CONDENSATION

TWEETABLE STATEMENT

How to make a low-cost, high fidelity model to train for fetoscopic spina bifida repair. Fast, clean, and portable setup allows surgical training anytime, anywhere.

SHORT TITLE

Low-Cost High-Fidelity Model for Spina Bifida Repair

AJOG AT A GLANCE

A. Why was this study conducted?

- To reduce the need for training on animals and allowing surgeons to attain competency, we developed a high-fidelity synthetic model for training the neurosurgical steps of fetoscopic spina bifida repair.

B. What are the key findings?

- A synthetic training model, complete with detailed instructions for replication is now available.
- Skilled endoscopic fetal surgeons utilized the model for simulations and their measured competency was maintained.

C. What does this study add to what is already known?

- Animal-based and low-fidelity training models for fetoscopic spina bifida repair already exist.
- We developed a synthetic, reproducible, and low-cost high fidelity model.

ABSTRACT

BACKGROUND: Fetoscopic Spina Bifida repair (fSB-repair) is increasingly being practiced, but limited skill acquisition poses a barrier to widespread adoption. Extensive training in relevant models, including both *ex*- and *in-vivo* models may help. To address this, a synthetic training model that is affordable, realistic and allows skill analysis would be useful.

OBJECTIVE: To create a high-fidelity model for training the essential neurosurgical steps of fetoscopic spina bifida repair using synthetic materials. Additionally, we aimed to obtain a cheap and easily reproducible model.

STUDY DESIGN: We developed a three-layered silicon-based model resembling the anatomical layers of a typical myelomeningocele lesion. It allows for filling the cyst with fluid and conducting a water tightness test post-repair. A compliant silicon ball mimics the uterine cavity, and is fixed to a solid 3D printed base. The fetal back with the lesion (single-use) is placed inside the uterine ball, which is reusable and repairable to allow practicing port insertion and fixation multiple times. Following cannula insertion, the uterus is insufflated, and clinical fetoscopic, robotic or prototype instruments can be used. Three skilled endoscopic surgeons each did six simulated fetoscopic repairs following the surgical steps of an open repair. The primary outcome was surgical success, based on water tightness of the repair, operation time <180 minutes and an Objective-Structured-Assessment-of-Technical-Skills (OSATS)-score of ≥ 18/25. Skill retention was measured using a competence commulative sum (C-CUSUM) analysis on composite binary outcome for surgical success. Secondary outcomes were cost and fabrication time of the model.

RESULTS: We made a model for simulating spina bifida repair neurosurgical steps with anatomical details, port insertion, placode release and descent, undermining of skin and muscular layer, and endoscopic suturing. The model is made with reusable 3D-printed molds with easily accessible materials. The one-time startup cost was 211€, and each single-use simulated MMC-lesion costs 9.5€ in materials and 50 min working hours. Two skilled endoscopic surgeons performed six simulated three-port fetoscopic repairs, while a third used a Da-Vinci surgical robot. Operation times decreased over 30% from the first to last trial. Six experiments per surgeon did not show an obvious OSATS-score improvement. C-CUSUM analysis confirmed competency for each surgeon.

CONCLUSION: This high-fidelity low-cost spina bifida model allows simulated dissection and closure of a myelomeningocele lesion.

INTRODUCTION

Spina bifida aperta (SBA) is caused by incomplete neural tube closure during embryonic development, leading to bladder and bowel dysfunction, motor and sensory impairment, skeletal abnormalities, hindbrain herniation, ventricle enlargement, and cognitive impairments. Prenatal repair has been explored to address SBA's progressive nature[1]. There is level-1 evidence that, in selected fetuses, prenatal repair reduces the need for ventriculoperitoneal shunt placement, improves independent walking, volatile voiding, motoric function and independent functioning[2–5,]. These data were obtained in fetuses operated through a hysterotomy, which increases the risk of premature birth, uterine dehiscence, and uterine rupture in the index or subsequent pregnancies[6]. To mitigate these risks, less invasive techniques, e.g. mini-hysterotomy or minimally invasive approach have been investigated[7–9]. While these alternative techniques are gaining acceptance[10], there are still debates regarding percutaneous or uterine exteriorization for fetoscopic repair[11–13]. It is also noted that the learning curve of fetoscopic repair seems to be twice as long[14].

