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## Role of simulation in kidney stone disease: A systematic review of literature trends in the 26 years

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### Abstract

#### BACKGROUND

Minimally invasive techniques for treatment of urinary stones requires expertise, experience and endoscopic skills. Simulators provide a low-stress and low-risk environment while providing a realistic set-up and training opportunities.

#### AIM

To report the publication trend of 'simulation in urolithiasis' over the last 26 years.

#### METHODS

Research of all published papers on "Simulation in Urolithiasis" was performed through PubMed database over the last 26 years, from January 1997 to December 2022. Papers were labelled and divided in three subgroups: (1) Training papers; (2) Clinical simulation application or surgical procedures; and (3) Diagnostic radiology simulation. Each subgroup was then divided into two 13-year time periods to compare and identify the contrast of different decades: period-1 (1997-2009) and period-2 (2010-2022).

#### RESULTS

A total of 168 articles published on the application of simulation in urolithiasis over the last 26 years (training:  $n = 94$ , surgical procedures:  $n = 66$ , and radiology:

$n = 8$ ). The overall number of papers published in simulation in urolithiasis was 35 in Period-1 and 129 in Period-2, an increase of +269% ( $P = 0.0002$ ). Each subgroup shows a growing trend of publications from Period-1 to Period-2: training papers +279% ( $P = 0.001$ ), surgical simulations +264% ( $P = 0.0180$ ) and radiological simulations +200% ( $P = 0.2105$ ).

## CONCLUSION

In the last decades there has been a step up of papers regarding training protocols with the aid of various simulation devices, with simulators now a part of training programs. With the development of 3D-printed and high-fidelity models, simulation for surgical procedure planning and patients counseling is also a growing field and this trend will continue to rise in the next few years.

**Key Words:** Kidney calculi; Urolithiasis; Simulation; Ureteroscopy; Percutaneous nephrolithotomy; Artificial intelligence

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**Core Tip:** The role of simulation training in the management of kidney stones has evolved. There has been a step up of papers regarding training protocols with the aid of various simulation devices, with simulators now a part of training programs. With the development of three-dimensional printed and high-fidelity models, simulation for kidney stone procedure planning and patients counseling is also a growing field and this trend will continue to rise in the next few years.

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## INTRODUCTION

Minimally invasive techniques for treatment of urinary stones require expertise, experience and endoscopic skills[1]. The learning curve to gain precision and accuracy in endoscopic procedures such as ureteroscopy (URS) and percutaneous nephrolithotomy (PCNL), and shockwave lithotripsy (SWL), has proven to be steep, leading to the need for training in non-operating settings[2]. Simulators provide a low-stress and low-risk environment while providing a realistic set-up and training opportunities and example of endoscopic procedures[3].

Different types of simulators can be found in the literature, with various degrees of fidelity or realism, and varying in costs[4]. Benchtop simulators are inanimate models that come cheap and are widely available, reusable and portable. Being useful for mastering the use of endoscopic instruments, these models are yet not as realistic and seem to be more appropriate for novice surgeons[5]. Realistic ex-vivo models, for example animals or human cadavers would in fact be more appropriate for advanced training, who need to master more intricate steps and advanced procedures[6].

Animal and cadaver simulators have greater costs than inanimate devices, can only be used once, and can have ethical issues[7]. The most recently developed type of simulators is based on virtual reality (VR), a computer-based simulation model that can mimic basic procedures as well as advanced interventions, being realistic and able to instantly give feedback to the trainees[8]. VR is a reusable simulator with amazing applicability but has high purchase costs and unreliable haptics.

Numerous studies have been performed on application of simulators in training of residents and expert surgeons, with focus on costs, performance, learning curve and standardized protocols[9]. As gathered from data, simulators are increasingly relied on for urology resident training worldwide[10].

Nonetheless, VR simulators, benchtop and three-dimensional (3D) printed models are now being used as tools to improve performance of endoscopic procedure in a patient-specific settings[11], for example developing a case-specific surgical planning before entering the operation theatre or simulating outcomes of different approaches. In particular, several studies reported the application for preoperative simulated puncture in complex PCNL, on different simulator models[12]. Moreover, simulators can be used to study performance and comparison of different instruments as laser fibers and their settings, endoscopic baskets or flexible scopes, without risking endangering patients in an in-vivo surgical procedure[13].

