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The Complementary Roles of Live Porcine and Soft-Preserved Human Body Donors in Laparoscopic Colon Resection Training for General Surgery Residents

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Research Article

Keywords:

Posted Date: September 30th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10906777/v1

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Abstract

Purpose: To compare the educational utility of live porcine and Imperial College of London Soft-Preserved (ICL-SP) human body donor models for laparoscopic colon resection training in general surgery residents.

Methods: A single-institution, mixed-methods educational study was conducted within the general surgery procedural skills curriculum at a tertiary academic medical center. Resident experiences with the models were assessed via anonymous Likert-based questionnaires, and faculty perspectives were captured through semi-structured interviews following completion of both simulation sessions.

Results: Residents more frequently reported improved anatomical knowledge after ICL-SP exposure than after porcine exposure (82.4% vs 35.3%, $p<0.001$; Cohen's $d=1.14$). Confidence identifying key operative structures, including the retroperitoneum (82.4% vs 35.3%), ureters (82.4% vs 23.5%), and mesentery (76.5% vs 41.2%), was more consistently improved after ICL-SP exposure. In contrast, the porcine model was rated superior for tissue elasticity (58.8%) and arterial/venous structural integrity (52.9%). Senior residents favored ICL-SP over porcine models (mean benefit 4.05 vs 2.83), whereas junior residents rated both models similarly. Faculty unanimously described the ICL-SP donor as more anatomically representative of live human operative conditions, while recognizing the porcine model's advantages for active tissue physiology.

Conclusions: Live porcine and ICL-SP human body donor models appear to serve complementary rather than interchangeable roles in laparoscopic colon resection training. Integration of both models within surgical residency curricula, aligned with trainee experience level, may optimize procedural education across stages of training.

Introduction

Simulation-based training has become an essential component of modern surgical education as operative exposure is constrained by work-hour limitations, increasing procedural complexity, and heightened expectations for patient safety. The traditional apprenticeship model remains foundational, but it is no longer sufficient as the sole pathway for procedural skill acquisition. As operative exposure during residency becomes more constrained, simulation platforms that closely approximate live surgical conditions have assumed a correspondingly greater role in postgraduate training [1–3]. Cadaveric simulation in particular, has assumed an important role in postgraduate surgical education. However, while increasingly prevalent, the literature on body donor-based simulation has yet to definitively link these simulations to retained skills and improvement in the operating room [4].

For resident education, the value of a simulation platform depends not only on fidelity, but also on the ability to support repeated exposure over time. Procedural skills are acquired through deliberate practice, observation, feedback, and repetition, making access to simulation outside the operating room particularly important in contemporary training environments [1, 2]. Cadaveric simulation has therefore become increasingly attractive, and preservation methods that maintain tissue realism while permitting reuse may offer additional utility for longitudinal surgical curricula [4]. In contrast, live porcine models are widely used in surgical training because they provide tissue perfusion, vascular responsiveness, live bleeding, and realistic tissue handling [7–9]. This distinction between models is especially relevant for laparoscopic colon resection, where species-specific

differences in colonic configuration and plane-specific relationships may limit the porcine model's usefulness as an anatomic teaching platform [7].

Human body donors address the problem of anatomic fidelity, but their educational utility depends heavily on preservation methods. Fresh-frozen cadavers most closely replicate living tissue, yet they require freezer capabilities, deteriorate rapidly after thawing, and carry infectious and logistical burdens that can limit repeated use [10, 11]. Formalin-fixed cadavers are durable and relatively inexpensive, but do not accurately reflect native tissue morphology, phenotypic appearance, or realistic tissue properties for procedural simulation. Soft-preservation techniques attempt to bridge this gap by preserving more natural tissue flexibility and handling, while allowing greater reuse than fresh tissue [10]. Among soft-preservation methods, the Imperial College of London Soft-Preservation (ICL-SP) technique has attracted growing interest. Comparative embalming studies suggest that ICL-SP better preserves joint range of motion than formalin and may provide tissue characteristics comparable to or better than Thiel preservation for certain surgical training applications [12, 13]. More recently, residents have been shown to prefer soft-preserved donor models over formalin-fixed donors for anatomy learning [14, 15]. Despite this growing literature published data on ICL-SP in general surgery resident education remains limited.