Transitioning to an endoscopic approach requires a training program, that in turn necessitates a surgical training model. Typically, (endoscopic) surgical training first starts on computer simulators or synthetic models (benchtop/box trainers) due to their low cost as compared to animals or human cadavers, which also have ethical constraints and logistical challenges[15]. Creating realistic synthetic models would simplify training logistics, reduce or even obviate the need for animal training, and ensure competency before clinical practice. For fetoscopic spina bifida repair, several in-vivo high-fidelity models including rabbits[16], sheep[17] and rhesus monkeys[18] have been proposed. Three synthetic trainers have been reported, of which two are referred to as low-fidelity [19,20] and one as high fidelity [21], although limited data on their use were reported. Herein, we aimed to develop a low-cost, high-fidelity synthetic model capable of simulating all neurosurgical steps of a fetoscopic repair of a cystic "myelomeningocele" lesion, i.e. placode release, skin excision, undermining the skin and muscle, and closing the myofascial and skin layers. Additionally, we used the model to obtain baseline data from experienced endoscopic surgeons performing simulated repairs.

MATERIALS AND METHODS

Model description

The model consists of 2 parts, (1) a single-use silicon replica of the fetal back with a cystic lesion in the center and (2) a uterine cavity represented by a silicon ball tightly clamped to a 3D printed reusable plastic base. The replica mimics clinical conditions present between 24 and 26 weeks dimensionally[22] ,with the lumbar region being the primary focus in 95% of cases and around half of the lesions being cystic[23]. The lesion measures 30x50 mm and has three layers of soft silicone (Figure 1(a)). The silicon used for the layers is EcoFlex 00-30 (Smooth-On, Macungie, PA) and the molds were 3D printed using fused deposition modeling (FDM) printers (Prusa I3 MK3S) and polylactic acid (PLA) filament. The 3D printing was outsourced to a local fabrication lab (Fablab). The top layer (layer-3) represents the skin with a cystic bulge and a placode (yellow pigmented region) measuring 20x10 mm[24]. The cystic bulge is reinforced with a gauze mesh to prevent tearing when suturing. The middle layer (pigmented red) represents the fascia with a small midline spinal defect just below the placode. Cotton threads (yellow) are connected to the placode and inserted through the midline defect to exit between the simulated fascia and the base silicone layer through two holes. This allows one to pull on the threads once the placode has been freed, mimicking its descent into the spinal canal. These threads also represent the nerves originating from the placode, so surgeons must avoid touching or cutting these as well as the placode. The structures to the sides of the midline defect represent the muscle flaps that are typically closed over the placode after undermining. The bottom layer forms a water-tight cystic cavity. Layers are joined together using EcoFlex Gel (Smooth-On, Macungie, PA) pigmented (Silc-pig™) with the color of blood, allowing separation similar to anatomical layers (Supplementary video 1). A small tube between the base and middle layer serves as an inlet to fill the cyst with water and assess water tightness post-repair. The replica of the fetal back and the silicone ball are mounted on a solid 3D-printed base (Figure 1, Video 1).

The 3D printed plastic base is clamped to a surgical bed or table. A curved two centimeter high soft silicon pad mimicking the lower back curvature, is placed over the base and under the cystic lesion. A threaded plastic ring clamps the silicon cyst plate to the base, and the silicon ball is placed tightly over the ring. This creates an air-tight seal for CO_2 insufflation. This air-tight simulated uterine cavity can also be filled with water to simulate amniotic fluid and allow for ultrasound imaging.

Table 2 presents one-time costs of molds, parts, engineering hours and production time associated with creating the model. Video 2 provides detailed instructions regarding the manufacturing of the synthetic model, while video 1 shows the installation instructions and surgical steps during endoscopic repair.

Simulated surgical procedure

The model is positioned on the operating table, and three ports are placed away from the placenta. Although possible, ultrasound guidance for port placement is not included in the exercise as our focus is on dry-lab and desktop training of neurosurgical steps. Surgeon may choose the distance between ports and their location, based on their preferred approach developed during training. During the procedure, an assistant holds the fetoscope and camera, while the surgeon handles the instruments. With the Da Vinci robot (Intuitive, Sunnyvale, CA), no camera assistant is required.

Belfort et al. divided the surgical procedure in ten consecutive steps, of which only port insertion and insufflation (step 2-3) and the neurosurgical steps (4 to 10)[25] are simulated herein (detailed in Table 1 and depicted in Figure 2). The repair is divided into five tasks: placode untethering and removal of excessive skin, skin undermining, fascia mobilization, fascia closure and skin closure. The goal is to achieve a water-tight closure over the released placode[26]. Surgeon may choose preferred sequence of surgical steps. The simulation may also include insertion of a dural patch prior to fascia closure, or even to close the skin defect. Unfortunately we have not yet made a cheap replica of the patches used to substitute for the expensive clinically used materials. Operation time of each step is noted, and a leak test is performed by attaching an open syringe filled with water to the infusion tube and raising to 35cm above the placode level to simulate the cerebrospinal fluid pressure[27].

Surgeon, performance and fidelity scoring.