As a tool for enhancing patient-surgeon relationship and counseling, simulators have even been used to improve patient understanding of the disease and surgical procedure, resulting in higher levels of postoperative satisfaction[14].

The increasing trend of application of artificial intelligence and its subsets in the management of urolithiasis has already been investigated, with promising results[15]. It appears that the application of simulators is spreading in the urologic scientific community, from training to research and surgical planning. In this comprehensive review, we aim to report the publication trend of 'simulation in urolithiasis' over the last 26 years.

## MATERIALS AND METHODS

Research of all published papers on “Simulation in Urolithiasis” was performed through PubMed database over the last 26 years, from January 1997 to Dec 2022, using MeSH terms, title words, and key words (Figure 1).

### Search strategy and study selection

Cochrane methodology and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed to shape the study design[16]. All papers with relevant abstracts were identified through search on online database PubMed from 1997 to 2022.

Keywords used for searching included: “Urolithiasis”, “Kidney calculi” and “Stones”. MESH terms used in this screening process were: “Simulation”, “Virtual Reality”, “Augmented Reality”, “Mixed Reality”, “URS Simulation”, “PCNL Simulation”, “SWL Simulation”, “3D printing”, “Training”, “Training box”, “Bench Training”, “Phantom” and “Bench model”. All English and non-English abstracts were screened as there was no language restriction in the study. Systematic and non-systematic reviews were included in the study. Studies without a published abstract were excluded, as well as animal studies, human cadaveric studies and case reports.

After screening and extraction, papers were label according to subject: Training papers, studies on clinical applications or surgical procedures (surgical: URS, PCNL, SWL; instruments performance: Ureteral stent, scope, lithotripter, laser), studies of diagnostic (radiology) simulation on phantoms.

To better analyze the trend variation, papers were divided according to time of publication into two time periods: Period-1 (1997-2009) and Period-2 (2010-2022).

### Evidence acquisition: criteria for including studies for this review

**Inclusion criteria:** All English language studies with a published abstract; All non-English studies with abstracts published in the English language; Studies reporting on simulation in urolithiasis: Training simulations with box simulators, phantoms for both diagnostic and therapeutic procedures; Simulations device for surgical planning (URS, PCNL, SWL) and patient-specific simulation; Studies of surgical performance using simulators (scopes, ureteral stents, laser fibers, lithotripters).

**Exclusion criteria:** Studies without a published abstract; Studies for non-urolithiasis conditions; Studies on human cadavers or animals; Case reports and meeting abstracts.

Two authors (C.N., V.J.) independently performed a literature search to identify studies and discrepancies were resolved after input and discussion with the senior author (B.K.S). Extracted articles on simulation were then divided in three subgroups according to field of interest: (1) Training; (2) Clinical application; and (3) Radiology simulation (Figure 2). Each subgroup was then divided into two 13-year time periods to compare and identify the contrast of different decades: Period-1 (1997-2009) and Period-2 (2010-2022).

Data were collected using Microsoft Excel (version 2007), analyzed through the independent *t* test. A statistically significant threshold level was stated at  $P < 0.05$  to rule out possible difference in the data collected from Period-1 *vs* Period-2.

## RESULTS

### Overall number of papers

A total of 168 articles published on the application of simulation in urolithiasis over the last 26 years (training:  $n = 94$ , surgical procedures:  $n = 66$ , and radiology:  $n = 8$ ). 164 papers were published in English; only 4 articles had an English language abstract and a non-English full paper: 1 in Chinese, 1 in French, and 2 in Russian.

For training procedures, articles included URS training ( $n = 53$ ), PCNL training ( $n = 22$ ) or simulation training for both these procedures ( $n = 19$ ). Clinical application of simulation in surgical procedures included articles on URS ( $n = 29$ ), PCNL ( $n = 26$ ), SWL ( $n = 5$ ) and ureteral stenting ( $n = 6$ ). Regarding radiological simulations with phantoms, articles were found with application on diagnostic procedures ( $n = 5$ ) and intraoperative imaging features ( $n = 3$ ).

