Utilizing 3-D Printing and Rapid Prototyping for Innovation and Education

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3D printing and Rapid Prototyping

- Manufacturing methods
- 3D printing in anesthesiology
- Future directions
- Getting started

Types of Traditional Manufacturing

SUBTRACTIVE

FORMATIVE

1/13/20
Types of Traditional Manufacturing

- **SUBTRACTIVE**
- **ADDITIVE**

Additive Manufacturing

- Multiple types
  - Fused Deposition Modeling (FDM)
    - Most common
    - Cheapest
  - Stereolithography (SLA)
    - First type of additive manufacturing
    - Limitations on materials
  - Selective Laser Sintering (SLS)
    - Most expensive
    - Metal

Rapid Prototyping

1. PROTOTYPING
2. TEST & REVIEW
3. REFINE & ITERATE
4. FINAL PRODUCT

3D Printing in Anesthesiology

- **Education**
  - A randomised, controlled trial evaluating a low cost, 3D-printed bronchoscopy simulator.
  - 3D model was rated most realistic.
  - 3D printed model was >20 times cheaper.

- **Education**
  - 91% success in experimental group.
  - 29% success in control group.
  - Trainer group also required less time and attempts for success.

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**Original Article**

- Improving Clinical Proficiency Using a 3-Dimensionally Printed and Patient-Specific Thoracic Spine Model as a Haptic Task Trainer.
  - 91% success in experimental group.
  - 29% success in control group.
  - Trainer group also required less time and attempts for success.
Education

A versatile ultrasound simulation system for education and training in high-fidelity emergency scenarios

- 3D printed chest plate and US probe using RFID
- Significantly cheaper than comparable simulators
- Allowed for customization of chest plate to existing simulator


Planning

Personalized anaesthesia: three-dimensional printing of facial prosthesis for facial deformity with difficult airway

- Patient-specific prosthesis for deformity
- Test of ventilation using prosthesis on 3D printed model of patient face
- Allowed for successful mask ventilation
  - Unable to ventilate without prosthesis

Fan. BJA. 2018.
Planning

Three-dimensional printing as an aid to airway evaluation after tracheotomy in a patient with laryngeal carcinoma

- 3D reconstruction of neck CT allowed for evaluation of inner airway dimensions
- Airway management trialed multiple times
  - Appropriate tracheotomy cannula selected
  - Proceeded with procedure successfully

Planning

3D modeling of anomalous pulmonary vein

- 3D printing of congenital heart disease allows for visualization of patient-specific anatomy
- Further non-invasive imaging
- Allows for easier communication between colleagues

Tools

Design and evaluation of a novel and sustainable human-powered low-cost 3D printed thermal laryngoscope

- Low-resource regions don’t have reliable electricity
- Prototype for laryngoscope powered by warmth of operator’s hand
Tools

3D printed low-cost video laryngoscopes

Infection Control, Cleanliness

Efficiency and Usability of a Novel Barrier Device for Preventing Infection Port Contamination: A Pilot Simulation Study

Novel mandibular advancement bite block with supplemental oxygen to both nasal and oral cavity improves oxygenation during esophagogastroduodenoscopy: a bench comparison

- Bite block developed for EGD
  - O2 delivery
  - EtCO2 detection
  - Jaw thrust
- Provides highest FIO2 with same O2 flows compared to commonly used supplemental O2 delivery methods
Tools

Description of a Novel Set-up for Functional Echocardiographic Assessment of Left Ventricular Performance During Ex Vivo Heart Perfusion

▶ 3D printed platform, “esophagus” track, and spacer allow for accurate “TEE/TTE” of ex-vivo heart
▶ Proof of concept

Future applications

▶ Continued innovation in all 3 domains
   – Education
   – Planning
   – Tools
▶ Easier sharing of education/tools to low resource areas
▶ More patient-specific medicine
   – Bioprinting/organ transplant

How to get started

▶ Printer
   – Desktop FDM printers continue to decrease in cost
     • <$20,000 → $200-$2,000
   – Consider available materials with each printer
▶ Software
   – CAD program (open source)
   – Radiology DICOM → STL file conversion (3D slicer-NIH)
▶ Training
   – Numerous free online training resources
## References

- Wax et al. Efficacy and usability of a novel barrier device for preventing injection port contamination. 2019. [Epub ahead of print]