We used this set up with three experienced endoscopic surgeons, routinely performing pediatric or gynecologic surgery. All simulations were recorded and reviewed by an endoscopic surgeon (FDB, blinded to the surgeon and sequence of trials) for time use and OSATS scoring[28].The OSATS scoring assessed criteria such as: tissue respect (minimal damage to the placode and nerves), time and motion, instrument handling and knowledge, and overall operation flow (Figure 3)[12,26]. As model's construct validity assessment, a composite binary outcome for surgical success, i.e. watertight repair[6], an repair time ≤180 minutes in accordance with the FDA Drug Safety Communication about potential risks of general anesthesia in pregnant women[29] and an OSATS score ≥18/25 (>70%)[12,26] was calculated and used for the C-CUSUM analysis[16].

Surgeons completed a questionnaire using a 5-item Likert-scale to asses model's realism (face validity), utility (content validity), acceptability, and educational effect. Fidelity scale (Low-medium-high) of a surgical simulator is not very well defined, and may depend on its likeness towards the functional requirements of the clinical task rather than its educational value[30–32]. Experience of the trainee (expert vs. novice) may also affect the perceived fidelity of a model[33]. Tun et. al argue that high-fidelity does not require a faithful replication of the reality but rather an accurate representation of real-world cues and stimuli[34]. Based on requiring replication of the clinical scenario (cystic defect and its repair) itself, we define our model as high-fidelity if the face and content validity scores are rated ≥4/5, medium-fidelity if =3/5 and low-fidelity of ≤2/5 on average.

RESULTS

We created a low-cost synthetic surgical training model with detailed reproduction instructions (supplementary video 2). Initial material cost for reusable parts and molds is 211€ (table 2). The single-use replica of the cystic spina bifida lesion and fetal back costs 9.5€ and takes 50 min to make.

The uterus can be reused by repairing cannula insertion sites (supplementary video 2) in 5 min and negligible costs. The model has a quick 5 min setup time. It's a clean and portable desktop trainer made of synthetic materials. The base can be mounted on any flat table or adjustable surgical beds, allowing versatile positioning. It enables port insertion, simulates neurosurgical steps, placode release and descent, undermining of skin and muscle layer, and endoscopic suturing. The model displays anatomical details in color with realistic compliance properties (supplementary video 1).

After their six simulations, all surgeons rated the model's realism (face validity) positively in all categories (uterine ball and lesion position, surgical tools, surgeon and assistant positioning), with scores ≥4/5. One surgeon rated fetoscopic vision realism as =3/5. Content validity scores for all categories (realism and educational value of each surgical step, self-assessment) were also ≥4/5. The difficulty and stress of a clinical case received scores ≤3/5 from all surgeons. Based on this user feedback, we can confidently assert that the model demonstrates high fidelity in terms of both face and content validity.

Figure 3 shows results from six training sessions by three skilled endoscopic surgeons. Despite the low number of simulations, there was a significant reduction in operation time with increasing experience, both in laparoscopy and robotics. On average, task completion time decreased by over 30%, with one surgeon achieving a 50% reduction. This improvement was not specific to certain steps but overall. Interestingly, robotic experiments used significantly less CO_2 volume ($p<0.001$). All three surgeons remained proficient based on C-CUSUM analysis ($hC<3$). However, with eight failed exercises out of eighteen (Video 1), further practice on the model is needed. OSATS scores indicated "tissue respect" as an important aspect, with scores below 18 coinciding with low "tissue respect" scores (n=7). Robotic procedures excelled in "instrument handling" but scored low in "tissue respect", seen through suture breakage in initial trials (Video 1).

COMMENT

Principal findings

For fetoscopic myelomeningocele repair, we developed a low-cost synthetic training model, capable of simulating crucial surgical steps such as placode dissection, removal of excess skin, undermining of skin and muscle flap, layer closure, and objective water tightness testing. Experienced endoscopic surgeons ranked the model as “high fidelity”[34]. Although quite experienced with operative laparoscopy, the operation time of these surgeons progressively diminished. However, neurosurgical “failures” still occurred. Interestingly, the CO_2 volume used was significantly less for multi-arm robotic exercises, as well as instrument handling scored higher within the OSATS score. Conversely the surgeon broke a few sutures, which may be attributed to lack of haptic feedback and to which the surgeon eventually adapts.

