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Simulator training in gastrointestinal endoscopy — From basic training to advanced endoscopic procedures

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A B S T R A C T

Simulator-based gastrointestinal endoscopy training has gained acceptance over the last decades and has been extensively studied. Several types of simulators have been validated and it has been demonstrated that the use of simulators in the early training setting accelerates the learning curve in acquiring basic skills. Current GI endoscopy simulators lack the degree of realism that would be necessary to provide training to achieve full competency or to be applicable in certification. Virtual Reality and mechanical simulators are commonly used in basic flexible endoscopy training, whereas *ex vivo* and *in vivo* models are used in training the most advanced endoscopic procedures. Validated models for the training of more routine therapeutic interventions like polypectomy, EMR, stenting and haemostasis are lacking or scarce and developments in these areas should be encouraged.

Introduction

During the last decades simulation-based training has gained more acceptance in teaching basic endoscopy skills to novice endoscopists. Traditionally, trainees learn to perform endoscopy by hands-on training in a clinical setting under the supervision of a trained endoscopist, the so-called master apprentice model. The main benefit of this teaching method is on-the-job training under one-on-one supervision by an experienced endoscopist offering immediate feedback. However, taking the first steps in flexible endoscopy while performing procedures on actual patients has certain drawbacks. It is learning by 'trial and error', which potentially increases patient discomfort and risk of complications. It also adds extra time to each procedure affecting capacity and economics [1]. An important drawback of such an approach is that with this type of training it is difficult for novices to appropriately process feedback in a stressful situation with an overload of new information. The approach of 'see one, do one and teach one' therefore seems outdated and no longer appropriate in the modern education of medical professionals, in particular in their early learning curve. Skillslabs and simulators offer the potential to train in a dedicated 'learning environment'. This is a safe environment for trainees where no possible harm can be done to patients. Stress factors related to doing a procedure in a live patient are eliminated to create an optimal setting for training. In this particular learning environment, it is also entirely possible to combine hands-on training with thorough theoretical teaching. Exercises can be repeated multiple times in small building blocks or specific scenario's until fully mastered.

In recent years, a number of studies have been published on simulator training, usually describing the benefit of simulator training in the early learning curve towards competency. A recent systematic review demonstrated moderate quality evidence for simulator-based training in forward viewing flexible endoscopy and ERCP. The review reveals that the use of virtual reality simulators in the early training setting accelerates the learning of practical skills [2]. However, the literature on simulator training for more advanced therapeutic procedures is scarcer, aside from studies on managing acute gastrointestinal bleeds or advanced endoscopic resection in *ex vivo* or *in vivo* animal models. A realistic simulation model for polypectomy, one of the most frequently performed therapeutic procedures, is still lacking among currently available simulators. Compared to the aviation or automotive industry, we can only acknowledge with envy that we are miles behind when it comes to realistic medical simulators.

In this chapter we will outline the well-established role of simulators in basic endoscopy training and elaborate on the role of (virtual reality (VR)) simulators, mechanical models, *ex vivo* and *in vivo* models for training in advanced endoscopic procedures.

Available simulators

The first simulators for flexible endoscopy were developed in the 1960s. In general there are four types of simulators: 1) mechanical simulators, 2) live animal models, 3) *ex vivo* models and 4) VR computer simulators. The first endoscopic simulators were mechanical models, designed especially for training sigmoidoscopy and colonoscopy. Live animal models seem to be the most realistic compared to mechanical models with haptic feedback resembling that of human tissue, although there are distinct differences in wall thickness and orientation of various organs, resulting in a slightly different 'feel'. Live animal models have certain drawbacks including the costs involved, the fact that they can only be used in specially equipped facilities, that they cannot be used indefinitely, and that many ethical concerns have been raised by the public [4]. A good alternative for live animal models is *ex vivo* models, composite and explanted animal organ simulators. These models consist of a combination of plastic parts and explanted animal organs obtained from slaughterhouses. They overcome some of the aforementioned limitations of the live animal models and have proven useful in specific training scenarios. Currently VR simulators are the most promising tools. They are available plug-and-play, making it accessible for trainees to train at their own pace and procedures can be repeated as many times as desired.