Accordingly, the purpose of the current study was to compare live porcine and ICL-SP human body donor models for laparoscopic colon resection training in general surgery residents, with respect to anatomical knowledge acquisition, confidence identifying key operative structures, simulation realism, and perceived educational value. We hypothesize that the ICL-SP model would be favored for human anatomic fidelity, while the porcine model would retain advantages for life-tissue characteristics.

Materials/Methods

This research study was carried out following receipts of approval from the Institutional Review Board (IRB) # 2021E1010. Donors premortem signed written consent for use of their bodies for education and research.

The use of animals was reviewed and approved by the Institutional Animal Care and Use Committee (IACUC). The procedures for porcine anesthesia and euthanasia followed and met the requirements outlined by the Animal Welfare Act and Regulations, the PHS Policy, and the Guide for the Care and Use of Laboratory Animals. Euthanasia followed the AVMA Guidelines for the Euthanasia of Animals (2020 Edition). In order to meet regulations, the same commercially available agents used in veterinary and human hospitals were used in the form of pharmaceutical- grade compounds for anesthesia and analgesia.

Study Design

A single-institution, mixed-methods educational study was conducted within the general surgery procedural skills curriculum at tertiary academic medical center. The study incorporated anonymous quantitative post-session resident questionnaires and semi-structured qualitative interviews with faculty instructors. Residents were classified as junior (PGY-2/3) or senior (PGY-4/5) level residents. Among residents, six were PGY-2, five were PGY-3, 5 were PGY-4, and one was PGY-5. All included residents completed both porcine and human body donor simulation sessions, as well as the post-session questionnaires.

Participants were identified from the current enrollment of the general surgery residency program at the tertiary academic medical center. Participation was not separately recruited, as the laparoscopic colon resection skills laboratory was an established component of the procedural skills curriculum, and faculty participation represented a routine teaching responsibility within the residency program.

Simulation Models

Three human body donors were prepared using the Imperial College London Soft-Preservation protocol for alcohol-based preservation [12]. Six porcine models were used under anesthesia for live animal-training in accordance following the Animal Welfare Act and Regulations, the PHS Policy, and the Guide for the Care and Use of Laboratory Animals found on the IACUC website.

Skills Laboratory Structure

Two laparoscopic colon resection skills sessions were conducted using a crossover design. In the first session, half of the participants began on the ICL-SP donor model and half began on the porcine model; in the second session, participants crossed over to the alternate model. At each session, residents first reviewed the relevant anatomy and operative steps with faculty, then performed abdominal entry, gastrointestinal dissection, and identification of key surgical landmarks relevant to laparoscopic colon resection.

Data Collection

At the conclusion of the second procedural skills lab session, residents completed anonymous Likert-based questionnaires assessing perceived improvement in surgical skills, anatomical knowledge, confidence identifying surgical structures, and reflection of live operating conditions. Faculty instructors separately completed semi-structured interviews focused on the educational strengths and limitations of each respective model. Interview audio was transcribed and de-identified. All audio files will be destroyed upon completion of the research study.

Data Analysis

Descriptive statistics and exploratory t-tests for quantitative comparisons and thematic analysis were utilized. In order to analyze the general surgery residents' baseline survey, Likert-scale data, descriptive statistical analysis was utilized with cleaned and deidentified data. Thematic analysis was utilized in order to analyze the verbal accounts of surgical faculty instructors. T-tests were also performed in order to analyze data.

