BJUI
BJU INTERNATIONAL

Training in ureteroscopy: a critical appraisal of the literature

Andreas Skolarikos, Stavros Gravas*, M. Pilar Laguna†, Olivier Traxer‡, Glenn M. Preminger§ and Jean de la Rosette¶

*Athens Medical School, Second Department of Urology, Sismanoglio Hospital, *University of Thesaly, Department of Urology, Athens, Greece, †Department of Urology, AMC University Hospital, Amsterdam, The Netherlands, ‡Department of Urology, Pierre et Marie Curie University Paris VI, Paris, France, §Comprehensive Kidney Stone Center, Department of Urology, Duke University Medical Center, Durham, NC, USA, and ¶Department of Urology, AMC University Hospital, Amsterdam, The Netherlands*

Accepted for publication 11 March 2011

What's known on the subject? and What does the study add?

Ureteroscopy outcome depends on the availability of the technological equipment and the surgeon experience.

This study tries to define the learning curve of ureteroscopy, to underline the current quality of training and to propose the minimum requirements for a curriculum in ureteroscopy.

The aim of the present review was to study factors influencing training and the maintenance of skills in performing ureteroscopy (URS). We searched on the following keywords in the Medline, Embase and Cochrane databases: renal or ureteric stone; ureteroscopy; endourology; educational; training; learning curve; expertise; skill; residency; practice; simulator; and robotics. We have defined, when possible, levels and grades of evidence, based on 2009 recommendations of the Oxford Centre for Evidence-Based Medicine. We found that technological advancement and surgeon experience is a predictive factor for success or complications of URS. Experience may be related to special endourology training, time passed after basic training and the number of procedures performed. Studies suggest that a resident must perform a certain amount of cases to gain proficiency with URS, but there is still a need for well designed studies for the learning curve of URS to be accurately defined. Training models may be useful for training in URS and stone disintegration. Stone centres that provide all the endoscopic treatment options seem to provide the best conditions to ensure a sufficient volume of patients required. Defining minimum requirements for training in URS and for maintaining certification is a major challenge, as is defining the learning curve in URS. Careful curriculum design in high-volume stone centres may be the key to optimizing URS training.

KEYWORDS

education, lithotripsy, training, ureteroscopy

INTRODUCTION

Since the first endoscopic visualization of the upper urinary tract by Young and McKay [1], technological advances and physician innovation have dramatically expanded the diagnostic and therapeutic applications of ureteroscopy (URS). Although ureteroscopic techniques were initially limited to diagnostic evaluation of the distal ureter, the development and ongoing refinement of semirigid and flexible instruments now make nearly all areas of the urinary tract accessible [2,3]. In addition, the introduction of new technology has broadened the diagnostic and therapeutic implications for URS beyond the realm of urinary stones to include the evaluation of patients with essential haematuria, the definitive management of ureteropelvic junction obstruction and ureteric strictures and the surveillance and treating of select patients with TCC involving the upper urinary tract [4,5] (Oxford Centre for Evidence-Based Medicine [OCEBM; http://www.cebm.net/index.aspx?o=1025] level of evidence: R).

Despite the versatility of modern URS, definitive treatment of urinary stones remains the most common indication for performing ureteroscopic techniques [6] (R). Recently, the combined AUA and European Association of Urology (EAU) guidelines highlighted the changes in technology in URS that have made an impact on first treatment ureteric stone-free rates when stratified by location and size, and when compared with shockwave lithotripsy (SWL). With the exception of proximal ureteric stones of <10 mm, where SWL has a slightly better outcome, URS leads to significantly higher stone-free rates compared with SWL. The latter is dependent on stone size and location for clearance, while the stone size effect on URS efficacy seems to be much smaller [7] (2a/B).

The introduction of flexible URS allowed proximal ureteric stones of almost any size, and some renal stones, to be endoscopically treated. It is anticipated that the guidelines for proximal ureteric stones will indicate flexible URS as a first line treatment for proximal ureteric stones in the future [7] (2a/B) (Fig. 1).

FIG. 1. Flexible ureterorenoscope and ureterolithotripsy.

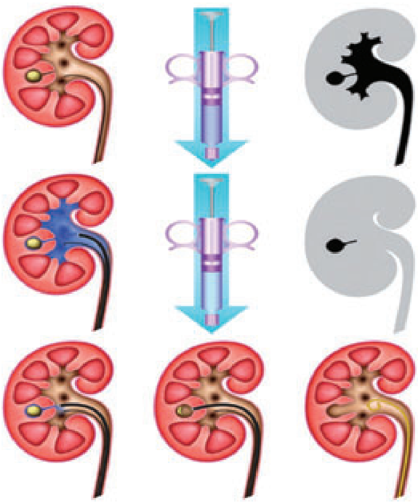
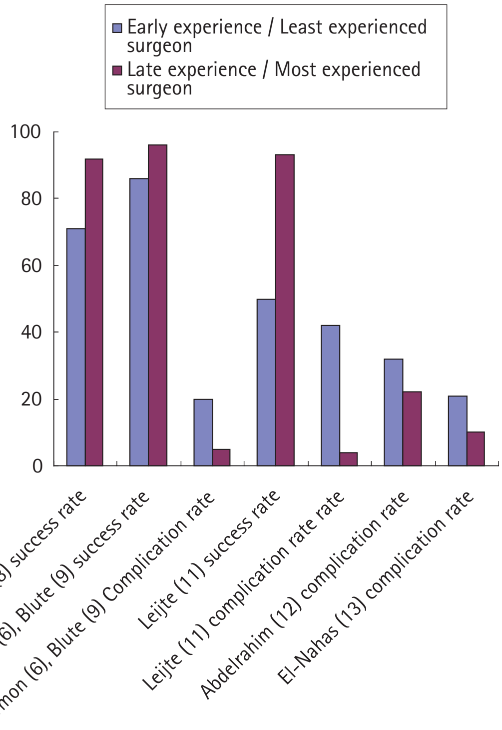