The overall number of papers published in simulation in urolithiasis was 35 in Period-1 and 129 in Period-2, with a significant increase of +269% ( $P = 0.0002$ ). Each subgroup shows a growing trend of publications from Period-1 to Period-2: training papers +279% ( $P = 0.001$ ), surgical simulations +264% ( $P = 0.0180$ ) and radiological simulations +200% ( $P = 0.2105$ ).

### Training simulation papers

Of the 94 papers on simulation for training in endourology, 72 were published in Period-2, accounting for more than 76% of current publications.

Analysis of application of simulators for URS ( $n = 51$ ) shows a significant rise by +225% ( $P = 0.0016$ ) in Period-2. Similarly, simulation papers on PCNL training ( $n = 21$ ) had a steep increase of +850% ( $P = 0.0023$ ) in Period-2. Looking at simulations with a mixed setting with both URS and PCNL procedures, the rise by +180% was not statistically significant ( $P = 0.1275$ ). In this research, 11 reviews were found, with great interest in residents’ training with simulators, assessing learning curves and developing standardized protocols of training. In the last 5 years, from 2018 to 2022, the numbers of papers on training with simulation for URS, PCNL and mixed endourological training were 17, 11 and 10 papers respectively.

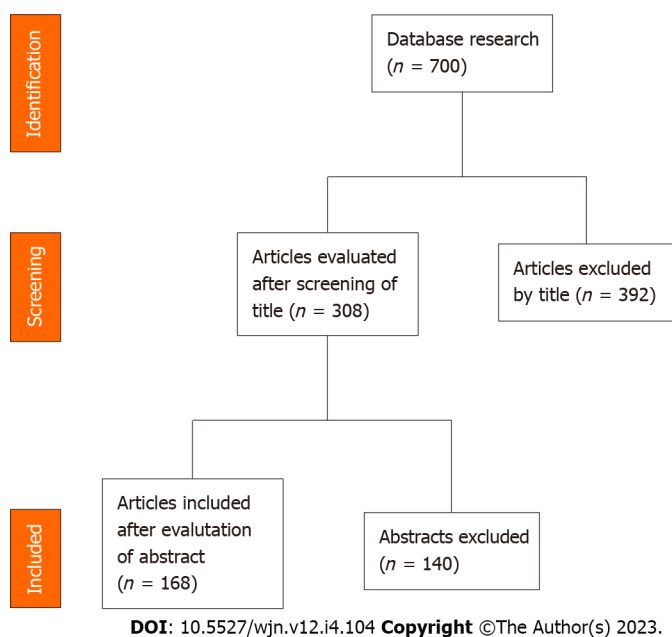


Figure 1 PRISMA flowchart of the included studies.

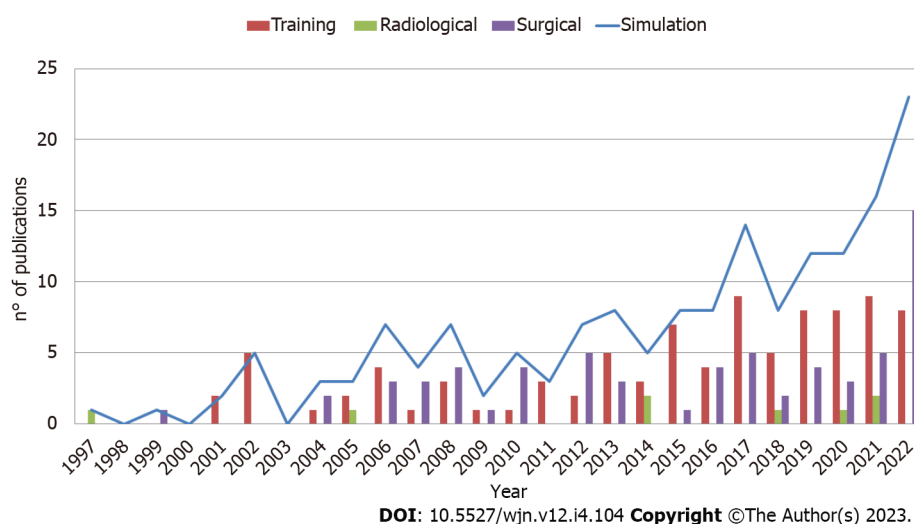


Figure 2 Trend of publications on 'Simulation in Urolithiasis' (trend line), with different subgroup as Training, Surgical and Radiological simulation.