Results

Participant Characteristics and Baseline Demographics

A total of 20 participants contributed to the data with 17 residents and three faculty instructors providing completed survey responses. Among the resident participants, 11 (64.7%) were classified as junior residents

and six (35.3%) were senior residents. The distribution of residents included six PGY-2 (35.3%), five PGY-3 (29.4%), five PGY-4 (29.4%), and one PGY-5 (5.9%). Faculty instructors had between five and 17 years of surgical experience. All participants completed procedural skills laboratory sessions focused on laparoscopic colon resection techniques using both the porcine model and the ICL-SP human body donor model.

Residents reported limited baseline prior exposure to laparoscopic colon resection, having scrubbed-in to a mean of 3.35 such procedures in the preceding six months. Prior simulation exposure varied with six (35.3%) residents reporting no prior porcine-model experience, whereas 11 (64.7%) reported some experience, defined as participation in one to five previous procedural skills laboratories. For the ICL-SP donor model, eight (47.1%) residents reported no prior experience, while seven (41.2%) reported some experience, and two (11.8%) reported substantial experience with the model.

With regard to baseline operative self-assessment, twelve (70.6%) residents reported having “some” confidence in their anatomical knowledge related to laparoscopic colon resection, while four (23.5%) reported “substantial” confidence. In terms of surgical skill confidence, five (29.4%) residents reported no confidence in their laparoscopic colon resection surgical skills, while ten (58.8%) reported some confidence, and two (11.8%) reported substantial confidence.

Perceived Educational Value

Both simulation models were viewed favorably. For the porcine model, 11 (64.7%) residents agreed that the model improved their surgical skills related to laparoscopic colon resection, while 10 (58.8%) agreed for the ICL-SP donor model. Similarly, with regard to residents' overall satisfaction as a tool for developing surgical skills, 12 (70.6%) residents rated the porcine model as satisfactory, compared with 14 (82.4%) for the ICL-SP model. Transferability to the operating room was endorsed by 12 (70.6%) residents with the porcine model and 14 (82.4%) for ICL-SP. These differences between models were not statistically significant, suggesting that both models were perceived as broadly useful for procedural education.

Anatomical Knowledge Acquisition

Residents reported greater improvement in anatomical knowledge following exposure to the ICL-SP donor model as compared to the porcine model. Following simulations, six (35.3%) residents agreed that the porcine model improved their anatomical knowledge associated with laparoscopic colon resection, whereas 14 (82.4%) residents agreed after ICL-SP exposure. Mean ratings likewise favored the ICL-SP donor model (mean 3.78, SD 1.04) with a statistically significant difference ($t(31) = -3.91$, $p < 0.001$) and large effect size (Cohen’s $d = 1.14$) between the models.

Confidence Identifying Key Structures

Confidence in identifying key structures improved more consistently after ICL-SP body [EA1] donor exposure. After simulation with the porcine model, the proportion of residents reporting increased confidence was five (29.4%) for the colon, seven (41.2%) for the mesentery, six (35.3%) for the retroperitoneum, four (23.5%) for the ureters, and seven (41.2%) for arteries and veins. After ICL-SP exposure, the corresponding resident responses reporting increased confidence were 10 (58.8%) for the colon, 13 (76.5%) for the mesentery, 14

(82.4%) for the retroperitoneum, 14 (82.4%) for the ureters, and 14 (82.4%) for arteries and veins. Similar patterns were seen for epiploic appendages and tenia coli. Overall, the porcine model often left confidence unchanged, whereas the ICL-SP model more consistently improved residents' confidence in identifying structures central to laparoscopic colectomy. A detailed breakdown of these changes in confidence across anatomical structures is provided in Table 1.

