Realistic Carotid Endarterectomy Simulation Using 3D Printing Technology and Hydrogel Polymers

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(1) Introduction

Training for a carotid endarterectomy has become difficult because of decreased volume secondary to advances in the medical management and regionalization of care. While live operative exposure is required, resident inexperience may compromise patient safety and lengthen case times. This needed training tool was designed to replicate all vital steps and measure operative performance.

(2) Methods

Anatomically accurate models of human necks were created using poly-vinyl alcohol hydrogels. 3D models of the carotid and all adjacent structures were created using CAD software. Injection molds were 3D printed and . Graded polymerization of the polymers were casted with realistic mechanical properties. A ventricular assistive device was used to create pulsatile blood flow.

Five residents and attending physicians (n=10) completed our simulator. Face validity surveys were collected and operative statistics were compared using students T-test and Chi Squared analysis. Face validity was determined from experts only.

(3) Results

The mean operative time for the expert group was 63.6 minutes versus 138.8 for the residents (p=0.002). Similarly, there was a difference in mean internal carotid artery clamp time of 43.4 minutes versus 83.2 (p=0.04). Only 2 hypoglossal nerve injuries occurred, both in the resident group. Attendings (n=5) reported an average of 4/5 on face validity questions.

(4) Conclusions

The presented simulator provides a realistic tool for practicing procedures in a safe and low cost environment. Surgical times on the models were similar to live cases suggesting appropriate difficulty of the task. Residents on average took twice as long as attendings and had more errors in technique.