FIG. 2. Ureterolithotripsy success and complication rates related to surgeon experience.



In the light of URS evolution over the last years and of increasing evidence relating the technological advancement and surgeon experience to ureteroscopic outcome, it is obvious that proper training in URS may further expand the indications to treat and the success rates, and further lower the complication rate related to the procedure.

In the present paper we aim to provide insight into the factors influencing training in ureteroscopic stone surgery and to propose a minimum training curriculum for URS. In addition, we provide specific recommendations for training and the number of URS procedures per year required to maintain a surgical proficiency.

METHODS

A critical review of the literature regarding the training in URS was conducted. We searched on the following keywords in the Medline, Embase and Cochrane databases: renal or ureteric stone; ureteroscopy; endourology; educational; training; learning curve; expertise; skill; residency; practice; simulator; and robotics. Only those articles that assessed the different aspects of training in URS were included. We have defined, when possible, levels and grades of evidence based on 2009 recommendations of the OCEBM.

RESULTS

Ninety-three manuscripts derived from peer review journals were evaluated. Of these, 50 articles dealing with ureteroscopic training and outcome were finally referenced. The rest of the studies were excluded owing to irrelevance of the topic, repeated or upgraded publication and evaluation of training in another sub-specialty of urology.

The following key factors related to training in URS were found: involvement in surgery and effect on URS outcome; definition of learning curve; quality of training; and different forms of training. Levels of evidence are stated in the corresponding sections for each one of the key factors.

INVOLVEMENT IN SURGERY AND EFFECT ON URS OUTCOME

Technological advancement and surgeon experience was shown in several studies to be a predictive factor for success and complications of ureterolithotripsy [6,8–13] (4/C) (Fig. 2 [6,8–13]). The degree of expertise of the surgeon in ureterolithotripsy or previous experience in URS performed for other indications were not assessed in any these studies. The definition of experience was also different in all these studies.

Experience may be related to special endourology training, time passed after basic training and the number of procedures performed. In a recent study, experienced endourologists who had been working as an endourological consultant for more than 3 years achieved more favourable results than general urologists who had been working as consultants in other urological subspecialties, such as oncology, female urology and paediatric urology [13] (4/C).

In an analysis of experience at 28 medical centres Weinberg *et al.* [8] observed a decrease from 4.9% to 3.3% in the number of intra-operative injuries with increased surgeon experience. The success rate reported by 11 hospitals that performed <20 procedures was lower (78%) compared with that of centres that had performed >50 procedures (84%) (4/C).

In the study by Schuster *et al.* [10], surgeon experience was evaluated by comparing the single surgeon who performed 44% of cases with all other surgeons performing URS. This surgeon had a minimum (range) of 37 (37–58) cases yearly compared with a mean (range) of 11.7 (0–42) yearly for the remaining surgeons (4/C).

Although having a junior urologist in charge of URS was associated with a significant decrease in stone-free rates and an increase in the incidence of intra-operative adverse events [12,13] (4/C) there is evidence to suggest better performance for trainees under direct supervision [11]. In the study by Leijte *et al.* [11] surgeon experience was categorized into four groups depending on the number of cases performed by each urologist: >20, 10–20, <10, and residents under supervision. The success rate in the supervised residents group was higher than in the least experienced staff group. In addition the complication rate was lower (4/C). This finding indicates that URS is suitable for residents in training, provided that they are supervised by an experienced surgeon and that a video monitor is available. Indeed, residents are actively involved in URS. In a recent Canadian survey more than 75% of urologists were trained to perform URS and, among trainees, flexible URS was performed by 98.2% of residents in their final year. Approximately 39.3% of responders reported performing >50 flexible ureteroscopic procedures in the past year [14].

DEFINITION OF LEARNING CURVE

The surgical learning curve remains primarily a theoretical concept. In urology, studies defining the learning curve as a means of evaluating the surgical expertise and the number of procedures needed to gain surgical competence are mostly focused on cancer surgery and specifically on laparoscopic procedures [15] (2a/B). There is no published study on the learning curve for semirigid or flexible URS. Potential surrogate outcomes for use in defining the learning curve for URS may include stone-free rates, complication rates, operating times, fluoroscopy time, radiation doses, instrument damage and cost. The selection of endpoints was shown to affect significantly the definition of competence in endourology. When operating time was used as a surrogate marker for percutaneous nephrolithotomy, an estimated case load of 60 patients was necessary to reach a plateau [15–17] (4/C). However, if stone-free rates were regarded as an endpoint the plateau was achieved at the very initial cases, and the learning curve was a horizontal line [17] (4/C).