The optimal training model or simulator has to show the highest degree of content validity as well as concurrent validity. This means that the system has a high level of resemblance to the real life activity and that performance on the model should be readily transferrable to the real life activity, *in casu* patient-based endoscopy. Lesser, but more commonly used forms of validity are expert and construct validity. These terms describe the degree of realism as judged by experts and the ability of the simulator to distinguish different levels of competence [3]. The reliability of a simulator relates to its ability to provide consistent results with minimal errors of measurement. The most commonly used test is the test—retest reproducibility. It predicts to what extent a subject can 'beat the test' by repeated assessment [5].

Role of simulators in basic forward viewing flexible endoscopy training

Advanced therapeutic endoscopy has proven itself as an effective and safe first-line treatment for the management of early gastrointestinal neoplasia, pancreatico-biliary disease and many more conditions. Conditions formerly restricted to the domain of surgeons are now managed using minimally invasive endoscopic techniques, not only with considerably less morbidity and mortality, but also superior post-procedural functional results. Moreover, diagnostic endoscopic procedures are gaining importance largely as a result of the initiation of colorectal cancer screening programs in many countries worldwide. As a consequence, the increasing number and in particular the higher complexity of endoscopic procedures demands more skilled endoscopists able to perform these procedures in a competent manner. Simulation-based learning programs have proven to be of added value, they can effectively speed up the learning process in the early stages of training, avoid patient harm and lower one-on-one instructor time. Consequently, the use of simulators in the early training phase in different gastrointestinal procedures is gaining acceptance and several simulators have been validated for this purpose [2,6].

Oesophagogastroduodenoscopy

Oesophagogastroduodenoscopy (upper gastrointestinal endoscopy, OGD) is widely used for the diagnosis and treatment of oesophageal, gastric and small bowel conditions. In general, it is a safe and well-tolerated procedure. A variety of technical and cognitive aspects must be mastered in order to perform a high-quality examination. Although OGD is a common gastrointestinal (GI) procedure, studies concerning simulator-based training are scarce compared to colonoscopy. A possible explanation might be the fact that by gaining competency to perform a colonoscopy, where the need for endoscope handling and manoeuvring is much higher, performing OGD seems relatively easy. Several simulators have been developed for training OGD: mechanical models, *in vivo* and *ex vivo* animal models and VR simulators. The only validated VR-simulator for training upper endoscopy is the 'GI Mentor' virtual reality computer simulator (Fig. 1) [7,8].

Fig. 1. The Simbionix GI Mentor II.

Not much is known about the validation and use of mechanical models for basic training in upper GI endoscopy. Most models appear inappropriate for training as the level of competency gained by the trainee has been negligible [9]. The best known *ex vivo* model is the Erlangen Endo-Trainer [10]. The model is mostly appreciated for training bleeding situations and seems to offer a good training scenario. Validation studies or studies on learning curves are however few. These include three studies that used the 'GI Mentor' VR simulator, to evaluate the learning curve in simulator-based OGD training [11—13]. The main outcome measures in these studies were procedure time and time to reach specific landmarks such as passing the oesophagus and the pylorus and intubating the duodenum. Secondary outcomes were intubation time, movement techniques, procedural success rates and patient outcome such as pain and discomfort. All these studies have shown that simulator-trained participants, compared to controls, have a significantly lower overall procedure time and a significantly improved technical accuracy. The simulator-trained group also appears to operate more independently compared to the controls. The training with these simulators was of no benefit to experienced endoscopists [7,11—14].

The model has an added value in training novice endoscopists, but the effect of training overall seems to be limited. One study showed that the effect of simulation-based training was still visible after the first 60 endoscopic procedures as measured by a shorter procedure time, but not with regards to

neither the technical and diagnostic accuracy nor the patients' comfort levels [12]. Another important finding was that performance scores derived from the simulator, did not correlate with performance scores given by blinded experts [15,16]. These findings suggest that the virtual reality simulator training in OGD offers limited added value to patient-based training and only in the very early learning period [12,14,17–19].