Table 1
Change in Residents' Confidence in Identifying Anatomic Structures in the Operating Room, After Exposure to a Simulation Model[a]

Anatomic Structure	Porcine Model			ICL-SP Donor Model		
	Decreased Confidence	No Change in Confidence	Increased Confidence	Decreased Confidence	No Change in Confidence	Increased Confidence
Colon	0	12	5	0	7	10
Mesentery	0	10	7	0	4	13
Retroperitoneum	0	11	6	0	3	14
Haustra (Epiploic Appendages)	0	12	5	0	6	11
Tenia Coli	0	12	5	0	6	11
Ureters	0	13	4	0	3	14
Arteries	0	10	7	0	3	14
Veins	0	10	7	0	3	14

[a] All numerical values represent the total number of resident confidence ratings based on anatomical structure. Comparing resident responses for confidence in identifying anatomic structures associated with laparoscopic colon resection in the operating room, no residents had decreased confidence after exposure to the simulation models. Comparing the porcine and alcohol-preserved human body donor models, the majority of residents experienced no change in confidence for the porcine model, and the minority of residents had increased confidence in identifying anatomic structures in the operating room, after exposure to the porcine model. For the alcohol-preserved human body donor, the results are reversed with the minority of residents having no change in confidence, while the majority of residents had increased confidence in identifying anatomic structures associated with laparoscopic colon resection within the operating room.

Reflection of Live Operating Conditions

The two models diverged most clearly in domain-specific realism. All 17 (100%) residents rated the ICL-SP donor model superior for gross anatomy and anatomic relevance. In contrast, 10 (58.8%) residents rated the porcine model as being better for tissue elasticity and nine (52.9%) rated it better for artery/vein structural integrity. For colon suturing or stapling during anastomosis, the ICL-SP model was preferred by nine (52.9%) residents, compared with three (17.6%) who preferred the porcine model. Skin suturing was rated similarly between the two models. Mean overall realism scores modestly favored ICL-SP (5.13 vs. 4.65 on a 7-point

scale), although this difference was not statistically significant (t(31) = -0.82, p = 0.42). Faculty unanimously regarded the ICL-SP donor as more anatomically similar to operating on a live human, while simultaneously highlighting the porcine model's advantages for active blood circulation, tissue handling, and identification of tissue planes. A more detailed breakdown of resident perspectives on models' reflection of live operating conditions is provided in Table 2. Similarly, visual representation of tissues based on presence, absence, or type of preservative can be visualized in Fig. 1.

Table 2

Relationship Between Resident Prior Experience Practicing Surgical Skills on the Porcine/Alcohol Models, and the Simulation Models' Improvement of Resident Laparoscopic Colon Resection Surgical Skills[b]

Prompt	**Model**	**Prior Experience/Confidence**		
Working with this model helped improve my surgical skills associated with laparoscopic colon resection.		Resident prior experience practicing surgical skills on the porcine/ICL-SP donor models.		
		None	Some	Substantial
	Porcine	3.67	3.91	N/A
	ICL-SP Donor	3.13	4.00	4.00

[b] All numerical values represent the averages of all resident responses based on the amount of prior experience they had practicing surgical skills on the porcine and alcohol-preserved human body donor models. Numerical values are also on a scale from 1 to 5 in relation to the prompt on the left, with 1 being strongly disagree, 3 being neither agree nor disagree, and 5 being strongly agree. Residents with no prior experience practicing surgical skills on the porcine model slightly agreed that the porcine model improved their surgical skills associated with laparoscopic colon resection, while residents with some experience agreed that the model improved their surgical skills. No residents had substantial experience practicing on the porcine model, represented by the "N/A". Residents with no experience practicing surgical skills on the alcohol-preserved human body donor model slightly agreed that the alcohol-preserved human body donor model improved their surgical skills associated with laparoscopic colon resection, while residents with some and substantial confidence both agreed that the model improved their laparoscopic colon resection surgical skills.

