World J Urol (2016) 34:741–746
DOI 10.1007/s00345-015-1676-3

ORIGINAL ARTICLE

Simulation of RIRS in soft cadavers: a novel training model by the Cadaveric Research On Endourology Training (CRET) Study Group

Emre Huri[1] · Andreas Skolarikos[2] · İlkan Tatar[3] · Murat Binbay[4] · Mustafa Sofikerim[5] · Emrah Yuruk[6] · Tolga Karakan[7] · Mustafa Sargon[3] · Deniz Demiryurek[3] · Roberto Miano[8] · Murat Bagcioglu[9] · Mehmet Ezer[1] · Cecilia Maria Cracco[10] · Cesare Marco Scoffone[10]

Received: 16 June 2015 / Accepted: 24 August 2015 / Published online: 30 August 2015

Abstract
Purpose The aim of the current study was to evaluate the use of fresh-frozen concurrently with embalmed cadavers as initial training models for flexible ureteroscopy (fURS) in a group of urologists who were inexperienced in retrograde intrarenal surgery (RIRS).
Methods Twelve urologists involved in a cadaveric fURS training course were enrolled into this prospective study. All the participants were inexperienced in fURS. Theoretical lectures and step-by-step tips and tricks video presentations on fURS were used to incorporate the technical background of the procedure to the hands-on-training course and to standardize the operating steps of the procedure. An 8-item survey was administered to the participants upon initiation and at the end of the course.
Results Pre- and post-training scores were similar for each question. All the participants successfully completed the hands-on-training tasks. Mean pre-training duration [3.56 ± 2.0 min (range 1.21–7.46)] was significantly higher than mean post-training duration [1.76 ± 1.54 min (range 1.00–6.34)] ($p = 0.008$). At the end of the day, the trainers checked the integrity of the collecting system both by endoscopy and by fluoroscopy and could not detect any injury of the upper ureteral wall or pelvicalyceal structures. The functionality of the scopes was also checked, and no scope injury (including a reduction in the deflection capacity) was noted.
Conclusions The fURS simulation training model using soft human cadavers has the unique advantage of perfectly mimicking the living human tissues. This similarity makes this model one of the best if not the perfect simulator for an effective endourologic training.

Keywords Retrograde intrarenal surgery soft cadaver · Urology training · RIRS simulation

Cadaveric Research on Endourology Training (CRET) Study Group.

✉ Emre Huri
emrehuri@gmail.com; emrehuri@hacettepe.edu.tr

1 Faculty of Medicine, Urology Department, Hacettepe University, Sıhhiye-Ankara, Turkey

2 Urology Department, Athens Medical School, Athens, Greece

3 Anatomy Department, Faculty of Medicine, Hacettepe University, Ankara, Turkey

4 Department of Urology, Haseki Teaching and Research Hospital, Istanbul, Turkey

5 Urology Department, Faculty of Medicine, Acıbadem University, Istanbul, Turkey

6 Department of Urology, Bağcılar Teaching and Research Hospital, Istanbul, Turkey

7 Department of Urology, Ankara Training and Research Hospital, Ankara, Turkey

8 Urology Department, Roma Tor Vergata University, Rome, Italy

9 Urology Department, Faculty of Medicine, Kars Kafkas University, Kars, Turkey

10 Urology Department, Cottolengo Hospital, Turin, Italy

Introduction

Flexible ureteroscopy (fURS) has gained popularity and widespread use in recent years. The indications of retrograde intrarenal surgery (RIRS) have expanded from treatment of small upper calyceal or pelvic stones to disintegration of large stones or stones located in difficult-to-reach sites of the pelvicalyceal system such as the lower pole and diverticula, as well as to the treatment of intrarenal transitional cell carcinoma. A number of recent technical advancements supported this evolution, while increasing the complexity of the procedure. The learning curve of ureterorenoscopy has not been studied adequately, as different surrogate outcomes defining the learning curve for fURS are very variable and may include stone-free rates, tumor recurrence rates, complication rates, operating time, fluoroscopy time, radiation doses, instrument damage, and repair costs [1, 2].