### Surgical simulation papers

Publication trend on surgical application of simulators in endourology has increased significantly ( $P = 0.0180$ ) from Period-1 to period-2 (+264%), with 14 and 51 papers respectively.

Analysis of those papers found varied topics from application of patient-specific simulators (benchtop, 3D printed models, VR simulators) for surgical planning both in URS and PCNL, simulators of SWL (phantoms, VR) for predicting performance of lithotripsy, analysis of stent features in 3D models, evaluation of procedural instrumentation such as scopes, lasers, lithotripters and endoscopic baskets during surgical procedures (URS and PCNL).

Papers on simulations in URS ( $n = 28$ ) rose significantly in Period-2 (+360%,  $P = 0.0039$ ), PCNL simulations ( $n = 26$ ) increased too (+1100%,  $P = 0.0181$ ). SWL simulation and ureteral stent simulation on the other had reduced in period-2 (-33%,  $P = 0.6983$  and -50%,  $P = 0.5912$  respectively).

### Radiological simulation papers

Application of simulators in radiology differed in our results from a diagnostic setting (preoperative), with phantoms used as tools to test efficiency of examinations, to a surgical setting (intraoperative), assessing quality of imaging and reconstructions. These increased from period-1 ( $n = 2$ ) to period-2 ( $n = 6$ ), a rise by +200% ( $P = 0.2105$ ).



## DISCUSSION

The role of simulation devices has been widely analyzed in the last decades, with particular attention to its application for training and assessment. Different studies have been proposed to rule out the efficacy in teaching residents' surgical skills in a non-operative setting, mostly with the aim to improve patient safety and reduce harm, while allowing a safe pre-surgical exposure to trainees[17]. The possibility to experiment difficult steps of endoscopic procedure, surgery that requires high level of training and experience, has been in fact a blessing in disguise[18]. The role of simulation in easing the learning curve of trainees has been positively reported, as well as its impact in leading the residents through difficult procedures in a low-stress setting[19].

Protocolshave then been developed to standardize resident training in a more efficient way[20], proposing different steps of expertise and accuracy, sometimes even with the aid of different simulators based on their grade of fidelity and accuracy[21].

What emerges from literature is that simulation can play a game-changing role in training. Its applications are almost infinite, ranging from easier procedure such as cystoscopic examination[22] and ureteral stent insertion, through to gain accuracy with complex procedures such as flexible URS and PCNL. Some models have even been developed to simulate unexpected scenarios like ureteral strictures, kinking and complications[23]. This allows trainees to get experience in more advanced scenarios without putting patients at risk.

Not every aspect of simulator training is perfect and even the more modern and technological simulators (VR for example) often lack enough realistic sensibility to train the haptics, and the absence of stress in a simulated environment can be misleading in the training process and may not allow trainees to deal with unexpected events[24].

There is an increasing trend of the use of simulators and simulation training over the last decade, and it is difficult to ignore the leading role simulators are playing in surgical improvement[10]. Our research found numerous papers on the application of simulation devices, especially phantoms and 3D printed models, for testing new technological devices.

In the studies regarding URS, laser fibers were tested to understand the effect different settings had on the stones or soft tissue, comparing different baskets and smaller scopes[25]. In PCNL simulation, the main focus emerged in the planning of renal puncture with accuracy and without perforation of neighboring structures[26]. To this aim, several studies have been performed in a patient-specific setting with realistic 3D-printed models[27]. As this review found out, the role of SWL in stone treatment has become progressively confined with only few papers found on application of simulation for SWL, for example analyzing gel properties or stone disruption, and none of them has been published in the last 10 years[28].