The question of how many procedures are needed to achieve satisfactory results in URS is still unanswered. In a retrospective study, Botoca *et al.* [18] evaluated how accumulating experience led to a satisfactory level of skills. The acceptable level of skills was defined as the moment when the rates of success and complications showed a tendency to plateau at a level similar to the results mentioned in the EAU guidelines. The tendency to plateau appeared after approximately 50 procedures without wide variations between the five surgeons enrolled in the study. The authors comment that the ureterosocopy learning curve is relatively long although we should not forget that individual skills may differ and each urologist may have their own learning curve pattern.

In July 2009 the Accreditation Council for Graduate Medical Education [19] mandated minimum numerical thresholds for procedures as part of the accreditation process for urology residency programmes. Three participation categories count towards minimums: surgeon; teaching assistant; and first assistant. For all these categories a minimum of 40 ureteroscopies are required for a qualified trainee. Under the term 'ureteroscopy', the following pathologies are included: stricture; ureteropelvic junction obstruction; stone removal; laser tumour biopsy; and resection. The Review Committee for Urology indicates that urological practice should focus on the number of individual cases performed for a given indication (e.g. URS vs SWL) and that training should provide a sufficient number of cases to each resident to allow for competence.

QUALITY OF TRAINING

Another objective is to determine the durability of training and whether the practice after residency is related to the training. Approximately 75% of urologists in north central USA were trained to perform URS during their residency as shown in a recent e-mail survey. Fellowship-trained endourologists, academic urologists, and urologists in practice for <5 years were more likely to use URS and less likely to use SWL for urinary calculi. This finding was clearly related to their training. Compared with other urologists, fellowship-trained endourologists were more likely to use URS for lower pole calculi <5 mm (25% vs 35%) and 5 to 10 mm (24% vs 60%) in size [20]. These findings are to be expected, as most fellowship-trained endourologists receive additional training in performing advanced URS, and so would be more comfortable performing these procedures for smaller stones as well.

Chatterjee *et al.* [21] evaluated whether the technical skills acquired during a 1-h didactic session and 1-h hands-on-training course are maintained over time. They have evaluated residents' performance on rigid URS and basket manipulation of a small midureteric stone immediately after the course and 1 year and 2 years after training. Interestingly, URS skills were retained and continued to improve 2 years after completing an intense training session that uses high-fidelity bench models (2c/B).

Ureteroscopic experience during residency is important for the maintenance and development of skills, even though they appear to plateau after 1 year. Over the 2-year of follow-up, the mean (range) number of ureteroscopies, of which the residents performed >75% of the surgery, was 6.4 (0–32). Residents performing >50th percentile of cases improved by 59% compared with a 45% improvement for those who performed fewer cases. This difference, however, was not significant. Although observing URS, defined as performing <75% of the surgery, would be expected to further improve residents' skill, separate analysis showed no correlation with improvement and the number of cases observed. Although this evidence may strengthen the value of proper basic training, the authors underline possible study biases such as the small sample size, the lack of power and under-reporting of observed cases. Relative improvement may imply that residents' clinical experience improved their performance on the bench model but no direct correlation with competence in the clinical setting can be made [21].

TRAINING MODELS

Training models may have a certain role in the training of novices in urological practical skills. Recently, Schout *et al.* [22] (2a/B) published an update on training models in endourology, including URS. The authors systematically reviewed the literature describing an endourological training model and incorporated all articles that have subjected a model to testing with regard to a face, content, construct or criterion validity. In all, 19 articles have described URS, with 27 models of nine different types [23–44] (2a/B to 5/D). Since their review three more studies have been published [45–47] (2b/B) (Table 1).

These training tools included virtual reality (VR) [46], bench [26,33,47], animal

TABLE 1 Key issues, level of evidence, and recommendations as cornerstones for training and maintaining surgical skills in ureteroscopic stone surgery

Key issues	Evidence	Recommendation
Definition of learning curve	No clear definition of which outcomes should be used as surrogate markers	Definition of outcomes to be used as endpoints of the training
Quality of training	Performing URS during residency increases the chances of performing routine URS after training	Defining a minimum training curriculum and fellowships in endourology in reference stone centres
Training models	Sufficient inanimate and VR models. Scarcity of animal models	Define general guidelines concerning methods, settings, and data interpretation. Correlation of trainee's performance on a model with operating room performance

FIG. 3. Uro Mentor system (Simbionix) for ureterorenoscopy.

[33,36,42,43,45] and human models [44] (Table 2). The most frequently described URS model was the URO Mentor (Simbionix, Cleveland, OH, USA), a computer-based VR model offering semirigid and flexible URS modules (Fig. 3). The second most described model was the Uro-Scopic trainer (Limbs & Things, Bristol, UK). This high-fidelity bench model creates the possibility of training with real-time instruments as used in the operating room.

There are several considerations that prevail in selecting a model, including effectiveness in shortening trainees' learning curves, associated research evidence and financial issues. Validation of the various models is crucial and, also of upmost importance, is the assessment of whether the laboratory proficiency acquired in inanimate and VR models correlates with improved performance in humans.

The majority of studies validating URS training models focus on construct validity which has the ability to distinguish between different levels of experience [22] (2a/B).