Colonoscopy

The use of simulators in colonoscopy training has been extensively studied and remains a topic of ongoing research. Multiple studies have been performed in which mechanical, *ex vivo* and VR simulators have been validated for training colonoscopy [2]. The Kyoto Kagaku Colonoscope Training model is currently the only mechanical model that has been validated. Performance on this model has been shown to correlate well with the level of expertise of endoscopists as measured by caecal intubation in patient-based endoscopy [20]. A validation study using an *ex vivo* bovine colon model demonstrated good construct, expert and concurrent validity. A strong correlation was seen between performance on the model and outcome during patient-based colonoscopy, suggesting the potential of an effective tool for assessment of competency [21]. The most convincing evidence currently available in training

Fig. 2. The Olympus Endo TS-1 VR simulator.

colonoscopy is on VR simulators. Multiple validation studies have been performed, evaluating three different VR simulators; The Simbionix GI Mentor II (Fig. 1), the Olympus Endo TS-1 VR Simulator (Fig. 2) and the CAE Endo VR Simulator, formerly known as the AccuTouch Immersion Medical Computer Simulator [2,7,14,16,17,21—32]. All of these simulators appear to be valid for basic colonoscopy training. Training on VR colonoscopy simulators focusses mainly on intubation skills. There are hardly any data available on training withdrawal skills and mucosal inspection or therapeutic procedures like polypectomy. Most studies had a randomized design, comparing simulator-based training versus no training followed by routine patient-based training or comparing simulator-based training versus patient-based training followed by patient-based assessment [33—42]. It has been demonstrated that simulator training leads to improved performance compared to no training lasting up to the first 80 colonoscopies in humans and that simulator training compared to patient-based training results in equal performance in the early phase of learning. A recent study using the GI Mentor demonstrated increased performance during patient-based colonoscopy after prolonged training on the simulator. After an average of 60 simulator procedures the learning effect on the simulator itself ceased which coincided with observations in patient-based colonoscopy. This tells us that when the learning effect on the simulator stops, the same applies for the transfer to patient-based endoscopy and the time has come to continue training in a human setting. The simulator derived learning effect can probably be extended when the degree of realism of the simulator increases. This observation is a well-known concept in high fidelity aviation simulators [43]. Based on currently available evidence, the effectiveness of simulator-based training in speeding up the early learning curve, thereby reducing patient's burden has been well established. The use of simulators in colonoscopy is therefore strongly recommended prior to performing patient-based endoscopy. To get the most out of simulator training it seems to make sense to train up to the point where the learning effect on the simulator itself levels off. This provides the opportunity to offer tailored training programs to novice endoscopists and determine when to commence patient-based endoscopy on an individual basis.

Role of simulators in advanced endoscopy training

Endoscopic retrograde cholangiopancreatography

Endoscopic Retrograde Cholangiopancreatography (ERCP) is considered an advanced endoscopic procedure and, in most countries, is not part of the routine training of novice endoscopists. It is one of the most technically demanding and high-risk procedures in GI endoscopy. Serious life-threatening short-term and long-term complications may arise as a result of an ERCP procedure, including post-ERCP pancreatitis, bleeding and perforation. It requires a great deal of training and an extensive number of procedures to achieve competency. Nowadays diagnostic ERCP procedures are considered obsolete, meaning that all ERCP procedures are performed with a therapeutic intent. In order to minimize patient risk, trainees need to be properly trained both clinically as well as technically and exposed to high numbers of procedures under the guidance of experts before reaching a status of competency. Simulator-based training seems ideally suited as a training platform for this complex procedure before embarking on real life procedures. Surprisingly, there is very limited data available concerning endoscopic simulators in ERCP training. A total of 6 simulators have been described, including mechanical simulators, a model utilizing *ex vivo* porcine organs, the anesthetized pig model and computer models. Known mechanical simulators with a module for ERCP training include the X-Vision ERCP Training system and the ERCP Mechanical Simulator (EMS) [44,45]. These models are made out of aluminium, plastic and rubber components, with either a synthetic or *ex vivo* papilla and provide the possibility to train with real endoscopes and accessories. Selective bile duct or pancreatic duct cannulation can be practised with selective stent placement, balloon dilatation, brush cytology and, in some, sphincterotomy. Practising stone extraction has not been described in any of the models. Primary outcome parameters in studies evaluating the mechanical model are successful selective cannulation of the biliary duct and the time required to complete several procedures. Both models are able to distinguish between novice endoscopists and experienced endoscopists by means of expert assessment. After a short mechanical simulator training course a higher number of successful cannulation rates was seen in simulator-trained participants in patient-based ERCPs [45—48]. This