Several training models have been used to reduce the steep learning curve of fURS, including virtual reality simulators [3], low- and high-fidelity bench [4] and animal (porcine) models [5–8]). The use of these models helped to differentiate the level of experience among the trainees and resulted in more rapid acquisition of ureteroscopic skills in novice trainees with no prior surgical training [9–11]. Training on a simulator may be useful in the education process and assessment of the trainee at the end of the course. However, they cannot override the impact of clinical training [3]. Despite the growing interest in training models in urology, the validation studies of these models are few in number and with low evidence levels [12].

Although the use of human cadavers as training models for various extra-urogenital surgical procedures has been well-studied [13–17], their relevance to endourological interventions has yet to be investigated. Beside the advantage of having the real human anatomy, cadaveric models easily transfer the skills from the simulator to the patient, the most important step in a model's validation process.

The aim of the current study was to evaluate the use of fresh-frozen concurrently with embalmed cadavers as initial training models for flexible ureteroscopy in a group of urologists who were inexperienced in RIRS.

Materials and methods

Cadaveric simulator preparation

Both fresh-frozen and embalmed cadavers were used. Injection of one amount of pure ethanol, one amount of 37 % formaldehyde, 3 amounts of distilled water and 0.2 amount of glycine via the route of common carotid and femoral arteries was performed for embalmment procedure. The embalmed cadavers were used just for anatomical dissection in the preliminary program, and not for hands-on-training fURS (is this correct?).

Overall, two female amputated fresh-frozen cadavers were used for the hands-on-training procedures. Amputated cadavers lack the head and extremities and consist of the torso (Fig. 1). They were placed in supine position over a radiolucent table. The bladder was entered with a rigid 16 Fr cystoscope, and a0.038-in. hydrophilic guidewire was passed into the renal pelvis under fluoroscopic guidance. Following successful placement of the guidewire, an 11/13 Fr ureteral access sheath (Navigator™ Ureteral Access Sheath, Boston Scientific, Marlborough MA, USA) was placed 2–3 cm below the ureteropelvic junction and fixed to the both labium majors to allow optimal upper tract visualization and manipulation. An 8.5 Fr digital flexible ureteroscope (Flex XC Flexible Uretero-Renoscope, Karl Storz GmbH and Co, Tuttlingen, Germany) was used for investigation of the collecting system. A 5 × 2 mm stone fragment was also placed into the lower calyx using a basket device.

Training protocol

Certified urologists involved in the cadaveric fURS training course were enrolled in this prospective study. All the participants were inexperienced in fURS. Theoretical lectures on stages of the procedures together with the tips and tricks video presentations of fURS and anatomical retroperitoneal dissection of the embalmed cadavers were used to incorporate the technical background to the subsequent hands-on-training course. Nine trainers—six academic urologists and three anatomists, who were eligible and experienced in cadaveric training models—participated in the course as instructors.

An 8-item survey was administered to the participants upon initiation and at the end of the course (Table-1). The survey consisted in questions designed to evaluate the expectations and the degree of satisfaction of the trainees (1 point = very low (much less than expected) and 5 points = very high (far above the expectations)).

During the first day of the course, lectures focusing on the anatomy of the collecting system and the technical details of the fURS procedure were followed by two live surgeries performed by the course trainers. During the fURS procedures, the important anatomical landmarks, preparation of the operating room and of the patient, handling of the instruments, steps of the procedure, orientation within the collecting system and the simultaneous use of endoscopy and fluoroscopy were explained in detail.