The results of 26 validation studies in the present review and of other contemporary studies [22,45–47] (2a/B, 2b/B) of either VR models or bench models for the URS procedure concluded that the URO Mentor as well as the Limbs & Things and Mediskills bench models can discriminate between different levels of expertise [28,30–32,34,36,39,40]. Only three of these articles, two on VR models and one on a bench model, reported on prospective randomized controlled trials [28,36,37] and received the highest OCEBM level of evidence (1b/A). They have all confirmed that use of VR or bench models resulted in more rapid acquisition of ureteroscopic skills in novice trainees with no prior surgical training.

The most important step in the validation process, the transfer from simulator to the patient, has been addressed in three studies [31,32,40]. Ogan *et al.* [31] (3b/B) found, in a prospective experiment, that training on a VR ureterorenoscopy simulator improved performance on a male cadaver. Brehmer *et al.* [40] (2b/B) compared experts' real-time performances with their performances on a simulator. Knoll *et al.* [32] (3b/B) trained five residents in the URS procedure on the URO Mentor and compared their performances on the simulator with performances in patients by five other residents by having unblinded supervisors rate the residents' performances. All these studies agreed that individual experience correlated with individual performance on the simulator. Simulator training was helpful in improving clinical skills [32]. For novice endoscopists, performance on the simulator after training predicted operative performance, but simulation was unable to override the impact of clinical training [31]. Those urologists who were sub-specialised in endourology scored significantly higher than the others on both patients and the model [40].

Regarding the significance of the model's fidelity, Matsumoto *et al.* [37] did not find significant differences between the performance of groups trained on a high-fidelity model ($3700) and low-fidelity model ($20) (1b/A). The same conclusion was reached by Chou *et al.* [33] (2b/B) who showed that medical students' skills and ability to perform a basic ureteroscopic stone management procedure was independent of whether the training method was a VR simulator or a URS training model.

DISCUSSION

For centuries it was believed that the cornerstone of surgical skills acquisition was practice. Without underestimating the importance of the Halstedian apprenticeship, which involves an extensive period of hands-on training with patients, the acquisition of surgical competence is far more complicated. The mastery of surgical techniques involves the theoretical and practical knowledge of the procedure and its indications and the technical expertise to practise the procedure. In addition, the cognitive aspects of surgical practice constituted mainly by accurate judgment and clinical decision-making, sufficient communication and collaboration skills, together with leadership and professionalism, have a major impact on surgical outcome.

There is no doubt that both psychomotor and cognitive skills are acquired by appropriate training. An ideal curriculum should be able to affect adequate knowledge and help in the acquisition of all necessary skills (Table 3).

TABLE 2 Ureterorenoscopy models

Type of model	Manufacturer	Reference	Level of evidence (OCEBM 2009)
VR	Duke University Medical Center, Durham, NC, USA; Simbionix	[23–25]	2c/B
VR	Simbionix	[26–36,46]	1b/A to 5/D
Bench (low fidelity)	University of Toronto, Ontario, Canada	[37,38,45]	1b/A, 2c/B
	Department of Urologic Surgery, University of Minnesota, Minneapolis, MN, USA		2b/B
Bench (URO Mentor) (high fidelity)	Limbs & Things, Savannah, GA, USA	[26,33,36–39]	1b/A to 3b/B
Bench (high fidelity)	Mediskills Models, Northampton, UK	[36,40,41]	1b/A, 2b/B, 2b/B
Bench (high fidelity)	Michigan State University www.idealanatomic.com	[47]	2b/B
Animal, porcine kidney	Klinikum Coburg Germany	[36,42]	1b/A, 4/C
Animal, porcine kidney	Southern Illinois University School of Medicine, Springfield, IL, USA	[43]	5/D
Animal, porcine kidney	University of California, Irvine, CA, USA	[33]	2b/B
Human, uterus	University Medical Center, Shreveprot, LA, USA	[44]	5/D

Residency training in urological surgery is changing to an educational experience driven by outcomes instead of process. In the USA the change was driven by the recertification operating logs submitted to the American Board of Urology. The data indicated that the average urologist at the time of certification and at the time of recertification performs a relatively low number of major urological operations [48]. A minimum of 40 ureteroscopies during residency were decided to be sufficient for the qualified trainee [19].

Although this number of URS cases appears reasonable, there are concerns about whether it is achievable for the average trainee. Recently there has been an increase in the trend for using URS for stones in every day practice. In a survey, which was conducted using the electronic mail lists of the AUA and the Endourological Society, 75% and 30–40% of the urologists will use URS for mid- and upper ureteric stones, respectively [49]. This certainly constitutes an improvement when compared with the 50% and 15% figures in an older report [50]. However, even when academic departments were included, among urologists in north central USA, use of URS was largely restricted to the management of distal ureteric calculi (44%, 80%, 90% and 84% for stones <5 mm, 5–20 mm, 10–20 mm and >20 mm in size, respectively) and proximal ureteric calculi (23%, 43%, 46% and 43% for stones <5 mm, 5–10 mm, 10–20 mm and >20 mm in size, respectively) [20]. This finding certainly raises concerns regarding the number available for residents. Indeed, approximately 39.3% of Canadian trainees reported performing >50 flexible ureteroscopic procedures per year [14].