Results in context of what is known

Animal models are often used for training in spina bifida due to their high fidelity, but they have limitations. For instance, the lamb spina bifida model[17] lacks tissue required for primary repair and can be expensive and logistically difficult to work with. Low-fidelity models, such as the one described by Belfort[35], lacks the multiple layers required to simulate the clinical procedure and is not suitable for dry-lab experiments. The Miller model[19] can be used with a silicon skin but only allows closure of the skin layer. The Surgical Touch[36] model also lacks the multi-layered defect and is relatively more expensive. To our knowledge no evaluation of these models is available. Spoor *et al.*[21] proposed a high-fidelity synthetic model, with features that allow for a layered repair and a model of the uterus. The report however lacks details on reproduction, neither data on its use by surgeons. In this study, we present a synthetic multi-layer model of the region of interest in a fetus with spina bifida, which is easy to use and produce as well as low-cost. Experienced surgeons can use it to improve confidence, shorten operation times, achieve watertight closure, and facilitate skill development for novices or new team members. Our aim is to provide a realistic alternative to animal models and promote ethical and sustainable surgical skill development.

Clinical implications

For complex and delicate procedures such as fetoscopic spina bifida repair, surgeons should optimally prepare, logically first in a simulated environment. Neurosurgeons are quite familiar with the open fetal repair which is similar to the postnatal repair. On the other hand, fetoscopy introduces new challenges such as lack of depth perception, constrained tissue handling and suturing which can be simulated using our model. Study of the learning curve of clinical spina bifida repair has shown that experience reduces operation time even in experience endoscopic surgeons, and that training for fetoscopic repair takes longer. Pre-operative practice/rehearsal has been shown to reduce operation time [19,37], port placement, team building, and standardization of the technique. Our model is an addition to the available tools, that concentrates on the neurosurgical steps, which are more complex when the repair is done by fetoscopy.

To ensure the acquisition of correct surgical technique and get appropriate advice, it seems logical that any training is proctored by a surgeon familiar with this clinical procedure.

Research implications

Three experienced laparoscopic surgeons participated in our simulation and demonstrated reasonable competency in transferring their endoscopic skills. Further studies can explore skill improvement and the acquisition and retention of skills for novice endoscopic surgeons.

The model's logistical and ethical advantages make it possible to investigate complex research questions without relying heavily on animal experiments. This training model has the potential to aid in the development of new surgical instruments and facilitate comparisons of techniques, including robotic surgery. Our immediate goal is to compare the performance of robotic systems to straight stick laparoscopy, especially for neurosurgeons without laparoscopy training. Previous studies have shown that non-endoscopic surgeons learn robotic surgery faster than straight stick laparoscopy[38]. We also aim to utilize the model for training robotic repair to mitigate the lack of haptic feedback. Additionally, we plan to evaluate stereo versus monocular fetoscopy and explore the use of single-port surgical robotics [39, 40]. While a robotic approach may already reduce stresses on the uterine walls due to the remote center of motion, the use of a single (as opposed to multiple ports) robot may reduce that even further [41]. Data generated from experiments can contribute to extensive datasets for deep learning algorithms, including tool segmentation [42], skill analysis [43], and anomaly detection [44]. The model's clean, fast, and portable setup enables training and demonstrations at conferences, facilitating knowledge dissemination and advancing surgical research.

Strengths and limitations

The synthetic model is ideal for desktop dry-lab training due to its easy setup and quick preparation. It can be securely mounted on any surface using a clamp, and the adjustable surgical beds allow for versatile orientations. The model is cost-effective and ethically sound. Its portable design facilitates use in multi-centric trainings and knowledge sharing. The model further facilitates joint training of surgeons and their team leading to effective teamwork, coordination, and communication. Additionally, the model has the potential for water filling, enabling ultrasound scanning and guided port insertion. Manufacturing the model is straightforward with a 3D printer, allowing customization based on patient-specific needs.

However, it's important to note that the synthetic silicone material cannot perfectly replicate the fragility and fidelity of fetal structures. The model also lacks specific procedural steps like ultrasound assessment to assist in entry point determination and fetal positioning, appropriate cannula insertions, fetal membranes fixation, compromised vision due to in-utero humidity, an additional abdominal cavity, and suturing of fetal membranes at the end of the procedure. Also the model was evaluated by three expert surgeons. However, to establish it’s generalizability, it is imperative to conduct further testing with surgeons of varying levels of experience. Lastly, the manufacturing process may be time-consuming (50 min per model), but efficiency can be enhanced by producing models in batches.

CONCLUSIONS

We have created a synthetic high-fidelity and low-cost model that is capable of mimicking the neurosurgical steps fetoscopic spina bifida repair. We report on its use by three experienced laparoscopic surgeons using either straight stick or robot-assisted (Da Vinci Xi) instruments. We propose its further use for measuring the learning curve of novices and the retention of operative skills.