Development of 3D-printed models and VR has also been used in literature as an aid to counsel patients. Anatomically accurate models can influence the understanding of a patient's own disease, along with the surgical procedure, the possible complications and outcomes[29]. Recent studies have in fact pointed out the positive correlation that lies between the use of simulators in patient counseling and their overall satisfaction, with a positive role on surgeon-patient relationship and for avoiding misunderstandings[30]. This relatively new application of simulation could gain an important role in daily clinical practice.

Simulation based curriculum is now endorsed by the European Association of Urology (EAU) and European School of Urology (ESU)[31]. Other educational articles will help reinforce the training perspective to trainees[32]. There also seems to be an increasing role of artificial intelligence for training and education[33].

### **Strengths and weakness of bibliometric trend analysis**

In this review, the first to our knowledge to evaluate the trend of publication of simulation in urolithiasis over the last 26 years, we aimed to report a comprehensive scenario of current literature. Both English and non-English language studies have been included in this review. On the other hand, the authors are aware that limiting our research to PubMed database, some articles published in non-index journals might have been missed. We consider though this to be a minor limitation, as bibliographic accuracy should still be obtained from this database alone[34]. This review is intended to analyze publication trends on simulation in the management of urolithiasis, and it does not just include training or clinical papers[35,36], but all studies performed with the application of simulators in endourology.

## CONCLUSION

This review found an increasing bibliometric publication trend on the application of simulators in endourological practice. In the last decades there has been a step up of papers regarding training protocols with the aid of various simulation devices, with simulators now a part of training programs. With the development of 3D-printed and high-fidelity models, simulation for surgical procedure planning and patients counseling is also a growing field and this trend will continue to rise in the next few years.

## ARTICLE HIGHLIGHTS

### **Research background**

Minimally invasive techniques for treatment of urinary stones requires expertise, experience and endoscopic skills. Simulators provide a low-stress and low-risk environment while providing a realistic set-up and training opportunities.



**Research motivation**

To report the publication trend of 'simulation in urolithiasis' over the last 26 years.

**Research objectives**

To analyze the simulation trends over the last 26 years.

**Research methods**

Research of all published papers on "Simulation in Urolithiasis" over the last 26 years: (1) Training papers; (2) Clinical simulation application or surgical procedures; and (3) Diagnostic radiology simulation. Data was further analyzed in two 13-year time periods to compare and identify the contrast of different decades: Period-1 (1997-2009) and period-2 (2010-2022).

**Research results**

A total of 168 articles published on the application of simulation in urolithiasis over the last 26 years (training:  $n = 94$ , surgical procedures:  $n = 66$ , and radiology:  $n = 8$ ). The overall number of papers published in simulation in urolithiasis increased over time for all three areas with more simulation based studies in the last decade.

**Research conclusions**

In the last decades there has been a step up of papers regarding training protocols with the aid of various simulation devices, with simulators now a part of training programs.

**Research perspectives**

Simulation trends could guide future researchers on training and safe surgical practice patterns.

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**FOOTNOTES**

**Author contributions:** Nedbal C contributed to writing; Nedbal C and Jahrreiss V contributed to data collection; Cerrato C contributed to data analysis; Pietropaolo A, Galosi AB, Veneziano D, Kallidonis P, and Somani BK contributed to editing; Somani BK contributed to conceptualization and coordination.