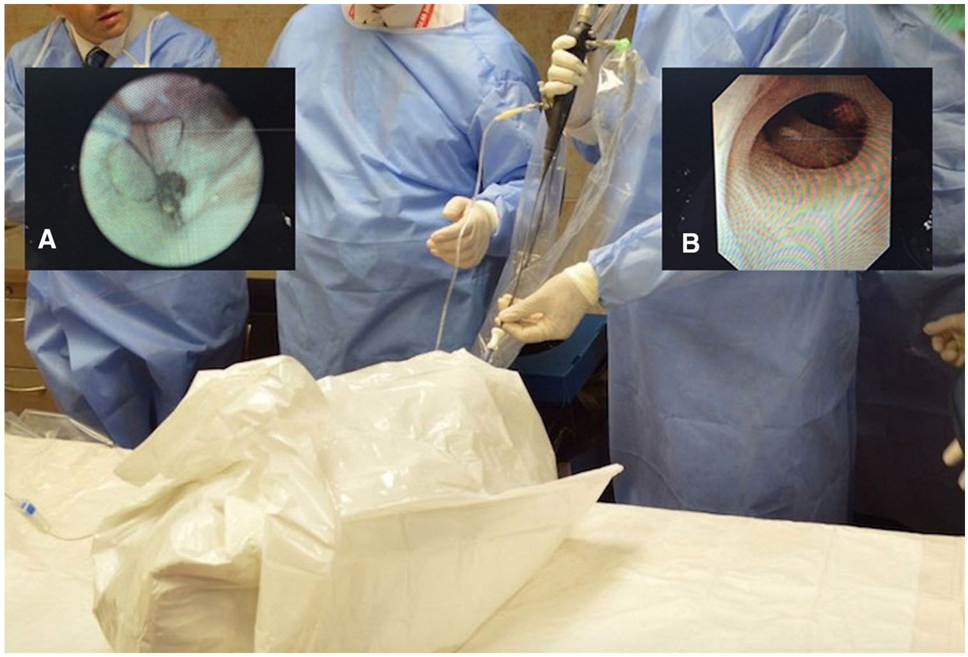

Fig. 1 Hands-on-training performance of a trainee, starting the cadaveric RIRS procedure

Table 1 Survey questions and results

Category	Pre-training	Post-training	*p*
Mean duration (minutes) ± SD	3.56 ± 2.0	1.76 ± 1.54	0.008
A—suitability for the educational content	4.25	4.18	0.999
B—satisfaction from training	4.17	4.17	0.915
C—contribution to your knowledge	4.25	4.00	0.458
D—eligibility for the physical environment	4.00	3.91	0.163
E—satisfaction from the course organization	4.17	4.36	0.380
F—educational materials	3.58	4.30	0.168
G—eligibility for the training methods	4.25	4.18	0.999
H—suitability for the training period	3.58	3.55	0.863

The comparison of pre- and post-training duration of the time needed to complete all of the tasks, together with the trainee satisfaction scores (significance was set to $p < 0.05$)

On the second day of the course, after a brief theoretical and practical retroperitoneal anatomy lecture on the embalmed cadavers, the trainees were divided into two groups. The experienced trainers explained and demonstrated the steps of the procedure in a one-by-one fashion. The steps of the simulation consisted in: (1) advancing the scope inside the access sheath, (2) advancing the scope inside the proximal ureter up to the renal pelvis, overpassing the ureteropelvic junction, (3) visualizing the whole collecting system with fluoroscopy and retrograde contrast medium injection, (4) locating the stone into the collecting system, (5) grasping the stone with the basket, (6) re-locating the stone into the upper calyx, (7) releasing the stone, and (8) removing the scope from the access sheath.

For each participant, the total duration of the procedure—starting from the entrance into the renal pelvis and ending with the removal of scope from the access sheath—was measured using a stopwatch. Pre- and post-training scores of the survey and the duration of the tasks were compared.

Statistical analysis

Statistical analysis was performed using the SPSS version 17.0 (SPSS, Chicago, IL, USA). In addition to descriptive statistics (mean values, standard deviation (SD), median values, interquartile range), nonparametric Wilcoxon signed-rank test was used to compare repeated measurements. Statistical significance was set as $p < 0.05$.

Results

Overall, 12 certified urologists with a mean age of 37.41 years ±8.19 SD who attended the theoretical and hands-on-training sections were enrolled.

Of the 12 trainees, five rated the suitability for the education content as very high and three as high. Satisfaction from training was very high in four of the trainees. Contribution to the knowledge and satisfaction from the training course organization was achieved far away from the expectations in four and six participants, respectively. The lowest score was obtained for the suitability for the training period. Pre- and post-training scores were similar for each question (Table 1).