improved performance was only described for the first 25 consecutive procedures in humans as follow-up time was limited. Live anesthetized porcine models also have been used as a model for ERCP training. This model has been shown to be adaptable to all procedural aspects of ERCP including cannulation, stent placement and sphincterotomy. After a two-day hands-on training course participants showed an increase in confidence scores, especially in performing more complex procedures like needle-knife pre-cut sphincterotomy [49,50]. Puzzlingly, confidence in performing basic skills did not increase. The Erlangen Endo Trainer can also be equipped with an ERCP module, consisting of an *ex vivo* porcine stomach model with attached biliary system. It allows trainees to train with a real endoscope and accessories. The model has been extensively used in ERCP training workshops [51,52]. The Erlangen Endo Trainer, as well as the live animal model, scored high on realism and the model seems most useful in teaching basic ERCP skills [10,52]. The only validated VR endoscopy simulator in ERCP is the Simbionix GI Mentor II VR Simulator. The model is able to differentiate between novices and experts in time to complete procedures and time to reach the papilla; however the model received a low score for realism [53]. Recently, a study was performed using the CAE Endo VR Simulator. This simulator provides a platform for training in diagnostic procedures, however it seems not to be useful in measuring change in performance over time and assessing competency [54]. Sedlack et al. performed a comparison validation study including the Erlangen Endo Trainer, the live porcine model and the GI Mentor II. The study concluded that each model has the potential to be included in training programs; however the Erlangen Endo Trainer scored highest on indices of realism, usefulness and performance. The GI Mentor II scored significant lower at indices of realisms but is easier to incorporate in a training program [52]. The most common performance parameter in simulator-based training in ERCP is successful cannulation rate. This measure reflects only part of the complexity and diversity of this therapeutic procedure. A successful biliary cannulation is a prerequisite to complete a therapeutic procedure successfully but is not a good predictor for successful ERCP procedure. All of these simulators show definite training potential, but based on the scant scientific data available, a definite recommendation for a well-described training program cannot be provided.

Endoscopic ultrasound

Since the description of the first transgastric pancreatic pseudocyst drainage using a linear echo endoscope by Grimm et al., endosonography (EUS) has rapidly changed from a mere diagnostic tool to a technique with advanced therapeutic capabilities [55]. Notably, the advanced EUS therapeutic procedures have a marked overlap with ERCP and demand a great deal of expertise and experience. Although the need for highly skilled endoscopists is obvious, validated simulators or models for training are lacking. There are only a few reports on simulator-based training in EUS. A learning effect by repeated exercise and improvement of performance during EUS procedures in the live porcine model was demonstrated by Barthet et al. but no formal attempts at validation or transfer of competence to a patient-based setting have been made [56]. Advanced endoscopic resections such as endoscopic mucosal resection (EMR) and endoscopic submucosal dissection (ESD) are typically trained in a simulator-based setting using animal models. Both *ex vivo* and *in vivo* models are used. The *ex vivo* model is mostly used for training bleeding complications. These topics are discussed in a separate paragraph below.

Advanced therapeutic procedures

Simulator-based training has demonstrated its use in training the basic skills in GI endoscopy. However, as GI endoscopy is no longer a merely diagnostic procedure, this obviates the need for training an increasing diversity of advanced therapeutic procedures outside the standard clinical scenario. Unfortunately we must acknowledge that there is very limited evidence to support training of these procedures in a skillslab environment. Standard polypectomy or endoscopic mucosal resection (EMR) are perfect examples of techniques that currently cannot be trained in any of the models or VR simulators with a degree of resemblance that comes close to the real thing. A few studies using the Erlangen Endo Trainer have demonstrated a positive effect of simulator-based training for certain interventional skills like endoscopic haemostasis and perforation closure. Haemostasis was simulated

using several techniques and a significant improvement has been documented in performing successful injection or coagulation therapy [4,10,57]. The transfer of these skills to patient-based endoscopy and its impact in real-life practice is usually not described, so from a scientific point of view we cannot conclude that training in these models is useful. However, as these training scenarios closely resemble the clinical setting, using the same instruments, it seems common sense that training in these models will at least partially improve the skills necessary to apply these techniques.