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**REFERENCES**

- 1 Brunckhorst O, Aydin A, Abboudi H, Sahai A, Khan MS, Dasgupta P, Ahmed K. Simulation-based ureteroscopy training: a systematic review. *J Surg Educ* 2015; **72**: 135-143 [PMID: [25130385](#) DOI: [10.1016/j.jsurg.2014.07.003](#)]
- 2 Ng CF. Training in percutaneous nephrolithotomy: The learning curve and options. *Arab J Urol* 2014; **12**: 54-57 [PMID: [26019924](#) DOI: [10.1016/j.aju.2013.08.002](#)]
- 3 Sarmah P, Voss J, Ho A, Veneziano D, Somani B. Low vs. high fidelity: the importance of 'realism' in the simulation of a stone treatment procedure. *Curr Opin Urol* 2017; **27**: 316-322 [PMID: [28403125](#) DOI: [10.1097/MOU.0000000000000401](#)]
- 4 Pelly T, Shanmugathas N, Bowyer H, Wali A, Pankhania R. Low-cost simulation models in Urology: a systematic review of the literature. *Cent European J Urol* 2020; **73**: 373-380 [DOI: [10.5173/cej.2020.0122](#)]
- 5 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**: 1243-1247 [DOI: [10.1016/S0022-5347\(05\)65274-3](#)]
- 6 Bowling CB, Greer WJ, Bryant SA, Gleason JL, Szychowski JM, Varner RE, Holley RL, Richter HE. Testing and validation of a low-cost cystoscopy teaching model: a randomized controlled trial. *Obstet Gynecol* 2010; **116**: 85-91 [PMID: [20567172](#) DOI: [10.1097/AOG.0b013e3181e45a52](#)]