All participants successfully completed the hands-on-training tasks. Mean pre-training duration for completing the task was significantly longer than mean post-training duration (3.56 min ± 2.0 SD and 1.76 min ± 1.54 SD, respectively, $p = 0.008$) (Table 1).

At the end of the day, the trainers checked the integrity of the collecting system of the fresh-frozen cadavers both by endoscopy and by fluoroscopy, and could not detect any injury of the upper ureteral wall or pelvicalyceal structures. The functionality of the scope was also checked and no scope damage was noticed, being the scope deflection fully preserved.

Discussion

The human cadaver model has been traditionally used by anatomists to educate medical students on basic anatomy knowledge during their medical education. On the other hand, surgeons usually revisit the clinical and surgical anatomy during the live cases with their trainees. It can be summarized that training on human cadavers has a value during both the undergraduate and postgraduate periods for medical training. The human cadaver model has some advantages including the similarity of real anatomical structures to the real patient and the bloodless environment [1, 18, 19]. However, training models other than human cadavers—including animal models and simulators—have their own pros and cons. High costs, suboptimal simulation of virtual training models or lack of human anatomical landmarks of animal models are the main disadvantages [19]. Also although not proven by other studies, it has been speculated that training models using animals may have the risk of contamination with bovine spongiform encephalopathy virus [10]. Giger et al. reported that surgery training on human cadavers provided high overall attendees satisfaction [19, 20]. The fresh-frozen cadavers used in the current course offer a normal human anatomy and the possibility to have a tactile sensation of the elasticity of the ureter and of the collecting system, possibly involved in a subsequent decreased morbidity in the real patient. However, the collaboration of faculty from the anatomy and urology departments is crucial for the success of the cadaveric training programs as we improved the novel training model on fURS with the support of anatomists [19]. The popularity of minimal invasive urologic surgery (MIUS) is globally gaining popularity among the urologists. Due to this popularity, the exploration of appropriate training models for MIUS became essential. fURS has become the standard diagnostic and treatment modality for upper urinary stone disease, ureteral strictures and transitional cell carcinoma [21]. The increasing indications of fURS forced the endourologists to improve their surgical skills. Indeed, this was the main reason for our team to set up the novel fURS training model on a fresh-frozen cadaver model. Ogan et al. [3] reported that for novice endoscopists performance on the virtual reality ureteroscopy simulator after training predicted cadaveric performance may be useful for the education and evaluation of physicians in training. In another report, the MIS training on soft cadavers was shown as a feasible model with great satisfaction in laparoscopic surgery [2]. Brehmer et al. [4] underlined the need for alternative training models in endourology apart from the computerized simulators. In order to improve the dexterity in semi-rigid ureteroscopy, they presented the bench model and achieved results similar to the real surgery. Skolarikos et al. in their meticulous review article confirmed their findings with similar papers and recommended to incorporate these novel models into the ureteroscopy training [1]. There are several reports in the literature describing the training models for rigid ureteroscopy using human cadavers [12], but the most suitable method for postgraduate training has not been determined yet. However, to the best of our knowledge, this is the first report defining the training model for fURS using fresh-frozen cadavers. To our knowledge, this is the first MIUS training on RIRS using fURS to implement anatomical coordinated use of soft and embalmed cadavers. Blaschko et al. [10] confirmed that the preservation technique of cadavers has provided excellent tissue quality for dissection and allows for refrigeration of the cadaver between the first and second use. We also demonstrated that despite being used by each participant during the hands-on-training session, these cadavers could be reused in the next training program without compromising the tissue quality. This effectively reduces the cost of cadaver use for training by half; however, endoscopic surgical training on cadaver also provides excellent tissue preservation compared to open surgical training model. Wong et al. reported that a limited supply of cadavers, the difference in tissue quality between cadaveric and blood-perfused tissue, and only once usage, were the limitations on widespread use of human anatomical material for surgical skills training [10, 22]. Adversely, we believe that the improvement in soft tissue preservation technique and minimal invasive approach to the tissue obtain similar quality and satisfaction compared to live tissue. However, Özcan et al. [23] evaluated the efficacy of cadaveric dissection training on urology residents' knowledge in some urologic organs, and showed that the cadaveric model was effective in improving surgical anatomy knowledge in most urology residents.