Figure 1 Image a (left) shows a portion of the large and small intestines in the unembalmed human body. Image b (middle) is the large intestine framing the small intestine of the alcohol-preserved human body. Image c (right) is the large and small intestine of a formalin-fixed human body. In all three images the outpouching of the cecum, and its continuation superiorly as the ascending colon is visible. For Images b & c, you can identify the hepatic flexure, continuation of the colon as the transverse colon, splenic flexure, and descending colon. In the formalin-fixed body, you additionally can see the sigmoid colon

Additionally, analysis of residents' overall experience levels revealed a positive relationship between surgical experience and perceived realism of the ICL-SP donor model. Residents with greater surgical experience regarded the cadaveric model as more reflective of live operating conditions, whereas less experienced

residents perceived the porcine model as reflective of operative conditions. This relationship is illustrated in Fig. 2.

Figure 2 This figure demonstrates the relationship between resident experience and confidence level and which model they perceived as being more reflective of live operating conditions on a human in the operating room. Residents with less surgical confidence and experience generally rated the porcine model as being more reflective of live operating conditions, while residents with more experience and confidence rated the alcohol-preserved human body donor model as being more reflective of live operating conditions

Experience-Level Patterns

Experience level appeared to influence model preference. Junior residents rated both the porcine and ICL-SP models highly (mean benefit 4.09 vs 4.05), whereas senior residents rated the porcine model lower than the ICL-SP model (mean benefit 2.83 vs 4.05). The porcine model also appeared to confer greater confidence gains in residents with little or no prior colectomy exposure, while ICL-SP donors produced more stable confidence gains across levels of prior operative experience. A summary of the relationship between prior operating room experience and changes in confidence in performing laparoscopic colon resection is shown in Table 3.

Table 3

Relationship Between Resident Prior Experience Practicing Surgical Skills Associated with Laparoscopic Colon Resection in the Operating Room, and the Simulation Models' Improvement of Resident Confidence in Performing Laparoscopic Colon Resection in the Operating Room[c]

Prompt	**Model**	**Prior Experience/Confidence**		
After working on this model, I feel more confident about performing laparoscopic colon resection in the operating room.		Resident prior experience practicing laparoscopic colon resection surgical skills in the operating room.		
		None	Some	Substantial
	Porcine	4.25	3.45	1.00
	ICL-SP Donor	4.00	3.83	4.00

[c] All numerical values represent the averages of all resident responses based on the amount of prior experience they had practicing laparoscopic colon resection surgical skills in the operating room. Numerical values are also on a scale from 1 to 5 in relation to the prompt on the left, with 1 being strongly disagree, 3 being neither agree nor disagree, and 5 being strongly agree. Residents with no prior experience practicing laparoscopic colon resection surgical skills in the operating room agreed that the porcine model improved their confidence in performing the procedure in the operating room. Residents with some experience slightly agreed that the porcine model improved their confidence in performing laparoscopic colon resection in the operating room, while residents with substantial experience strongly disagreed that the porcine model improved their confidence in performing the procedure in the operating room. Residents with no experience, some experience, and substantial experience practicing surgical skills associated with laparoscopic colon resection in the operating room, all agreed that the alcohol-preserved human body donor model increased their confidence in performing laparoscopic colon resection in the operating room.

Discussion

Principal Findings

The present study compared live porcine and ICL-SP human body donor models for laparoscopic colon resection training among general surgery residents at a single academic medical center. To our knowledge, this represents one of the first studies to directly compare these two simulation platforms within a structured colorectal procedural skills curriculum for general surgery residents, and one of the first to apply the ICL-SP technique in this educational context. Several important findings are important to note. First, ICL-SP donor exposure was associated with significantly greater anatomical knowledge gains and more consistent improvement in confidence identifying key operative structures compared with porcine simulation. Second, the porcine model retained measurable advantages for live-tissue handling characteristics, including tissue elasticity and vascular integrity. Third, resident experience level appeared to moderate the relative educational benefit of each model, with senior residents more consistently favoring ICL-SP and junior residents rating both models comparably. These findings are consistent with prior comparative literature and extend it by demonstrating the educational utility of ICL-SP specifically within general surgery residency curricula.