Advanced endoscopic resections

Pre-malignant and early neoplastic lesions are commonly detected in clinical practice. Interventional endoscopy, namely endoscopic submucosal dissection (ESD) and complex endoscopic mucosal resection (EMR) have replaced surgery for the treatment of many of these conditions. EMR of large lesions can be technically demanding and allows for *en bloc* resection of lesions up to 20—25 mm. Lesions larger than this typically require piecemeal EMR which can complicate histological staging in some settings and can be considered a limitation regarding early cancers, depending on the location in the GI tract [58]. In these situations, ESD seems to be the resection technique of choice, but it is technically more challenging and has a more prolonged learning curve [59—62]. In the appropriate setting, ESD is comparable to surgery in terms of oncological outcomes, cancer free survival and recurrence, but with considerably lower costs, operative time, hospital stay, complication rates and mortality [63]. ESD had a widespread dissemination in Eastern countries but a relatively slow diffusion in Western countries due to its complexity, the requirement for considerable endoscopic skills, the high potential of serious adverse events and the difficulty in achieving adequate funding for these complex endoscopic procedures. A learning curve in performing successful ESD procedures has been demonstrated, and more experienced endoscopists have higher rate of *en bloc* resection, reduced procedure duration and fewer adverse events, mostly related to perforations [64,65]. Therefore, a pre-patient training program is recommended before ESD is performed in the clinical setting [64,66,67]. The differences between the East and West support the use of simulators for ESD training in the West, whereas in the East, where expert supervision and suitable learning cases are easily available, a simulator phase may not be necessary [68]. Pure mechanical simulators and VR simulators are not ideal when addressing advanced endoscopic resection training, due to the inability to reproduce the elasticity, tissue properties and tactile feedback of human tissue [69]. Workshops with animal models are being organized in many specialized training centres with the potential to aid in speeding up the learning process and achieve initial competence in ESD in a safe learning environment with direct one-on-one expert supervision. This is especially relevant where there are few adequate cases in clinical practice, and expert supervision is not readily available or hard to organize [70—72]. Simulation with explanted animal organs like the oesophagus, stomach and colon, facilitates the execution of therapeutic endoscopic procedures in a more realistic fashion with lower costs compared to mechanical simulators [73]. *Ex vivo* models have the advantage of being easy to assemble, more affordable and raising less ethical issues when compared to live animal models. On the other hand, the *ex vivo* model lacks a certain degree of realism due to its inability to bleed, although modifications can permit simulated blood flow and bleeding [64,73—75]. Harvested organs can be attached to insertion tubes or assembled in plastic models, thus oesophageal, gastric and colonic models are available [76—79]. The Erlangen Active Simulator for Interventional Endoscopy (EASIE) was the pioneer and is the best known model, in which explanted organs are mounted in a human shaped plastic torso [80]. It has been suggested that *ex vivo* models cannot substitute *in vivo* training to acquire competence in ESD because even fresh cadaveric animal tissue is stiffer and generally more robust than live human tissue which alters the ESD technique. It is advised that learners proceed to live animal models soon after acquiring adequate basic ESD skills on explanted organs [72,74]. Animal models, generally anesthetized pigs, have breathing movements, heart beats, peristalsis, intraluminal secretions, tissue reaction to injection and electrocautery, and abdominal distension which more closely resembles the human setting. It is possible to deal with adverse events, such as bleeding and perforation in a more realistic setup. Usually, the submucosal injection is more difficult compared to human cases, with a lesser degree of bleeding, and often more fibrosis. The orientation of various organs can be different and pathological scenarios are generally difficult to be reproduced [64,71,74,81]. The thickness and stiffness of the gastric porcine