TABLE 3 Proposal for the minimum requirements for a curriculum in URS

Competence	Identify outcomes. Levels to be reached for the different outcomes
Medical expertise	Theoretical and practical knowledge of the instruments, technique and its indications
Technical expertise	Access and lithotripsy in simple/medium complicated cases under strict supervision
	Complete or part of the procedure may be done under supervision depending on trainee skills and residency level
Judgement/clinical decision-making	Correct anamnesis with special emphasis on the previous stone history and operations
	Correct assessment of risk and benefits of the different lithiasis interventions and of URS
Communication	To be able to communicate with the patient and relatives the nature of the procedure as well as alternatives, possible complications and consequences
Collaboration	To be able to contact the different specialists involved in the management of stone diathesis as well those who can be potentially involved in the procedure
Management and leadership	Coordination of the procedure resulting in an effective, safe, and efficient treatment in the appropriate time frame
Health advocacy	To be able to counsel patients and take adequate preventive measures
Scholar and teacher	Participating in continuing medical education and be able to identify ways to update knowledge and implement new technical skills
Professionalism	To be able to apply the ethical principles that drive the patient–doctor relationship and to refer the patient to a more qualified colleague when indicated. To recognize their own professional limitations

Table adapted and modified from De la Rosette et al. *[15].*

In 2005, a European Society of Urotechnology's survey revealed that on average 23 URS procedures per month per department were performed globally, with URS more frequently performed outside Europe. At the time of that survey a significant majority of surveyed urologists performed URS with a semirigid (79%) instead of a flexible instrument (21%) [51].

These findings indicate that the challenge currently rests with organizational leaders of urology to design programmes that ensure the acquisition of both the theoretical and the practical needs of a modern curriculum.

Today, urologists must still learn how to perform URS safely and effectively by themselves with or without close supervision. Training in the more technically challenging aspects of upper ureteric URS and ureterorenoscopy with flexible instruments is highly recommended and must be encouraged, but the tenet, 'see one, do one, teach one' in surgical education is no longer practical. Time constraints, societal influences, medico-legal and ethical issues, and financial constraints make it difficult for surgical educators to use the operating room as the main venue to teach surgical skills. Endourological simulation seems to be realistic and useful for endourological purposes. Training on bench and VR models improves dexterity in URS. This was shown by randomized controlled studies [28,36,37]. Simulator training was also helpful in improving clinical skills when operating on patients [40]. Fortunately, it appears that inexpensive, low-fidelity URS simulators have a similar impact on educational experience to significantly more expensive VR simulation systems.

The study samples were, however, limited to <40, lowering the power of these studies. Irrespective of the low number of enrolments, the significant differences in at least some of the objective criteria during simulation imply that the effects of training with some models are very strong [22]. Yet, the significance of simulators cannot be overestimated. Anatomically incorrect models may lead to learning of an incorrect technique.

In a few studies on URS simulation the major factor examined was time. Although time is easy and objective to measure, it is not the main aim of training on a model. All models can and should yield more objective assessments using Objective Structured Assessment of Technical Skills (OSATS). OSATS results include psychomotor skills such as handling of instruments, identification of calices, lithotripsy and basketing and cognitive skills, such as knowledge of the procedure, respect of tissue treatment planning, troubleshooting and peri-operative management. All these factors appear to be stronger on relevance than just time [24,33,40,45]. The URS curriculum proposed by McDougall and Clayman [52] was based on these principles.

Yet the performance of OSATS has its own caveats. Although it has been shown to have reliability and validity in assessing URS performance, the specific cut-off point that distinguishes the competent from the incompetent surgeon has not yet been defined. In addition, there are differences between individuals in their level of skill acquisition whatever the training method. Some individuals may require more training time or additional expert supervision during training before reaching a competency level acceptable for the clinical environment. This has not been sufficiently validated within current models.

In summarizing the significance of training models we certainly agree with the conclusion of Schout *et al.* [22] in their comprehensive review that none of the urology training models described and researched up to now can be said to have proven validity for use in specialty training.

Surgical training in the operating room under the supervision of a senior surgeon is still, and may always be, a crucial step in training. Performance in the operating room environment is the desired endpoint and 'gold standard' with which all surgical skills training is eventually compared. Performance may remain erratic until the trainee undergoes sufficient and correct repetitive practice. Fellowship training in large volume stone centres may be an effective way to increase a surgeon's experience and strengthen his/her confidence in URS. Currently, the Endourological Society supports fellowships in endourology that require a minimum of 60 total ureteroscopies per fellow in 2 years. This minimum number required may eventually shorten the difficult learning curve of all types of URS [53].

Although this has not been evaluated for URS there are some data from other urological subspecialties indicating that fellowships modify the learning curve of the surgeon [54]. In addition, practice within high-volume stone centres may facilitate the acquisition of advanced skills to successfully overcome real-life anatomical and stone difficulties. It is in these centres that the role of the educator becomes clear. The educator remains a key element on the training process, initially as an instructor, and later in developing judgement and strengthening the knowledge and interpretation of what is observed in order to create a truly competent surgeon [33].

It has been our experience that as most fellowship-trained endourologists receive additional training in performing advanced URS, they become more comfortable performing these procedures as consultants [20].