There are several limitations of the current study. First of all, the fresh-frozen cadavers do not bleed. However, with the modern ureteroscopes, lasers and the well-defined steps of the procedure, the bleeding rates of fURS are also very low. Moreover, we think that—different from laparoscopy or percutaneous nephrolithotomy models—a bloodless medium offers a real advantage in fURS. The absence of respiratory movements influencing the mobility of the kidneys and of the targeted stone constitutes another problem that an endourologist may encounter during a fURS case. Another limit is the absence of ureteric tone and the immediate application of the ureteral access sheath from the very beginning, limiting the learning of the access technique to the ureteric orifice and of how to overpass ureteric spasms and/or kinkings. Finally, the survey does not reflect the effects of the described training on the daily clinical practice of the trainees as they just completed the course.

Conclusions

fURS simulation training model using soft human cadavers has the unique advantage of mimicking the living human tissues. This similarity makes this model one of the best if not the perfect simulator reported in the literature by now.

Author contribution Murat Bağcıoğlu analyzed data and collected or managed data; Murat Binbay collected or managed data; Cecilia Maria Cracco analyzed data; Deniz Demiryürek collected or managed data; Mehmet Ezer analyzed data and collected or managed data; Emre Huri developed protocol/project and wrote/edited manuscript; Tolga Karakan analyzed data; Roberto Miano developed protocol/project; Mustafa Sargon developed protocol/project; Cesare Marco Scoffone developed protocol/project and wrote/edited manuscript; Andreas Skolarikos developed protocol/project and wrote/edited manuscript; Mustafa Sofikerim collected or managed data and wrote/edited manuscript; İlkan Tatar developed protocol/project and wrote/edited manuscript; Emrah Yürük analyzed data and collected or managed data

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest, except Dr. Cesare Marco Scoffone, who is consultant for Boston Scientific, Coloplast Porgés, Cook Medical, Lumenis and Storz.

