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WILL LOW-COST, DISPOSABLE, SIMULATED TISSUES REPLACE HIGH-COST VIRTUAL REALITY SURGICAL TRAINERS?



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Medical Simulation Training (MST) is heading down two very divergent paths: a high-tech, high-cost one and the other low-tech, low-cost. While the former has received the largest attention to date from both bio-industry and the medical professions, we believe low-tech, low-cost biosynthetic tissues (BSTs) will find an enormous niche in MST. Our facility has been developing a line of inexpensive, high-fidelity BSTs and has employed them in training more than 300 individual medical students, residents, and faculty to date in minor surgery (e.g., IV insertion, arterial catheterization, subclavian line, umbilical artery catheterization, trans-femoral sheath placement), laparoscopic surgery (e.g., tumor removal, hysterectomy), and neurovascular surgery (e.g., external-internal carotid bypass, carotid endarterectomy).



Fig. 4: Simulated uterus for laparoscopic hysterectomy training. This is fashioned so it is inserted into a plastic pelvis and also contains important structures beneath peritoneal reflections such as ureters, iliac vessels and bifurcation, lymph nodes for samples, nerves, etc.

These materials are fabricated by a proprietary process using porcine, denatured subdermal collagen along with a variety of non-animal additives for color and elasticity. Different embedded matrices allow us to simulate subcutaneous adipose, dermis, fascia, adventitia, and loose connective tissue. Circulation of blue-colored water under low pressure and red water under high, pulsatile pressure create realistic intra-operative venous and arterial blood losses and obscuring of the operative field. BSTs are made on a weekly basis according to the upcoming needs of the simulation program schedule. Most BSTs can be manufactured in 1-3 hours and require less than \$20 to produce. BSTs have a conservative shelf-life of over four weeks if stored under refrigerated conditions. BSTs have significant advantages:

- Realistic in size, shape, color, texture, tensile properties
- Produced uniformly from molds
- Ability to create multi-layer, sophisticated multi-layer tissue.
- Produce realistic venous and arterial blood loss
- Low cost of materials & manpower; disposable
- BSTs can be re-melted and recycled into other BSTs



Figure 5: Simulated skin and subdermal layers have been dissected and retracted out of the way to expose underlying simulated blood vessels in preparation for end-to-side anastomosis.