Author’s Contributions

Mirza A. Ahmad: Conceptualization, Methodology, Formal analysis, Data curation, Model creation, Writing – Original draft. **Luc Joyeux:** Conceptualization, Methodology, Writing – Original draft. **Kanokwaroon Watananirun:** Fetoscopy assistance. **Felix De Bie:** OSATS scoring. **Ann-Sophie Page:** Expert surgeon, Writing – Review & editing. **Paolo De Coppi:** Expert surgeon, Writing

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Acknowledgements

J Deprest is funded by the Great Ormond Street Charity fund.

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TABLES

Table 1: Comparison of 10 steps in a clinical spina bifida fetoscopic repair as described by Belfort *et al.* [12] and a simulated fetoscopic repair in the silicon model.

	Surgical steps	Clinical fetoscopic repair	Simulated fetoscopic repair
1	Uterine exposition	Exteriorization, exposition and keeping the uterus moistened	Not simulated. Uterus is mimicked by a silicon ball.
2	Uterine access	Transmyometrial membrane fixation, cannulated uterine access via Seldinger-technique under ultrasound guidance	Incisions are made in the silicon ball, ports are inserted and sutured to the silicon.
3	Creating workspace	CO_2 pneumamnion	Air-tight seal allows the silicon ball to be pressurized/insufflated by CO_2.
4	Exposition of target area	Fetal manipulation by instruments to provide access to the lumbar region	Target area is present in form of a cyst on the removable silicon plate. The cyst is filled with water to mimic presence of CSF.
5	Dissection	Dissection of the placode to completely untether it.	Dissection of the placode to completely untether it. Access skin around placode is removed.
6	Tissue resection and undermining	Circumferential resection of the junction line and undermining of the skin.	Circumferential undermining of the mid-line feature (oval gap in layer-2).
7	Tissue mobilization	Approximation of lumbar skin edges	Pulling of the undermined flaps of layer-2 over the placode and approximating them in the middle.
8	Closure of the first layer	Dissection and suturing of myo-fascial flaps with/without patch	Suturing the layer-2 flaps.
9	Closure of the second layer	Fetal skin closure with running sutures.	Circumferential undermining of the skin (layer-3) and closure with running sutures.
10	Quality assessment of the repair	Quality assessment of the skin suture line by inspection and adjustment.	Inspection of the suture line and closure quality by water tightness test.

Table 2: Cost of the spina bifida training model. The cost for 3D printed parts depends on the local 3D printing service provider (0.1€/g for this study). All the Computer-Aided Design (CAD)-files (*.stl* format) are provided as supplementary material for 3D printing, which saves engineering costs. As the cost of working hours vary from place to place, only time use is reported.

Initial one-time cost:		
Part	Source	Cost (€)
Base	*base.stl,* 3D print PLA (207g)	20.7
Uterine ring	*ring.stl,* 3D print PLA (126g)	12.6
Silicon hump mold	*hump.stl,* 3D print PLA (87g)	8.7
Skin mold top	*skin_top.stl*, 3D print PLA (40g)	4
Skin mold bottom	*skin_bottom.stl*, 3D print PLA (80g)	8
Fascia mold	*fascia.stl*, 3D print PLA (65g)	6.5
Layer_1 mold	*layer_1.stl*, 3D print PLA (60g)	6
Cyst template	*template.stl*, 3D print PLA (4g)	0.4
Uterine ball mold inner shell	*uterine_ball_inner.stl, 3D print PLA, (340g)*	34
Uterine ball mold outer shell	*uterine_ball_outer.stl, 3D print PLA, (4x115g)*	46
Quick release clamp	Hardware store	3
Hose clamp	Hardware store	5
Uterine ball	Ecoflex 00-30 Silicon, 300g	~17.2
Silicon hump	Ecoflex 00-30 Silicon, 120g	~6.9
Silicon pigments	Smooth-on SilPig, 9 sample pack	31
Gauze	Kompres Medi S30 Gauze, 7.5x7.5	1
Total		**211**
Cost of one removable model of a myelomeningocele lesion:		

Layer_1	Ecoflex 00-30 Silicon, 35g	2
Fascia	Ecoflex 00-30 Silicon, 40g	2.3
Skin	Ecoflex 00-30 Silicon, 40g	2.3
Gel	Ecoflex Gel, ~8g	~0.44
Infuser tube	Braun Perfusor Line, 0.9MMx150CM, PE	2.5 (recyclable)
Time	0.8 hours	N.R.
Total		**22**
One time engineering and design cost incurred by the authors		**400 wage hours + 1000 euros in materials**