Comparison With Prior Preservation Literature

The current study adds to the growing body of literature on cadaveric preservation in surgical education. Formalin-fixed cadavers remain durable and accessible, but lack procedural realism due to rigidity and alteration to the native characteristics of most tissues [10]. Fresh-frozen models offer high fidelity, but their work time is limited after thawing and the physical and fiscal infrastructure required to maintain them are substantial [10, 11]. Soft-preservation methods attempt to balance fidelity with utility. In comparative embalming work, ICL-SP most closely approximated unembalmed joint range of motion among the tested methods, and Venne et al. found phenol-based soft embalming to be at least as realistic as Thiel for surgical training, with preference for phenol-based models in several domains [12, 13]. Additionally, more recent literature notes that orthopedic residents preferred ICL-SP to standard formalin-preserved donors for anatomy learning [14]. The findings of the present study further support these observations, as both residents and faculty instructors perceived the ICL-SP human body donor model to more accurately represent human anatomy than alternative simulation models.

At the same time, the literature does not recognize ICL-SP as being a universally superior model. One key caution is its biosafety and durability. Formalin remains the most effective disinfectant among commonly studied embalming methods, while ICL-SP donors have shown the weakest antimicrobial performance in comparative testing [15]. A 2023 review summarizing this work noted that bacterial colonies had the potential to reappear in ICL-SP specimens after approximately 2 month’s time, underscoring that that reusability must be balanced between tissue realism and storage/infection-control practices [15, 16]. For that reason, this study represents an educational comparison of simulation platforms, not a ranking of preservation methods.

Educational Implications for Surgical Training

One of the most notable findings of this study was the relationship between resident experience level and perceived simulation model utility. Junior-level residents consistently rated both the porcine and human body

donor models highly, whereas senior residents strongly favored the ICL-SP donor. This pattern potentially reflects differences in educational needs across stages of surgical training.

It is proposed that early in residency, trainees are still developing fundamental operative skills such as tissue handling, recognition of tissue planes, as well as the basic principles of hemostasis. These foundational skills can be effectively practiced using animal models that more aptly simulate bleeding and physiologic tissue characteristics. In contrast, more advanced residents derive greater value from the model that closely reproduces the anatomic and procedural contexts in which they will be operating.

This interpretation also fits the general literature on simulation-based procedural teaching, which emphasizes that simulation models may be most effective when strategically integrated into surgical curricula to align with the learner's developmental stage and the specific skills sought [1–3]. In practical terms, a staged curriculum could utilize porcine models for early tissue-handling and hemostatic learning, with more advanced procedural rehearsal and operative decision-making increasingly relying on anatomically accurate human donor platforms.

Continued Resident Education and Simulation Sustainability

For residency programs, the question is not only which model is educationally strongest based on the desired outcomes, but also which models can be sustained over time given logistical, ethical, and financial considerations. Live porcine simulation laboratories are inherently single-use and require animal procurement, anesthesia, veterinary personnel, and specialized facilities, resulting in substantial per-session costs. Reported estimates vary widely depending on procedure type and institutional resources, but systematic reviews of porcine-based training highlight the logistical and financial burden associated with repeated animal use [17, 18]. In contrast, fresh-frozen cadavers are widely regarded as the model most closely approximating live tissue, but they require freezer infrastructure, have limited usability after thawing, and carry infection-related considerations, limiting their practicality for repeated use in longitudinal curricula [10, 11]. Formalin-fixed cadavers, by comparison, are highly durable and can be used over extended periods with proper maintenance; however, their rigidity, altered tissue characteristics, and formaldehyde exposure reduce their utility for realistic procedural simulation [10, 12, 19].