mucosal layer appears to be different from the human stomach [82]. In fact, mucosal layer in this model is thinner in the proximal stomach and thicker in the distal area, particularly at the level of the greater curvature, where ESD is more challenging than in a similar human procedure. It has been suggested that the greater curvature, particularly the distal part of the porcine stomach is the least suitable place for ESD training [83]. Initial attempts ought to be in the gastric antrum and then progress can be made to more proximal regions of the stomach and other organs such as the oesophagus or colon [70,76,78]. Validity and clinical benefit of training ESD in this model and subsequent complication management has not been well established and is currently being investigated by our study group. Nevertheless, by training in the animal model it is possible to recognize a learning curve regarding procedure time, completeness of procedures and adverse events. A study demonstrated that the mean resection time was significantly decreased for porcine gastric ESDs in the second half of the study cases [71]. In another study, two novice endoscopists were able to decrease procedure times, perforation rate and achieve 100% *en bloc* resection after accomplishing 30 gastric ESDs in an *ex vivo* porcine model [77]. The rates of endoscopic closure for colorectal perforations by two non-experts increased from 40 to 60% in the first five cases compared to 100% in the last five procedures [75]. Lastly, four endoscopists without any ESD experience were able to perform uneventful human gastric ESD after training in *ex* and *in vivo* animal models, thereby demonstrating the transfer of skills to a patient-based setting [72]. Based on the few studies that are available on this subject, a minimum of 10–30 gastric ESD procedures in the animal model should be recommended before moving to human cases [77,84,85]. Performing ESD in the oesophagus is more demanding than gastric ESD. This is in part due to the thinner muscle layer and the tubular shape of the oesophagus which provides a limited space to work in [67]. It has been demonstrated that by training in *ex vivo* models for oesophageal ESD, endoscopists with experienced in gastric ESD, were able to reduce the operation time and the number of deep injuries to the muscularis propria after 10 procedures, when the five initial ESDs were compared to the final five [76]. Colorectal ESD is technically the most demanding. Difficult positioning and an increased risk for adverse events, mostly perforations, make it particularly challenging, even for the expert endoscopist. Training is therefore essential and animal models may play an essential role [74,86]. Live animal models for colorectal ESD are difficult to prepare as it requires adequate bowel preparation before attempting any procedure. For colorectal ESD training, porcine and bovine *ex vivo* models have demonstrated their feasibility [75,79]. In a study using an *ex vivo* model for colonic ESD, technical proficiency increased over 10 procedures. In the first two cases, incomplete resections and perforations occurred, whereas in the following cases procedure time decreased and no further adverse events occurred [78].

A glance at the future

Numerous simulators have been developed over the last decades. The aim of simulator-based training is to provide a platform for training in a specialized learning environment and the possibility to repeat procedures in order to gain competence before performing patient-based endoscopic procedures. Ideally, this reduces patient's burden and results in well-trained, well-prepared and to some extent competent endoscopists. Current simulators, whether (VR) simulators, *ex vivo* or *in vivo* models, are still lacking the degree of realism that would be necessary to achieve full competency at a level where certification could be applicable. The conclusion of a large overview of our current state is that simulators have proven their value in training novice endoscopists through their first steps in the world of flexible endoscopy. As well as at the far end of the spectrum, where they can be used to train a select group of experienced endoscopists in advanced endoscopic resection techniques. The large part in between seems to be void. The best example is the standard polypectomy training. A simulation-based scenario is not available for this kind of rather routine procedures, which however incur risks of adverse events and which is performed by virtually all endoscopists. Future research is needed to focus mainly on common therapeutic interventions such as polypectomy and EMR of sessile polyps up to 2 cm, stricture dilatation, stent placement and bleeding scenarios like variceal bleeds using rubber band ligation or endoscopic therapy for ulcer bleeds. Studies should focus on validating and improving the performance of the models, but also on the transfer of skills to patient-based settings, a step that is often omitted but that is in fact the only proof of concurrent validity. Another vast area in the broad arsenal of GI endoscopists includes ERCP and endosonography. Endosonography is no longer a

diagnostic procedure for the few where little harm is done but is widely practised with an increasing number of therapeutic possibilities. This makes EUS more complex. The therapeutic procedures have a particularly significant overlap with ERCP and demand a great deal of expertise. It seems that we have just touched the tip of the iceberg when it comes to simulation-based training for ERCP and EUS. This is in huge contrast with the fast developments in therapeutic indications and possibilities that these procedures offer. Models for ERCP training are already available but the full potential of these models have not yet been established, as well as their impact on clinical practice. Regarding EUS, data are even more scarce.

In a world where we are striving for more transparency in competency and procedural outcomes, simulation-based training is bound to have an increasingly important role. Certification and credentialing of simulator derived expertise would be the next logical step to ensure an optimal safety environment for everybody involved. The final stage of learning will always be to some extent patient-based. Our goal is that when this stage is reached we are dealing with trainees who have been well prepared by simulation-based scenarios.

Practice points

- The use of simulators in the early training setting accelerates the learning curve of basic endoscopy skills acquisition.
- Currently, both *ex vivo* and *in vivo* models provide the best platform to train advanced endoscopic procedures.
- There is no simulation-based training scenario available for common procedures like standard polypectomy.

Research agenda

- Development of a training platform for standard polypectomy and EMR of sessile polyps.
- Further development of simulation-based platforms for endosonography and ERCP and study of the transfer of simulator derived skills to patient-based endoscopy.
- Development of structured training programs with optimal use of simulator-based training.

Conflict of interest

None.

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