Finally, there is a trend in using URS more often and to advance its use for more complex stones of the upper tract, replacing both SWL and percutaneous nephrolithotripsy. We believe that a resident should perform at least 50 procedures to obtain good proficiency during the residency period. This number necessitates a large total number of stone cases per year per department to ensure a comprehensive training programme. Taking into consideration the impending shortage of urological surgeons and the increase in the estimated cost of training [55] the role of academic departments with an adequate caseload and an appropriate number of residents may be the key to the best training in URS in the future.

CONCLUSION

Defining the minimum requirements for training in URS and for the maintenance of certification is a major challenge, as is defining the learning curve in URS. Currently no validated surrogate markers define the learning curve, and consequently data on continuing educational markers cannot be extrapolated. The mean number of procedures performed during or after the training represents only a bare figure and does not provide any information on the complexity of the procedure or quality of the performance. Training models have a certain role in URS training, although high-quality studies are still needed. It is quite clear that new forms of training must be incorporated into learning the surgical skills. In addition, practising in specialized high-volume centres is recommended to maintain one's proficiency.

CONFLICT OF INTEREST

None declared.

REFERENCES

1 **Young HH, McKay RW.** Congenital valvular obstruction of the prostatic urethra. *Surg Gynecol Obstet* 1929; **48**: 509–12
2 **Sofer M, Watterson JD, Wollin TA, Nott

L, Razvi H, Denstedt JD. Holmium: YAG laser lithotripsy for upper urinary tract calculi in 598 patients. *J Urol* 2002; **167**: 31–4

3 **Fabrizio MD, Behari A, Bagley DH.** Ureteroscopic management of intrarenal calculi. *J Urol* 1998; **159**: 1139–43

4 **Gettman MT, Segura JW.** Indications and outcomes of ureteroscopy for urinary stones. In Stoller ML, Meng MV eds, *Urinary Stone Disease*, Totowa: Humana Press, 2007: 571–88

5 **Nakada SY, Elashry OM, Picus D, Clayman RV.** Long-term outcome of flexible ureterorenoscopy in the diagnosis and treatment of lateralizing essential hematuria. *J Urol* 1997; **157**: 776–9

6 **Harmon WJ, Sershon PD, Blute ML, Patterson DE, Segura JW.** Ureteroscopy: current practice and long-term complications. *J Urol* 1997; **157**: 28–32 (R)

7 **Preminger GM, Tiselius HG, Assimos DG *et al*.** EAU/AUA Nephrolithiasis Guideline Panel. 2007 guideline for the management of ureteral calculi. *J Urol* 2007; **178**: 2418–34 (2a/B)

8 **Weinberg JJ, Ansong K, Smith AD.** Complications of ureteroscopy in relation to experience: report of survey and author experience. *J Urol* 1987; **137**: 384–5: (4/C)

9 **Blute ML, Segura JW, Patterson DE.** Ureteroscopy. *J Urol* 1988; **139**: 510–2 (4/C)

10 **Schuster TG, Hollenbeck BK, Faerber GJ, Wolf SJ Jr.** Complications of ureteroscopy: analysis of predictive factors. *J Urol* 2001; **166**: 538–40 (4/C)

11 **Leijte JA, Oddens JR, Lock TM.** Holmium laser lithotripsy for ureteric calculi: predictive factors for complications and success. *J Endourol* 2008; **22**: 257–60 (4/C)

12 **Abdelrahim AF, Abdelmaguid A, Abuzeid H, Amin M, Mousa E, Abdelrahim F.** Rigid ureteroscopy for ureteral stones: factors associated with intraoperative adverse events. *J Endourol* 2008; **22**: 277–80 (4/C)

13 **El-Nahas A, El-Tabey N, Eraky I *et al*.** Semirigid ureteroscopy for ureteral stones: a multivariate analysis of unfavorable results. *J Urol* 2009; **181**: 1158–62 (4/C)

14 **Preston MA, Blew BDM, Breau RH, Beiko D, Oake SJ, Watterson JD.** Survey of senior resident training in urologic laparoscopy, robotics and endourology surgery in Canada. *CUAJ* 2010; **4**: 42–6

15 **de la Rosette JJMCH, Laguna MP, Rassweiler JJ, Conort P.** Training in percutaneous nephrolithotomy – a critical review. *Eur Urol* 2008; **54**: 994–1003 (2a/B)

16 **Allen D, O'Brien T, Tiptaft R, Glass J.** Defining the learning curve for percutaneous nephrolithotomy. *J Endourol* 2005; **19**: 279–82 (4/C)

17 **Tanriverdi O, Boylu U, Kendrirci M, Kadihasanoglu M, Horasanli K, Miroglu C.** The learning curve in the training of percutaneous nephrolithotomy. *Eur Urol* 2007; **52**: 206–11 (4/C)

18 **Botoca M, Bucuras V, Boiborean P, Herman I, Cumpanas A, Miclea F.** The learning curve in ureteroscopy for the treatment of ureteric stones. How many procedures are needed to achieve satisfactory skills? *Eur Urol Suppl* 2004; **3**: 138