- 7 **Hameed BMZ**, Somani S, Keller EX, Balamaniandan R, Mahapatra S, Pietropaolo A, Tonyali Ş, Juliebø-Jones P, Naik N, Mishra D, Kumar S, Chlosta P, Somani BK. Application of Virtual Reality, Augmented Reality, and Mixed Reality in Endourology and Urolithiasis: An Update by YAU Endourology and Urolithiasis Working Group. *Front Surg* 2022; **9**: 866946 [PMID: 35433825 DOI: 10.3389/fsurg.2022.866946]
- 8 **Aydn A**, Baig U, Al-Jabir A, Sarica K, Dasgupta P, Ahmed K. Simulation-Based Training Models for Urolithiasis: A Systematic Review. *J Endourol* 2021; **35**: 1098-1117 [PMID: 33198492 DOI: 10.1089/end.2020.0408]
- 9 **Aditya I**, Kwong JCC, Canil T, Lee JY, Goldenberg MG. Current Educational Interventions for Improving Technical Skills of Urology Trainees in Endourological Procedures: A Systematic Review. *J Endourol* 2020; **34**: 723-731 [PMID: 31691593 DOI: 10.1089/end.2019.0693]
- 10 **Hameed BMZ**, Pietropaolo A, Naik N, Noronha C, Juliebø-Jones P, Mykoniatis I, Esperto F, Shah M, Ibrahim S, Shetty DK, Karimi H, Sharma D, Rai BP, Chlosta P, Somani BK. Role of three dimensional (3D) printing in endourology: An update from EAU young academic urologists (YAU) urolithiasis and endourology working group. *Front Surg* 2022; **9**: 862348 [PMID: 36061049 DOI: 10.3389/fsurg.2022.862348]
- 11 **Hameed BMZ**, Shah M, Pietropaolo A, De Coninck V, Naik N, Skolarikos A, Somani BK. The technological future of percutaneous nephrolithotomy: a Young Academic Urologists Endourology and Urolithiasis Working Group update. *Curr Opin Urol* 2023; **33**: 90-94 [PMID: 36622261 DOI: 10.1097/MOU.0000000000001070]
- 12 **Favorito LA**. Kidney anatomy: three dimensional (3D) printed pelvicalyceal system models of the collector system improve the diagnosis and treatment of stone disease. *Int Braz J Urol* 2017; **43**: 381-382 [PMID: 28520334 DOI: 10.1590/S1677-5538.IBJU.2017.03.01]
- 13 **Ventimiglia E**, Sindhubodde S, Besombes T, Pauchard F, Quadrini F, Delbarre B, Jiménez Godínez A, Barghouthy Y, Corrales Acosta MA, Kamkoun H, Villa L, Doizi S, Somani BK, Traxer O. Operator-assisted vs self-achieved basketing during ureteroscopy: results from an in vitro preference study. *World J Urol* 2021; **39**: 2169-2175 [PMID: 33025141 DOI: 10.1007/s00345-020-03431-5]
- 14 **Bergmeister KD**, Aman M, Kramer A, Schenck TL, Riedl O, Daeschler SC, Aszmann OC, Bergmeister H, Golriz M, Mehrabi A, Hundeshagen G, Enkhbaatar P, Kinsky MP, Podesser BK. Simulating Surgical Skills in Animals: Systematic Review, Costs & Acceptance Analyses. *Front Vet Sci* 2020; **7**: 570852 [PMID: 33195561 DOI: 10.3389/fvets.2020.570852]
- 15 **Pietropaolo A**, Proietti S, Geraghty R, Skolarikos A, Papatsoris A, Liatsikos E, Somani BK. Trends of 'urolithiasis: interventions, simulation, and laser technology' over the last 16 years (2000-2015) as published in the literature (PubMed): a systematic review from European section of Uro-technology (ESUT). *World J Urol* 2017; **35**: 1651-1658 [PMID: 28593477 DOI: 10.1007/s00345-017-2055-z]
- 16 **Moher D**, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ* 2009; **339**: b2535 [PMID: 19622551 DOI: 10.1136/bmj.b2535]
- 17 **Skolarikos A**, Gravas S, Laguna MP, Traxer O, Preminger GM, de la Rosette J. Training in ureteroscopy: a critical appraisal of the literature. *BJU Int* 2011; **108**: 798-805; discussion 805 [PMID: 21884354 DOI: 10.1111/j.1464-410X.2011.10337.x]
- 18 **Villa L**, Somani BK, Sener TE, Cloutier J, Buttice F, Marson F, Ploumidis A, Proietti S, Traxer O. Comprehensive flexible ureteroscopy (FURS) simulator for training in endourology: The K-box model. *Cent European J Urol* 2016; **69**: 118-120 [DOI: 10.5173/cej.2016.710]
- 19 **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 [PMID: 16882051 DOI: 10.1111/j.1442-2042.2006.01436.x]
- 20 **Aydn A**, Ahmed K, Baig U, Raison N, Lantz Powers AG, Macchione N, Al-Jabir A, Abe T, Khan MS, Dasgupta P; SIMULATE Trial Contributors. The SIMULATE ureteroscopy training curriculum: educational value and transfer of skills. *World J Urol* 2021; **39**: 3615-3621 [PMID: 33533996 DOI: 10.1007/s00345-021-03604-w]