FIGURES

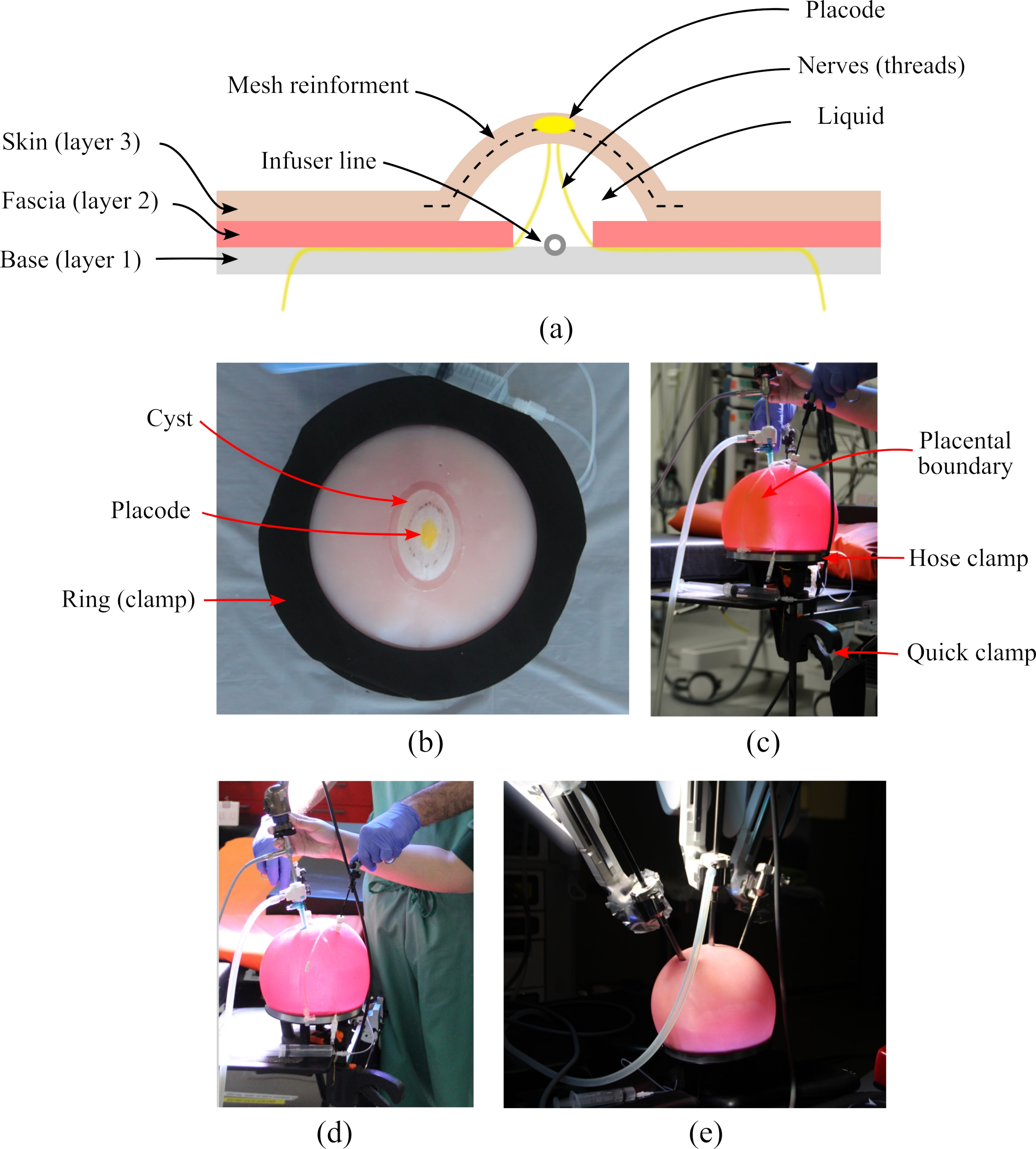
Figure 1: Setup for the model for simulated fetoscopic spina bifida repair. (a) Cross-sectional view of the three-layer single-use myelomeningocele (MMC) lesion, (b) the 3D-printed ring clamps the model of the lesion to the 3D-printed base, (c) silicon ball, mimicking the exposed uterus, is placed around the threaded ring and clamped to it by a hose clamp, creating an air-tight simulated uterine environment. The base is fixed to a surgical bed using a quick release clamp. (d) Set up during the exercise with ports for right and left hand instruments and fetoscope inserted, (e) Set up during the robot assisted repair exercise with instrument ports in place.