19 **Accreditation Council for Graduate Medical Education.** ACGME Program Requirements for residency Education in Urology. Available at: http://surgery.umc.edu/documents/professionals/residency/urology/UrologyProgramRequirements.pdf. Accessed June 2009

20 **Bandi G, Best SL, Nakada SY.** Current practice patterns in the management of upper urinary tract calculi in the north central United States. *J Endourol* 2008; **22**: 631–6

21 **Chatterjee S, Radomski SB, Matsumoto ED.** Durability of endourologic skills: two-year follow-up study. *J Endourol* 2007; **21**: 843–46 (2c/B)

22 **Schout BM, Hendrikx JM, Scherpbier AJ, Bemelmans BL.** Update of training models in Endourology: a qualitative systematic review of the literature between January 1980 and April 2008. *Eur Urol* 2008; **54**: 1247–61 (2a/B)

23 **Preminger GM, Babayan RK, Merril GL, Raju R, Millman A, Merril JR.** Virtual reality surgical simulation in endoscopic urologic surgery. *Stud Health Technol Inform* 1996; **29**: 157–63 (5/D)

24 **Shah J, Mackay S, Vale J, Darzi A.** Simulation in urology – a role for virtual reality? *BJU Int* 2001; **88**: 661–5 (2c/B)

25 **Kuo RL, Delvecchio FC, Preminger GM.** Virtual reality: current urologic applications and future developments. *J Endourol* 2001; **15**: 117–22 (2c/B)

26 **Laguna MP, Hatzinger M, Rassweiler J.** Simulators and endourological training. *Curr Opin Urol* 2002; **12**: 209–15 (2c/B)

27 **Michel MS, Knoll T, Kohrmann KU, Alken P.** The URO Mentor: development and evaluation of a new computer-based interactive training system for virtual life-like simulation of diagnostic and therapeutic endourological procedures. *BJU Int* 2002; **89**: 174–7 (5/D)

28 **Wilhelm DM, Ogan K, Roehrborn CG, Cadeddu JA, Pearle MS.** Assessment of basic endoscopic performance using a virtual reality simulator. *J Am Coll Surg* 2002; **195**: 675–81 (1b/A)

29 **Nedas T, Challacombe B, Dasgupta P.** Virtual reality in urology. *BJU Int* 2004; **94**: 255–7 (2c/b)

30 **Jacomides L, Ogan K, Cadeddu JA, Pearle MS.** Use of a virtual reality simulator for ureteroscopy training. *J Urol* 2004; **171**: 320–3 (3b/B)

31 **Ogan K, Jacomides L, Shulman MJ, Roehrborn CG, Cadeddu JA, Pearle MS.** Virtual ureteroscopy predicts ureteroscopic proficiency of medical students on a cadaver. *J Urol* 2004; **172**: 667–71 (3b/B)

32 **Knoll T, Trojan L, Haecker A, Alken P, Michel MS.** Validation of computer-based training in ureterorenoscopy. *BJU Int* 2005; **95**: 1276–9 (3b/B)

33 **Chou DS, Abdelshehid C, Clayman RV, McDougall EM.** Comparison of results of virtual-reality simulator and training model for basic ureteroscopy training. *J Endourol* 2006; **20**: 266–71 (2b/B)

34 **Matsumoto ED, Pace KT, D'A Honey RJ.** Virtual reality ureteroscopy simulator as a valid tool for assessing endourological skills. *Int J Urol* 2006; **13**: 896–901 (3b/B)

35 **Hoznek A, Salomon L, de la Taille A *et al*.** Simulation training in video-assisted urologic surgery. *Curr Urol Rep* 2006; **7**: 107–13 (2c/B)

36 **Watterson JD, Denstedt JD.** Ureteroscopy and cystoscopy simulation in urology. *J Endourol* 2007; **21**: 263–9 (1b/A)

37 **Matsumoto ED, Hamstra SJ, Radomski SB, Cusimano MD.** The effect of bench model fidelity on endourological skills: a randomized controlled study. *J Urol* 2002; **167**: 1243–7 (1b/A)

38 **Wignall GR, Denstedt JD, Preminger GM *et al*.** Surgical simulation: a urological perspective. *J Urol* 2008; **179**: 1690–9 (2c/B)