Soft-preserved donor models, including Thiel, saturated salt solution, and ICL-SP techniques, offer a potential balance between realism and reusability. Thiel-embalmed cadavers have been used across multiple sessions and specialties, although they require more technically demanding preparation and may have shorter effective dissection windows than formalin-fixed models [10, 20, 21]. Saturated salt solution models have been proposed as lower-cost, lower-infection-risk alternatives for surgical training [10, 22, 23]. Although standardized data on ICL-SP longevity and cost remain limited, existing literature supports its ability to preserve tissue fidelity while allowing repeated educational use [12–15]. Ethical considerations also influence model selection: animal-based simulation raises concerns regarding animal welfare, whereas human body donation represents a significant contribution to medical education that should be maximized through effective and respectful use. Collectively, these factors underscore the importance of selecting simulation models that support repeated exposure, deliberate practice, and staged skill progression within residency training [1–4]. While porcine models remain valuable for teaching live-tissue physiology, donor-based models,

particularly those that preserve realism while allowing reuse, may offer greater long-term value for anatomy-intensive surgical education.

Limitations and Future Research

Several limitations should be considered when interpreting the findings of this study. First, the study was conducted at a single academic institution with a modest sample of residents and faculty instructors. Although the findings provide valuable insights into resident experience with simulation models, larger multi-institutional studies would be necessary to confirm the generalizability of these results. Second, the study relied primarily on self-reported measures of resident confidence, perceived knowledge gain, and educational value rather than objective assessments of surgical performance. Future research should consider incorporating validated technical skill assessments or operative performance metrics to more directly evaluate the impact of simulation models on surgical competence. Third, residents were exposed to both simulation models sequentially, and the order of exposure may have influenced their experience with each model. Randomized study designs comparing simulation models may provide additional insights into the relative educational benefits of different simulation approaches. Finally, although the discussion addresses sustainability and costs, the present study did not include a formal prospective cost analysis and any statements about economics should therefore be understood as literature-informed context rather than direct findings of this study. Future studies should also continue evaluating emerging cadaver preservation techniques and their potential applications in surgical simulation. As surgical procedures become increasingly complex, high-fidelity simulation models that closely approximate live operative conditions will likely play an increasingly important role in surgical training.

Conclusion

Live porcine and ICL-SP human body donor models appear to serve complementary rather than interchangeable roles in laparoscopic colon resection training for general surgery residents. These data suggest that an integrated simulation curriculum incorporating both platforms, aligned with trainee experience level, may provide optimal benefit in general surgery residency programs. Future prospective studies are needed to validate these findings and establish standardized criteria for the staged incorporation of cadaveric and animal-based simulation across surgical training curricula.