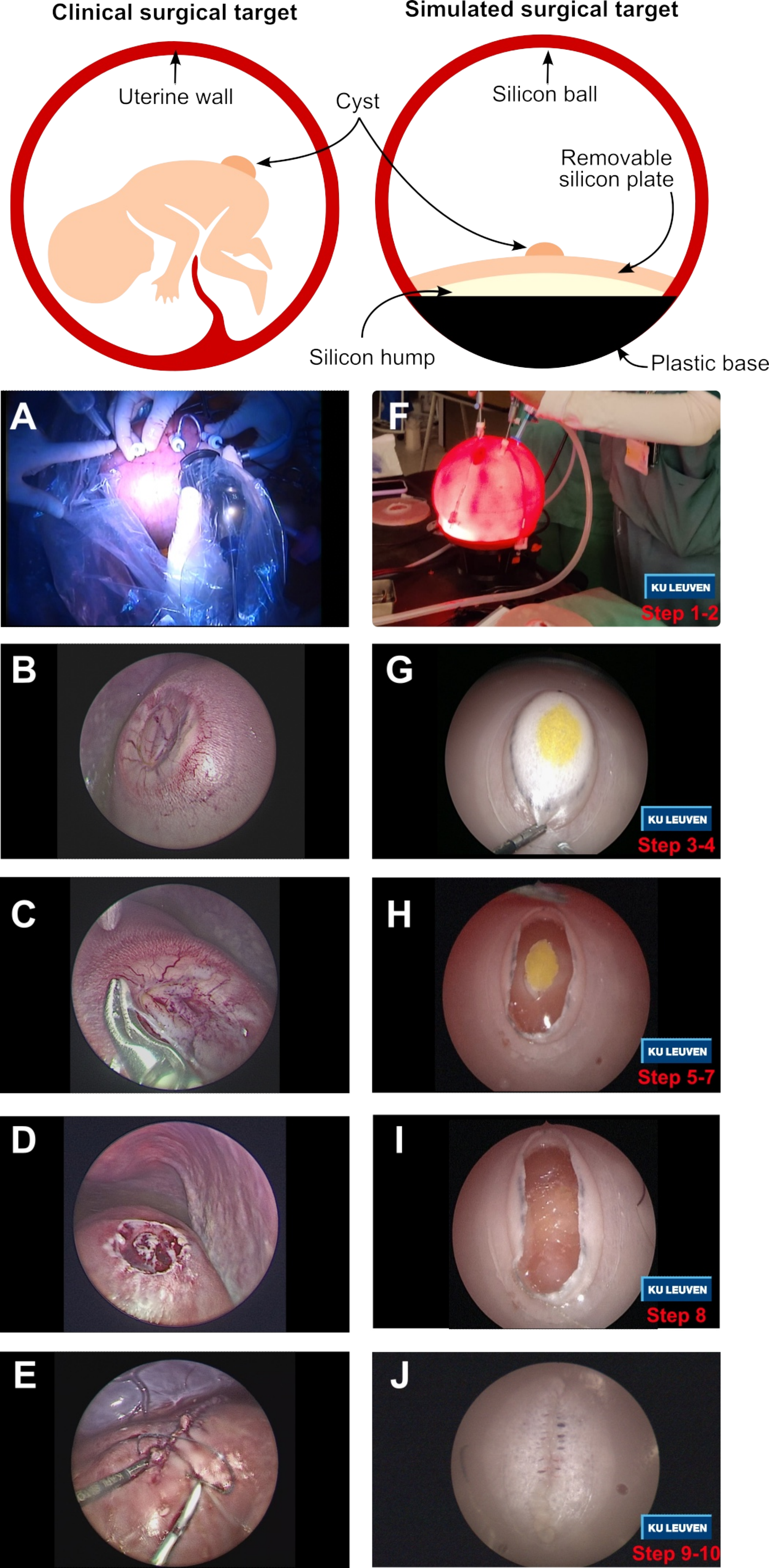
Figure 2: Comparison of essential steps performed during a clinical (A-E) and a simulated fetoscopic spina bifida repair in the silicon model (F-J).