39 **Matsumoto ED, Hamstra SJ, Radomski SB, Cusimano MD.** A novel approach to endourological training: training at the Surgical Skills Center. *J Urol* 2001; **166**: 1261–6 (3b/B)
40 **Brehmer M, Tolley DA.** Validation of a bench model for endoscopic surgery in the upper urinary tract. *Eur Urol* 2002; **42**: 175–80 (2b/B)
41 **Brehmer M, Swartz R.** Training on bench models improves dexterity in ureteroscopy. *Eur Urol* 2005; **48**: 458–63 (2b//B)
42 **Strohmaier WL, Giese A.** Porcine urinary tract as a training model for ureteroscopy. *Urol Int* 2001; **66**: 30–2 (4/C)
43 **Hammond L, Ketchum J, Schwartz BF.** Accreditation council on graduate medical education technical skills competency compliance: urologic surgical skills. *J Am Coll Surg* 2005; **201**: 454–7 (5/D)
44 **Wilson M.** An instructional model for T.U.R. *Urol Nurs* 1991; **11**: 33 (5/D)
45 **Kishore TA, Pedro RN, Monga M, Sweet RM.** Assessment of validity of an OSATS for cystoscopic and ureteroscopic cognitive and psychomotor skills. *J Endourol* 2008; **22**: 2707–11 (2b/B)
46 **Dolmans VE, Schout BM, de Beer NA, Bemelmans BL, Scherpbier AJ, Hendrikx AJ.** The virtual reality endourologic simulator is realistic and useful for educational purposes. *J Endourol* 2009; **23**: 1175–81 (2b/B)
47 **White MA, DeHaan AP, Stephens DD, Maes AA, Maatman TJ.** Validation of a high fidelity adult ureteroscopy and renoscopy simulator. *J Urol* 2010; **163**: 673–7 (2b/B)
48 **Bahnson RR.** Residency training: where do we go from here. *Urol Clin North Am* 2009; **36**: 73–7
49 **Gerber GS, Acharya SS.** Management of ureteral calculi. *J Endourol* 2010; **24**: 953–4
50 **Gerber GS.** Management of ureteral calculi. *J Endourol* 2004; **18**: 415–7
51 **Kauer PC, Laguna MP, Alivizatos G *et al.*** Present practice and treatment strategies in endourological stone management. Results of a survey of the European Society of Uro-technology (ESUT). *Eur Urol* 2005; **48**: 182–8
52 **McDougall EM, Clayman RV.** Rapid communication: minimally invasive urologic surgery curricula. *J Endourol* 2007; **21**: 197–217
53 **Endourological Society.** Clinical Endourology Fellowships. Fellowship program requirements. Available at: http://www.endourology.org/fellowship/fellowship.php (accessed April 2011)
54 **Bianco FJ, Cronin AM, Klein EA, Pontes JE, Scardino PT, Vickers AJ.** Fellowship training as a modifier of the surgical learning curve. *Acad Med* 2010; **85**: 863–8
55 **Williams TE Jr, Satiani B, Thomas A, Ellison EC.** The impending shortage and the estimated cost of training the future surgical workforce. *Ann Surg* 2009; **250**: 590–7

Correspondence: Jean de la Rosette, Department of Urology, AMC University Hospital, Amsterdam, The Netherlands.
e-mail: j.j.delarosette@amc.uva.nl

Abbreviations: **URS**, ureteroscopy; **OCEBM**, Oxford Centre for Evidence-Based Medicine; **EAU**, European Association of Urology; **SWL**, shockwave lithotripsy; **VR**, virtual reality; **OSATS**, Objective Structured Assessment of Technical Skills.

EDITORIAL COMMENT

TRAINING IN URETEROSCOPY: A CRITICAL APPRAISAL OF THE LITERATURE

As surgical educators, we have seen significant changes occurring in surgery over the past decade, which have had significant impact on the way we train surgeons. Financial constraints, medico-ethical issues of learning new procedures while treating patients, and greater restrictions on the number of hours a resident can work in a week, have all had an impact on opportunities for residents to learn their skills in the operating room [1–3]. As a result, we can no longer rely on the operating room as the sole teaching venue for surgical residents. The authors of this review have focussed on studies looking at factors influencing training and maintaining ureteroscopic skills. They have identified, critiqued and assigned levels of evidence scores based on quality of study design. The learning factors identified integrate well with existing psychomotor frameworks, such as one proposed by Fitts and Posner [4], where acquisition of new skills occurs in three phases: cognitive (steps are learned, movement is erratic), integrative (movements become smoother) and autonomous (procedures flow with little cognitive input). The learning curve of acquiring new skills can be accelerated by using bench, virtual reality, animal and cadaveric models, especially during the cognitive and integrative step. In theory, 'competence' can be achieved upon completion of residency. The autonomous phase, may not be achieved until further into independent practice. And finally, to become the expert or master, may require another 10 years of 'perfect practice' based on Ericsson's theory on expertise [5]. It is possible, that 'proficiency' could be achieved, in <50 cases, with the appropriate use of a training model and curriculum that stresses and teaches the critical constructs necessary for successful ureteroscopy. It is encouraging to see such interest in surgical education research. It will be a matter of time before we are able to attest to a residents' 'competence' using valid and reliable high-stakes technical skills assessment tools.

REFERENCES

1 **Bridges M, Diamond DL.** The financial impact of teaching surgical residents in the operating room. *Am J Surg* 1999; **177**: 28–32
2 **Cook M, Irby D, Sullivan W, Ludmerer KM.** American medical education 100 years after Flexner report. *N Engl J Med* 2006; **355**: 1339–44
3 **Carlin AM, Gasevic E, Shepard AD.** Effect of the 80-hour work week on resident operative experience in general surgery. *Am J Surg* 2007; **193**: 326–9
4 **Fitts PM, Posner MI.** *Human Performance*. Belmont: Brooks/Cole, 1967
5 **Ericsson KA.** The acquisition of expert performance: an introduction to some of the issues. In Ericsson KA ed., *The Road to Excellence: the Acquisition of Expert Performance in the Arts and Sciences, Sports, and Games*, Mahwah: Lawrence Erlbaum Associates, 1996: 1–50

Ed Matsumoto,
McMaster Institute of Urology, St Joseph's Hospital Institute of Urology at St Joseph's, Hamilton, Ontario, Canada