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Figures

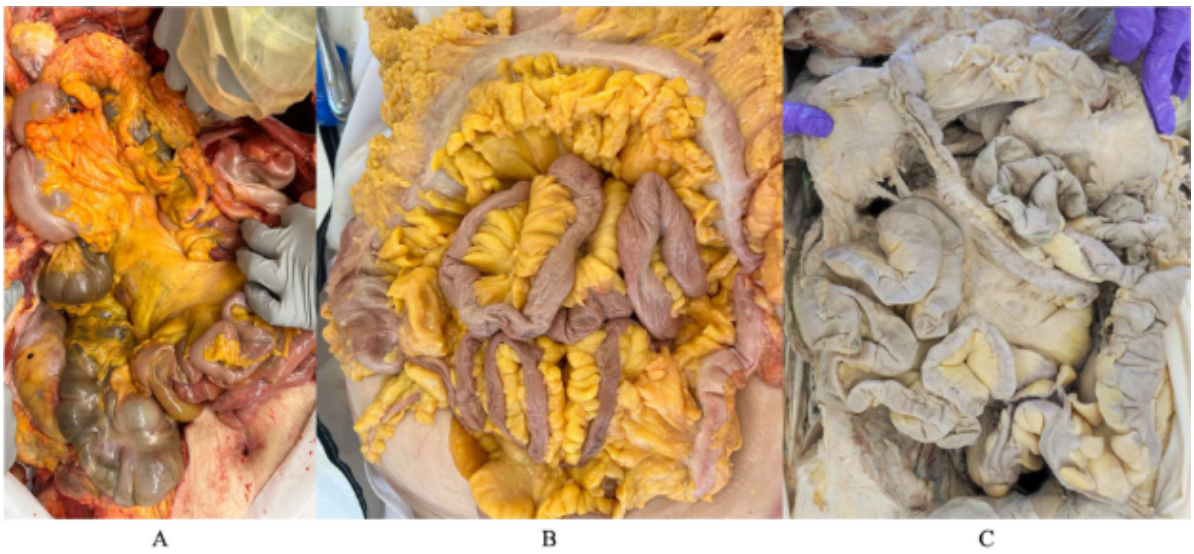

Figure 1

Comparison of Unembalmed, Imperial College of London Soft-Preserved, and Formalin-Fixed Large Intestines

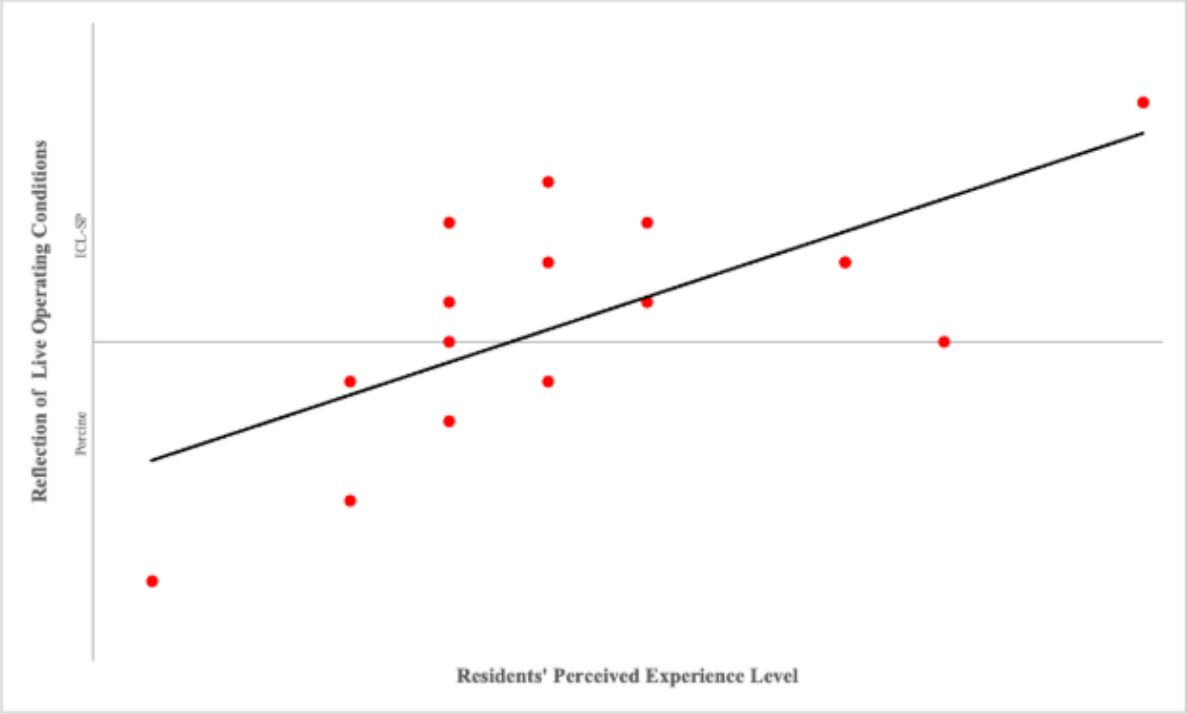

Figure 2

Resident Experience Level Versus Simulation Models' Reflection of Live Operating Conditions