rate to open and length of hospital stay. Unfortunately, improvement in intraoperative surgical skill was not specifically evaluated. Anastakis et al.[23] used an extensive curriculum to teach surgical residents from different specialties several surgical procedures such as bone biopsy and vascular anastomosis. Both animal models and cadavers were used for training. After two years of this training, 19 trained participants and 31 historic controls were tested via checklists and a validated global scale while performing surgeries on cadavers. There was no statistically significant difference between training and control group outcomes. However, the concentration on teaching procedures (not necessarily relevant to individual specialties), rather than specific basic motor skills, may account for the lack of difference in performance between groups. Scheeres et al.[24] demonstrated a significant improvement in laparoscopic skills in 12 general surgery residents six months after training on a porcine model. Unfortunately, there was no control group and the performance assessment scale was not validated.

Validated Tools for Technical Skill Assessment

Reznick noted that "Deficiencies in resident training are unlikely to be corrected without mechanisms for reliable and systematic feedback," and he initiated a series of publications establishing psychometric validation of a rating scale of surgical skill.[7] The scale addresses five essential intraoperative proficiency aspects: respect for tissue, time and motion, instrument handling, knowledge of instruments, and use of assistants. Each aspect of a trainee's performance is rated by the attending surgeon on a 5-point scale from "uncomfortable" to "performance worthy of an attending surgeon." The scale demonstrated adequate construct and criterion validity, as well as inter-rater reliability in an initial group of general surgery residents.[25] The global rating scale was subsequently tested and validated with bench models and animal simulations in a study of 20 general surgery residents rated by 48 attending surgeons.[26] The same rating scale was extensively validated in obstetrics and gynaecology residents using a porcine model[27] and bench models.[28–30] Yet another study[31] examined 116 obstetrics and gynaecology residents in five programs using realistic surgical models illustrating three open and three laparoscopic pelvic surgery tasks. Each resident was scored by one blinded and one unblinded staff gynaecologist. Internal

consistency, inter-rater reliability and construct validity of the global scale were again demonstrated.[31] Given this large body of evidence, the global rating scale, also known as OSATS (objective structured assessment of technical skill), is widely employed in gynaecology residency programs across the United States.

MISTELS (McGill Inanimate System for Training and Evaluation of Laparoscopic Skills) comprises a series of tasks, such as peg transfer and intracorporeal knot tying, performed in an endotrainer box. Evaluation includes timing and accuracy of performance. MISTELS was validated as an evaluation tool in a series of experiments involving general surgery trainees.[32,33]

Additional potentially useful tools for the assessment of surgical skills include timing on video trainer[12,14] or computer assessed performance on virtual reality tasks.[34–36] Complete psychometric validation of these will be required before they can be accepted as standard, meaningful evaluation tools.

Retention of Skills Over Time

A unifying feature of each of the studies reviewed was the satisfaction of residents with the training received and the manifest desire for more frequent sessions to be incorporated into the different curricula.[14,20,21,23,37,38] The ideal number of training sessions required during the course of a residency program to enhance and maintain skill is currently unknown. Few publications have addressed the issue of retention of skill following instruction.[9]

Torkington et al.[34] used video instruction and a box trainer for laparoscopic training of 13 surgical trainees with similar baseline laparoscopic skills. Assessment of skills was performed using the MIST-VR system before training, immediately after training, and at three weeks and three months after completion. The trainees showed statistically significant improvements over their pre-course scores in all five MIST-VR tasks immediately after the course ($P < 0.001$) and three weeks later ($P < 0.05$). After three months, they maintained significant improvement from baseline in only two of five MIST-VR tasks ($P < 0.05$).

In another study using the virtual reality simulator, Stefanidis et al.[35] evaluated 14 general surgery residents with no previous simulation experience. The residents practised 12 MIST-VR tasks and five video trainer (VT)[12,14] tasks in sequence until proficiency was achieved. This study showed that the residents had excellent skill retention for up to 11 months after instruction on the virtual reality and video trainer simulators.

Scheeres et al.[24] demonstrated statistically significant skill retention in 12 general surgery residents six months after they were taught advanced laparoscopic skills on a pig model. In addition, there was no correlation between the number of advanced laparoscopic cases performed during the six months on patients in the OR setting and the retention of skills in the porcine model tasks ($r = 0.25$, $P = 0.2$).

Similar long-term studies are needed to quantify skill retention in the context of various other training models and to determine the number of task repetitions required to optimize skill retention. For non-randomized studies, it is difficult to determine whether practice outside the OR or routine surgical residency training (including OR time) is responsible for maintenance or improvement of skill.

Cost

For a surgical training curriculum for residents to be successful and widely implemented, adequate long-term financial support is required. In the survey of endoscopic training conducted by Raymond et al.,[2] a lack of financial resources was the most important factor reducing the ability to teach endoscopic skills (mean rating 4.07 on a 5-point Likert scale). However, training residents exclusively in the OR may be expensive. Several studies have shown that OR time is increased when supervised residents operate.[39–43] Bridges and Diamond[41] analyzed the extra cost of training residents in the OR by calculating the cost per minute of running an OR and the extra time required for residents to operate, compared with staff surgeons operating alone. The average resident extended each case by 12.64 minutes. They found that the cost per graduating resident over four years of training and an average of 885 procedures was US$47 970. The expense in lost OR time may be higher than the average annual cost of a skills laboratory.