References

1. Skolarikos A, Gravas S, Laguna MP, Traxer O, Preminger GM, de la Rosette J (2011) Training in ureteroscopy: a critical appraisal of the literature. BJU Int 108(6):798–805. doi:10.1111/j.1464-410X.2011.10337.x **(discussion 805)**
2. Udomsawaengsup S, Pattana-arun J, Tansatit T, Pungpapong SU, Navicharern P, Sirichindakul B, Nonthasoot B, Park-art R, Sriassadaporn S, Kyttayakerana K, Wongsaisuwan M, Rojanasakul A (2005) Minimally invasive surgery training in soft cadaver (MIST-SC). J Med Assoc Thai 88(Suppl 4):S189–S194
3. Ogan K, Jacomides L, Shulman MJ, Roehrborn CG, Cadeddu JA, Pearle MS (2004) Virtual ureteroscopy predicts ureteroscopic proficiency of medical students on a cadaver. J Urol 172(2):667–671. doi:10.1097/01.ju.0000131631.60022.d9
4. Brehmer M, Swartz R (2005) Training on bench models improves dexterity in ureteroscopy. Eur Urol 48(3):458–463. doi:10.1016/j.eururo.2005.04.031 **(discussion 463)**
5. Chou DS, Abdelshehid C, Clayman RV, McDougall EM (2006) Comparison of results of virtual-reality simulator and training model for basic ureteroscopy training. J Endourol 20(4):266–271. doi:10.1089/end.2006.20.266
6. Watterson JD, Denstedt JD (2007) Ureteroscopy and cystoscopy simulation in urology. J Endourol 21(3):263–269. doi:10.1089/end.2007.9982
7. Strohmaier WL, Giese A (2001) Porcine urinary tract as a training model for ureteroscopy. Urol Int 66(1):30–32. doi:10.1159/000056559
8. Hammond L, Ketchum J, Schwartz BF (2005) Accreditation council on graduate medical education technical skills competency compliance: urologic surgical skills. J Am Coll Surg 201(3):454–457. doi:10.1016/j.jamcollsurg.2005.05.002
9. Katz R, Hoznek A, Antiphon P, Van Velthoven R, Delmas V, Abbou CC (2003) Cadaveric versus porcine models in urological laparoscopic t raining. Urol Int 71(3):310–315. doi:10.1159/000072684
10. Blaschko SD, Brooks HM, Dhuy SM, Charest-Shell C, Clayman RV, McDougall EM (2007) Coordinated multiple cadaver use for minimally invasive surgical training. JSLS 11(4):403–407
11. Anderson SM, Kapp BB, Angell JM, Abd TT, Thompson NJ, Ritenour CW, Issa MM (2013) Remote monitoring and supervision of urology residents utilizing integrated endourology suites-a prospective study of patients' opinions. J Endourol 27(1):96–100. doi:10.1089/end.2012.0406
12. Schout BM, Hendrikx AJ, Scherpbier AJ, Bemelmans BL (2008) Update on training models in endourology: a qualitative systematic review of the literature between January 1980 and April 2008. Eur Urol 54(6):1247–1261. doi:10.1016/j.eururo.2008.06.036
13. Calio BP, Kepler CK, Koerner JD, Rihn JA, Millhouse P, Radcliff KE (2014) Outcome of a resident spine surgical skills training program. J Spin Disord Tech. doi:10.1097/BSD.0000000000000211
14. Carey JN, Rommer E, Sheckter C, Minneti M, Talving P, Wong AK, Garner W, Urata MM (2014) Simulation of plastic surgery and microvascular procedures using perfused fresh human cadavers. J Plast Reconstr Aesthet Surg 67(2):e42–e48. doi:10.1016/j.bjps.2013.09.026
15. Jansen S, Cowie M, Linehan J, Hamdorf JM (2014) Fresh frozen cadaver workshops for advanced vascular surgical training. ANZ J Surg 84(11):877–880. doi:10.1111/ans.12361
16. Sharma M, Macafee D, Horgan AF (2013) Basic laparoscopic skills training using fresh frozen cadaver: a randomized controlled trial. Am J Surg 206(1):23–31. doi:10.1016/j.amjsurg.2012.10.037
17. Turner AJ, Mellington A, Ali F (2005) Fresh cadaver dissection for training in plastic surgery. Br J Plast Surg 58(5):742–743. doi:10.1016/j.bjps.2005.01.012
18. Huri E, Acar C, Binbay M, Sözen S (2012) Human cadaveric uro-oncology (HCU) surgical anatomy course: an "old" but contemporary training method. Glob J Med Publ Health 1(3):24–28
19. Huri E, Skolarikos A, Tatar İ, Binbay M, Sofikerim M, Yğrğk E, Karakan T, Sargon M, Miano R (2014) S192: Cad-rirs: The novel training modality of retrograde intrarenal surgery for stone disease (ri rs)-*cret (cadaveric research on endourology training) study group. Eur Urol Suppl 13(7):e1529–e1529a. doi:10.1016/S1569-9056(14)61730-9

20. Ziaee SA, Sichani MM, Kashi AH, Samzadeh M (2010) Evaluation of the learning curve for percutaneous nephrolithotomy. Urol J 7(4):226–231
21. Bach C, Nesar S, Kumar P, Goyal A, Kachrilas S, Papatsoris A, Masood J, Buchholz N (2012) The new digital flexible ureteroscopes: 'size does matter'—increased ureteric access sheath use! Urol Int 89(4):408–411. doi:10.1159/000341429
22. de la Rosette JJ, Laguna MP, Rassweiler JJ, Conort P (2008) Training in percutaneous nephrolithotomy-a critical review. Eur Urol 54(5):994–1001. doi:10.1016/j.eururo.2008.03.052
23. Özcan S, Huri E, Tatar İ, Sargon M, Karakan T, Yağlı ÖF, Bağcıoğlu M, Larre S (2015) Impact of cadaveric surgical anatomy training on urology residents knowledge: a preliminary study. Turkish J Urol 41(2):83–87. doi:10.5152/tud.2015.87422