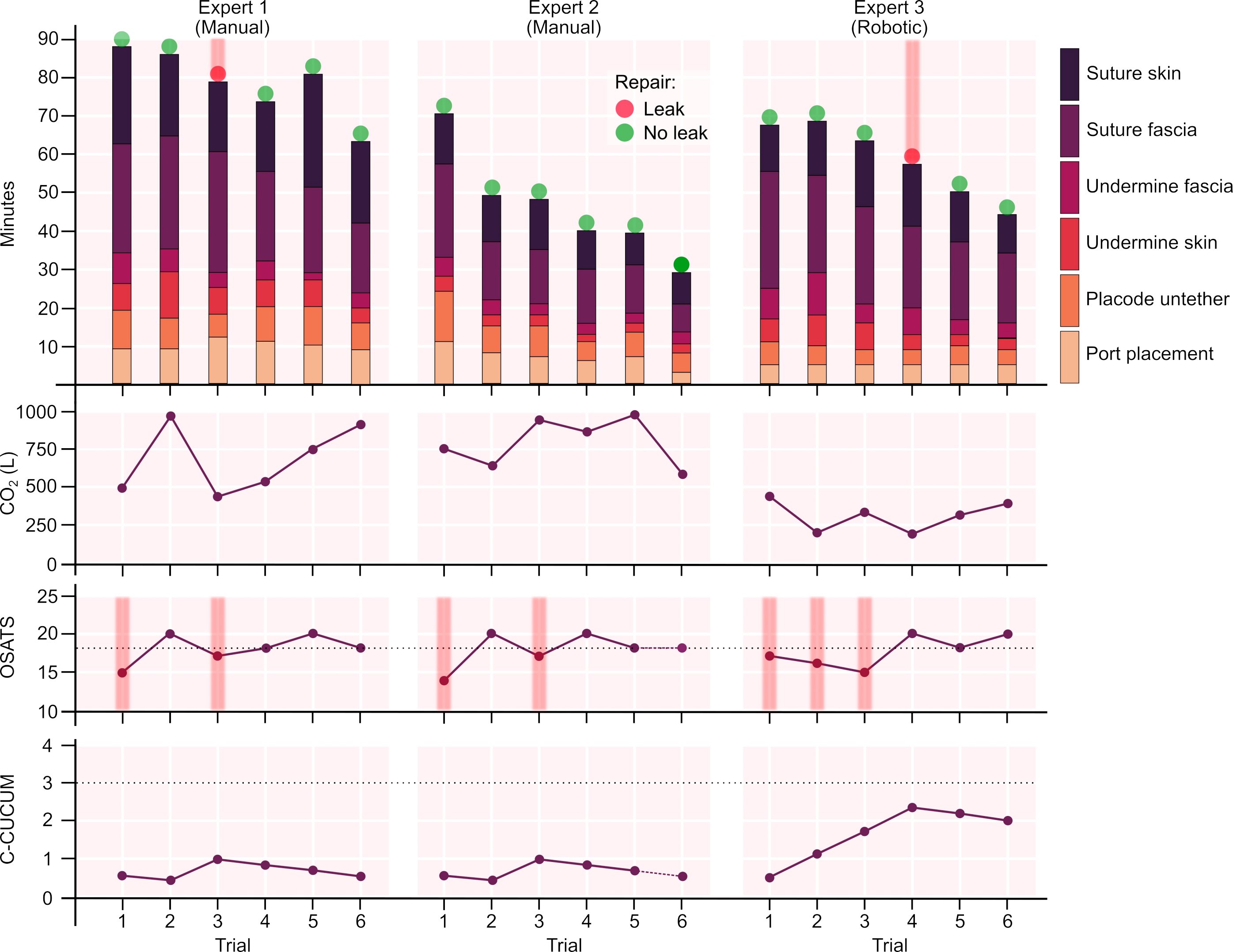
Figure 3: First row displays the time taken by each surgeon for the surgical steps, as well as the total time. On top of each bar the colored circle indicates whether there is leakage (red) or not (green). The second row displays the CO_2 used during the entire exercise. The third row plots the objective structured assessment of technical skill (OSATS) scores as given by an independent surgeon blinded to the operator and the sequence. The dotted line (score: 18) represents the cut off. The last row displays the competitive CUSUM analysis scores. The dotted line represents the competitive control limit (h_C = 3), staying below this line indicates surgeon's competency. Red bars are indicative of surgical failure of the trial in the given category.

Video 1: The installation setup of the synthetic spina bifida repair model. Fetoscopic view of a 3-port manual repair and a robot assisted repair using a Da Vinci Xi.

Video 2: Fabrication tutorial of the synthetic spina bifida repair model.


Placode
Nerves (threads)
Mesh reinforment
Liquid
Skin (layer 3)
Infuser line
Fascia (layer 2)
Base (layer 1)
(a)
Cyst
Placode
Ring (clamp)
Placental boundary
Hose clamp
Quick clamp
(b)
(c)
(d)
(e)


Clinical surgical target
Simulated surgical target
Uterine wall
Cyst
Silicon ball
Removable
silicon plate
Silicon hump
Plastic base
A
B
C
D
E
F
KU LEUVEN
Step 1-2
G
KU LEUVEN
Step 3-4
H
KU LEUVEN
Step 5-7
I
KU LEUVEN
Step 8
J
KU LEUVEN
Step 9-10



Expert 1 (Manual)
Expert 2 (Manual)
Expert 3 (Robotic)
Repair:
Leak
No leak
Suture skin
Suture fascia
Undermine fascia
Undermine skin
Placode untether
Port placement
Minutes
CO2 (L)
OSATS
C-CUCUM
Trial
Trial
Trial