Few publications have provided a full cost analysis of their described curricula. In many reports, surgical equipment was industry-sponsored, and faculty remuneration was not counted in the total cost. A comprehensive description of costs was provided by Milad and Lindau.[44] The total annual cost of their training program was US$34 544, with the largest cost components being room rental (US$15 000) and pelviscopic equipment (US$6000). Additional costs included US$6300 for animal care and US$2320 for an instructional library of videotapes and books. US$2800 of the total cost in endoscopic equipment was supplied by vendors. Faculty remuneration for supervision was not included in the cost. Their endoscopy training room, with inanimate trainer, surgical equipment, and library, was available to their residents 24 hours a day. Goff et al.[21] described the cost of an animal laboratory (US$100 per animal, US$1800 for animal care, and US$1500 for the facility for a 4-hour training session). In total, these authors described total costs of US$14 400 annually, providing two sessions for each of the 24 residents at their institution. Their equipment was also industry-sponsored, and faculty time was not

part of the above-mentioned costs. Bench models and video trainers cost significantly less. Van Blaricom et al.[30] described the cost of their reusable hysteroscopy model (US$407) and a cost per resident of US$20. Berg et al.[45] provided a description of the skills laboratory at Temple University, which includes open surgery and laparoscopy training modules with a combination of bench models, box trainers, and animate models. The cost per resident to use this facility three years after implementation was US$982.

A survey of United States general surgery residency program directors[46] showed that, of 89 programs with skills laboratories, 99% have video trainer equipment, and 46% have virtual reality training equipment. On average, residents train 0.8 hours per week. The mean development cost was US$133 000 (range US$300 to US$1 000 000). Mean annual budget for the skills laboratories was US$11 000 (range 0 to US$50 000). The monetary sources quoted included corporations (43%), departments (26%), hospitals (13%), government sources (3%), and private donations (14%).

There is good evidence to suggest that expensive virtual reality systems are similar to box trainers in enabling the acquisition of motor skills.[15,47] Residents prefer to use video trainers because of their superior tactile feedback and depth perception.[15] Skill retention was found to be better after video training than after virtual reality instruction ($P < 0.02$).[35] More randomized controlled trials comparing different training tools and their effectiveness are needed before the adoption of expensive commercially available virtual reality systems.

DISCUSSION

This review provides examples of realistic surgical training models for the acquisition of skills that are transferable to the OR. Training using box and video trainers, as well as virtual reality simulators, has been clearly shown to result in such transferable skills.[12,14–17] Models for gynaecologic surgical skill training in areas other than laparoscopy are in their infancy. Animal and cadaver models are realistic, but more evidence is needed to demonstrate their skill transferability to the OR. Short-term retention of acquired skills is achievable. Well-validated scales, such as Reznick's global rating scale,[13] allow objective assessment of procedural skills in obstetrics and gynaecology residents. Although the global rating scale is used across the United States for official resident evaluation during several surgical rotations, most programs do not require trainees to pass a practical skill examination prior to graduation. Depending on the equipment purchased, the cost of training surgeons exclusively in the OR could be higher than the cost of a surgical skills laboratory.

Given the variability in training and assessment across Canada,[2] residents may graduate with varying technical skills. Skills laboratories lead to improvement in procedural skills compared with standard surgical training or no training at all.[9] In an attempt to ensure excellence and uniformity of surgical training, general surgery educators in the United States have formed a Surgical Council on Resident Education,[48] which envisions the development of a "standardized curriculum to span the period from medical school to practice." An integral part of this effort deals with the acquisition of surgical skills, and a special task force has been created for this purpose. Moreover, the Residency Review Committee for Surgery of the US Accreditation Council for Graduate Medical Education has stated that all surgery residency programs will be required to provide access to a surgical skills laboratory by July 2008.[45,49]

A similar standardized curriculum, endorsed at a national level and across residency programs, would be beneficial for Canadian obstetrics and gynaecology residents. Surgical skills are multifaceted, and an adequate curriculum would include didactic training, the learning of relevant anatomy on cadavers,[37,50,51] practising surgical skills on trainers and animal models, and practice in the OR. Evaluation of surgical learning could be performed at regular intervals in the OR, throughout residency. To preserve objectivity, the resident's hands could be videotaped performing a procedure appropriate for their level of training, and the global scale[13] could be used by attending gynaecologists blinded to resident identity to rate performance.[52] Constructive feedback based on the global rating scale criteria could be given soon afterwards, to improve performance in subsequent operations.[53] Ultimately, Canadian women with gynaecologic complaints would be better served by more confident surgeons graduating with an accepted standard level of technical skill.

ACKNOWLEDGEMENT

The author wishes to thank Dr Sue Ross for invaluable help with revising the manuscript.

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