- 21 **Schout BM**, Hendriks AJ, Scherpbier AJ, Bemelmans BL. Update on training models in endourology: a qualitative systematic review of the literature between January 1980 and April 2008. *Eur Urol* 2008; **54**: 1247-1261 [PMID: 18597924 DOI: 10.1016/j.eururo.2008.06.036]
- 22 **Watterson JD**, Denstedt JD. Ureteroscopy and cystoscopy simulation in urology. *J Endourol* 2007; **21**: 263-269 [PMID: 17444769 DOI: 10.1089/end.2007.9982.A]
- 23 **Li D**, Suarez-Ibarrola R, Choi E, Jeong M, Gratzke C, Miernik A, Fischer P, Qiu T. Soft Phantom for the Training of Renal Calculi Diagnostics and Lithotripsy. *Annu Int Conf IEEE Eng Med Biol Soc* 2019; **2019**: 3716-3719 [DOI: 10.1109/EMBC.2019.8856426]
- 24 **Baker BG**, Bhalla A, Doleman B, Yarnold E, Simons S, Lund JN, Williams JP. Simulation fails to replicate stress in trainees performing a technical procedure in the clinical environment. *Med Teach* 2017; **39**: 53-57 [PMID: 27631579 DOI: 10.1080/0142159X.2016.1230188]
- 25 **So WZ**, Gauhar V, Chen K, Lu J, Chua WJ, Tiong HY. An in vitro Comparative Assessment of Single-Use Flexible Ureteroscopes Using a Standardized Ureteroscopy Training Model. *Urol Int* 2022; **106**: 1279-1286 [PMID: 35709703 DOI: 10.1159/000525246]
- 26 **Checucci E**, Amparore D, Volpi G, Piramide F, De Cillis S, Piana A, Alessio P, Verri P, Piscitello S, Carbonaro B, Meziere J, Zamengo D, Tsaturyan A, Cacciamani G, Rivas JG, De Luca S, Manfredi M, Fiori C, Liatsikos E, Porpiglia F. Percutaneous puncture during PCNL: new perspective for the future with virtual imaging guidance. *World J Urol* 2022; **40**: 639-650 [PMID: 34468886 DOI: 10.1007/s00345-021-03820-4]
- 27 **de la Rosette JJ**, Laguna MP, Rassweiler JJ, Conort P. Training in percutaneous nephrolithotomy--a critical review. *Eur Urol* 2008; **54**: 994-1001 [PMID: 18394783 DOI: 10.1016/j.eururo.2008.03.052]
- 28 **Mendez-Probst CE**, Vanjecek M, Razvi H, Cadieux PA. Ordnance gelatine as an in vitro tissue simulation scaffold for extracorporeal shock wave lithotripsy. *Urol Res* 2010; **38**: 497-503 [PMID: 20967432 DOI: 10.1007/s00240-010-0329-7]
- 29 **Choi YH**, Lee SJ, Kim HY. Effect of a three-dimensional (3D) printed kidney model on patient understanding of the percutaneous nephrolithotomy procedure: a preliminary study. *Urolithiasis* 2022; **50**: 375-380 [PMID: 35122486 DOI: 10.1007/s00240-022-01308-3]
- 30 **Atalay HA**, Canat HL, Ülker V, Alkan İ, Özkuvanci Ü, Altunrende F. Impact of personalized three-dimensional -3D- printed pelvicalyceal system models on patient information in percutaneous nephrolithotripsy surgery: a pilot study. *Int Braz J Urol* 2017; **43**: 470-475 [PMID: 28338309 DOI: 10.1590/S1677-5538.IBJU.2016.0441]
- 31 **Veneziano D**, Ahmed K, Van Cleynenbreugel B, Gozen A, Palou J, Sarica K, Liatsikos E, Sanguedolce F, Honeck P, Alvarez-Maestro M, Papatsoris A, Kallidonis P, Greco F, Breda A, Somani BK. Development Methodology of the Novel Endoscopic Stone Treatment Step 1 Training/Assessment Curriculum: An International Collaborative Work by European Association of Urology Sections. *J Endourol* 2017; **31**: 934-941 [PMID: 28693386 DOI: 10.1089/end.2017.0248]
- 32 **Somani BK**, Aboumarzouk O, Srivastava A, Traxer O. Flexible ureterorenoscopy: Tips and tricks. *Urol Ann* 2013; **5**: 1-6 [PMID: 23662000 DOI: 10.4103/0974-7796.106869]
- 33 **Shah M**, Naik N, Somani BK, Hameed BMZ. Artificial intelligence (AI) in urology-Current use and future directions: An iTRUE study. *Turk J Urol* 2020; **46**: S27-S39 [PMID: 32479253 DOI: 10.5152/tud.2020.20117]
- 34 **Zhao X**, Jiang H, Yin J, Liu H, Zhu R, Mei S, Zhu CT. Changing trends in clinical research literature on PubMed database from 1991 to 2020.

*Eur J Med Res* 2022; **27**: 95 [PMID: 35725647 DOI: 10.1186/s40001-022-00717-9]

- 35 **Jones P**, Elmussareh M, Aboumarzouk OM, Mucksavage P, Somani BK. Role of Minimally Invasive (Micro and Ultra-mini) PCNL for Adult Urinary Stone Disease in the Modern Era: Evidence from a Systematic Review. *Curr Urol Rep* 2018; **19**: 27 [PMID: 29516304 DOI: 10.1007/s11934-018-0764-5]
- 36 **Whitehurst L**, Jones P, Somani BK. Mortality from kidney stone disease (KSD) as reported in the literature over the last two decades: a systematic review. *World J Urol* 2019; **37**: 759-776 [PMID: 30151599 DOI: 10.1007/s00345-018-2424-2]



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