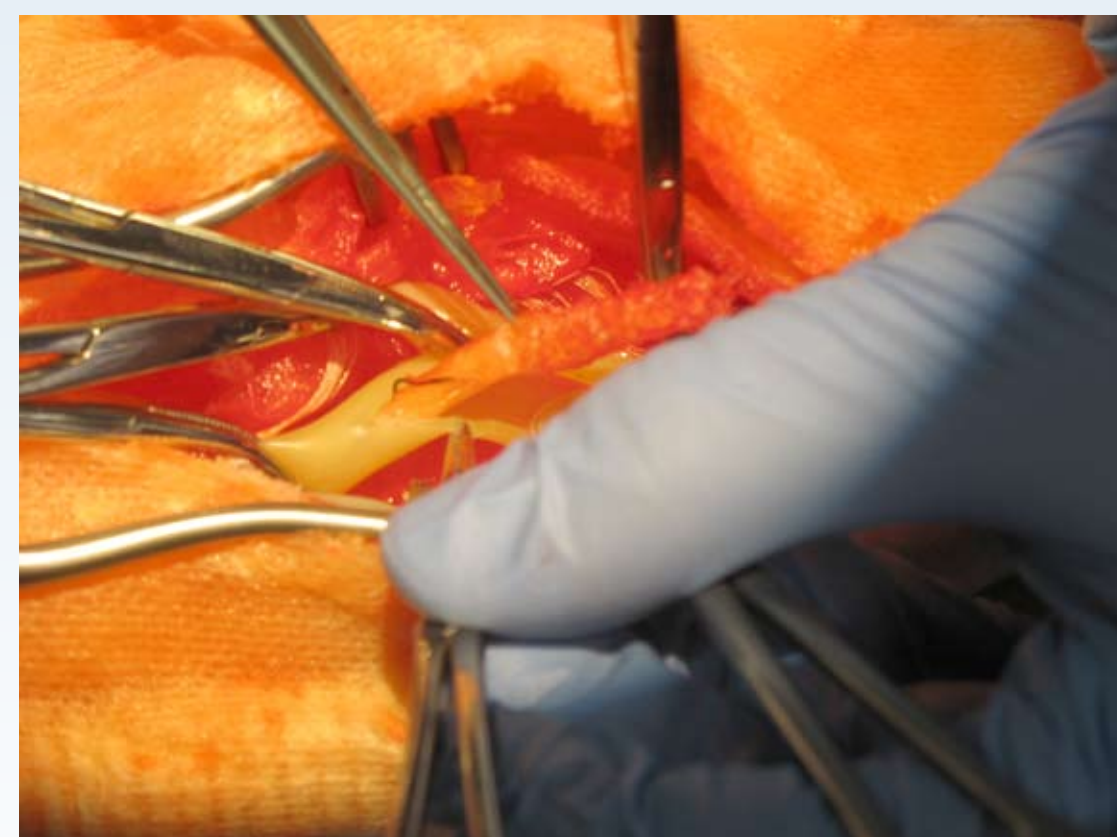


Fig. 1: Simulated atheromatous plaque being realistically removed from bifurcation of common carotid artery in simulated carotid endarterectomy model (See also figure 2).

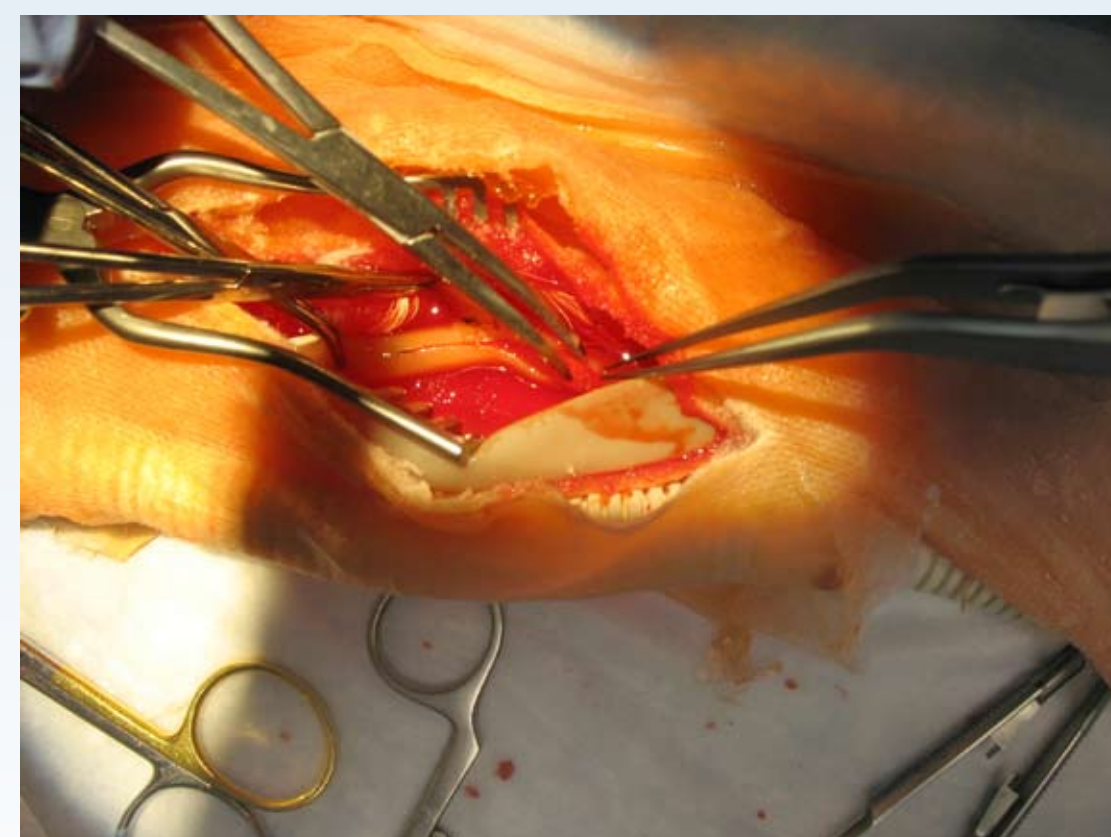


Figure 2: Arteriotomy site after atheroma removed from bifurcation of common carotid artery

We believe disposable BSTs will quickly create a niche in developing accurate, realistic methods of assessing surgical skills. BSTs will likely become an integral, disposable component of computer simulation trainers, producing "hybrid trainers" combining Virtual Reality modalities to maximize realism in MST while still maintaining low-cost and low-maintenance.